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Contents

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Posters

Watsonia control: Effectiveness of 2,2-DPA, impacts on native flora and influence of a prescribed-burn

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Across the Mount Lofty Ranges, Bulbil Watsonia, *Watsonia meriana* var. *meriana*, has naturalised and poses a significant threat to bushland and wetland areas. Where Watsonia invades native vegetation, it tends to form dense monocultures displacing native herbs, grasses and other understorey species. The optimal time for herbicide control is when the parent corm has been fully exhausted but before the daughter corm has fully developed. This is just as the flowering spikes appear in spring. This is also the time when most components of the native flora are actively growing so a herbicide that is highly selective for Bulbil Watsonia in native vegetation is required. A study conducted in south-west Western Australia (Brown et al. 2008) suggests that the herbicide 2,2-DPA (Propon®) presented with such selectivity. A recent trial in the Adelaide Hills tested the effectiveness of 2,2DPA, its impacts on the flora of Stringybark Woodland where Bulbil Watsonia poses a significant threat and tested the use of fire as a post herbicide regeneration tool.

Burnt Trees: Habitat or Hazardous?

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Presenter: Kirstin Abley

Fire (bushfires and prescribed burns) can structurally compromise some trees, increasing the chances they will collapse. Managing the risk that these trees potentially pose to fire fighters, landholders and the general public is challenging, particularly during bushfire situations when this risk must be managed quickly and within the midst of a stressful environment.

From an ecological perspective the loss of large trees represents a significant loss of habitat resources. Trees, particularly those with hollows, provide critical foraging and nesting habitat for native fauna. In areas like the Adelaide Hills, large trees are already scarce due to past logging practices and since tree hollows typically take over 100yrs to develop, these resources are irreplaceable in our lifetime. It is therefore imperative that our risk assessment processes are able to adequately reduce the risk that burnt, structurally compromised trees pose to human safety, while also considering the benefits that large trees provide to native fauna.

The recent Sampson Flat and Pinery Bushfires resulted in the loss of many large, hollow-bearing trees from the landscape. Some trees collapsed during the fire, while others were removed in the days and weeks after the fire. It appears that in some instances trees were removed due to incorrect perceptions or assessments about the public risk they presented or the extent to which they would contribute to the fuel-load of future bushfires. This presentation examines the reasons that trees are being cleared following bushfires and then looks at what we need to do to address this issue.

Tree collapse is also an issue during prescribed burns. Importantly though, the reduced fuel areas created by these burns can also help prevent much more significant tree collapses if the area is later affected by a high intensity bushfire.

The same risk management challenge exists for prescribed burns as it does for bushfires; it is imperative to provide a safe working environment for fire fighters whilst also minimising impacts on significant trees. Unlike bushfires, prescribed burns occur in a relatively controlled environment after significant planning. It is therefore possible to implement strategies to reduce identified risks, such as tree collapse. We will present data from monitoring we have undertaken to investigate the collapse rates of 'at risk' trees during prescribed burns and will comment on the effectiveness of the available mitigation strategies.

Using Prescribed Burns to Achieve Weed Management Objectives

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While the primary purpose of prescribed burning is to minimise the risks that bushfires pose to human life and property, there are also considerable opportunities to achieve ecological benefits from prescribed burn programs.

In the Mount Lofty Ranges, areas that are subject to prescribed burning are also often those that are degraded by weeds due to their proximity to urban areas. Tackling fire-responsive weeds is a significant challenge in these areas but, where possible, the Region's Fire Ecology team are using prescribed burns to their advantage to manage weed infestations.

Preliminary results from a recent trial have found that prescribed burning can increase the efficiency of *Erica arborea* control. The results from this trial and from other fire-related, weed control initiatives, will be presented and discussed with an emphasis on the potential benefits of using pre-fire weed control to increase the effectiveness of post-fire follow-up.

Habitat suitability mapping and fire management – towards improved conservation outcomes for the Endangered Mount Lofty Ranges Chestnut-rumped Heathwren and associated heath species

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The vegetation remnants of the Mount Lofty Ranges (MLR), particularly in the peri-urban landscape, are subject to prescribed burning to reduce fuel loads primarily to protect human life and property. A number of threatened species occur within this landscape and ecologically informed fire management practices are essential to ensure these species are not negatively impacted. For some threatened species, opportunities exist to use prescribed burns to improve habitat quality and assist with conservation goals. However, this can only be achieved by improving species level ecological knowledge and spatial data to assist with fire management planning.

The Endangered (EPBC Act, 1999 and SA NPW Act, 1972) Mount Lofty Ranges Chestnut-rumped Heathwren (MLR CRHW) *Hylacola pyrrhopygius parkeri* is one such species whose population viability depends on careful burn planning processes. The MLR CRHW is a small terrestrial passerine, with limited dispersal capacity, that persists in isolated, heath dominated, remnant habitat patches of the MLR. The impacts of habitat loss and fragmentation are continuing to increase the extinction risk of local populations, adding to the complexity of ecologically sustainable fire management for this and other heath dependant species in the MLR.

Habitat suitability for the MLR CRHW was mapped across key sites in the MLR to improve our understanding of the quality and extent of MLR CRHW habitat. Repeated mapping over time has also enabled us to informally examine the relationship between time since fire, fire intensity, habitat quality and the response of MLR CRHWs to these factors. The recovery program for this species is in its infancy and recovery actions are being undertaken without a formal recovery plan at this stage. The information gathered from this work will be instrumental in framing and developing future recovery actions for the MLR CRHW and informing fire management planning in areas inhabited by this species.

Integrated Remote Sensing and GIS in Linear Features Mapping For Water Resources Study in Central Flinders Ranges, South Australia

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Presenter: Alaa Ahmed

Integration of remote sensing data and geographical information systems (GIS) for studying water resources has become important in the field of water research, particularly in assessing groundwater resources. The aim of this research was to demonstrate the spatial correlation between linear features identified as lineament and fracture traces located in a part of the Central Flinders Ranges. An important goal of this study was to improve understanding of the water resources and their management. Linear features mapped using remote sensing (ETM 7+ bands), existing geologic mapping and field interpretation of structural features. Field studies of 420 fractures, complemented by Landsat ETM image studies of 254 lineaments and 85 surface faults from published geologic maps were traced. The spatial relationship between fractures and bores, wells and springs was determined to reveal any existing patterns. Different thematic layers were created and later displayed on a GIS environment to investigate the geospatial correlation. The results highlight the effect of groundwater proximity to lineaments on the water yield, water composition and location of springs. Due to the good correlation between the above factors and hydrological occurrences, it was concluded that structural elements influence groundwater occurrence and act as groundwater transmission routes in the Oratunga area. The overall results prove that using remote sensing and GIS is effective in the study water resources and can lead to better management of groundwater resources.

Seasonal variation in the nature of DOM in a river and drinking water reservoir of a closed catchment in South Australia

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Presenter: John Awad

Dissolved organic matter (DOM) in surface waters used for drinking purposes can vary markedly in character depending on its source within catchments and the timing and intensity of rainfall events. Here we report the findings of a study on the character and concentration of DOM in waters collected during different seasons from Myponga River and Reservoir, South Australia. The character of DOM was assessed in terms of its treatability by enhanced coagulation and potential for disinfection by-product i.e. trihalomethane (THM) formation. During the wet seasons (winter and spring), water samples from the river had higher DOC concentrations ($\bar{x}$: 21 mg/L) and DOM of higher average molecular weight (AMW: 1526 Da) than waters collected during the dry seasons (summer and autumn: DOC: 13 mg/L; AMW: 1385 Da). Even though these features led to an increase in the percentage removal of organics by coagulation with alum (64% for wet compared with 53% for dry season samples) and a lower alum dose rate (10 versus 15 mg alum/mg DOC removal), there was a higher THM formation potential (THMFP) from wet season waters (raw waters: 603 µg/L vs 472 µg/L; treated waters: 217 µg/L vs 172 µg/L). For reservoir waters, samples collected during the wet seasons had an average DOC concentration ($\bar{x}$: 15 mg/L), percentage removal of organics by alum (54%), alum dose rates (13 mg/mg DOC) and THMFP (raw waters: 539 µg/L; treated waters: 207 µg/L) that were similar to samples collected during the dry seasons (mean DOC: 15 mg/L; alum dose rate: 13 mg/mg DOC; THMFP: 504 µg/L for raw waters and 212 µg/L for treated waters). These results show that DOM present in river waters and treatability by alum are highly impacted by seasonal environmental variations. However DOM in reservoir waters and its treatability exhibit less seasonal variability.

Introduction

The concentration and character of dissolved organic matter (DOM) present in surface waters (e.g., streams and reservoirs) are influenced by climate and season [1]. It has been reported that during storm events, there is an increase in DOM concentration in stream water [2] that is attributed to flushing of the upper organic soil horizons [3]. Organic matter in drinking waters sourced from reservoir catchments can pose health risks that need to be addressed. These risks include formation of disinfection by-products (DBP), such as trihalomethane (THM). Here we report the findings of a study on changes in the character and concentration of aquatic DOM during different seasons in a river and reservoir of an enclosed catchment. The character of DOM was also assessed in terms of potential treatability by coagulation/flocculation and THM formation potential (THMFP).

Material and Methods

This study was conducted in the Myponga Reservoir catchment (35°18′ to 35°25′S and 138°24′ to 138°33′E), which is part of the Mount Lofty Ranges watershed, 50 km south of Adelaide, South Australia, Australia. Water samples were collected from the Myponga River and Myponga Reservoir between March 2014 and February 2015. Filtered (0.45 µm) water samples were analyzed for DOC and UV-visible absorbance and by HPSEC with UV and fluorescence detection to characterize the DOM. The weight-averaged molecular weight (AMW= $\sum n \times MW / \sum n$) was calculated. mEnCo© Software [4] was used to estimate the coagulant [$Al_2(SO_4)_3$–$18H_2O$] dose with target pH level at 6. Total THMFP and the concentration of individual THM species before and after treatment were determined under controlled laboratory conditions of 35°C and pH 7.4, 20 mg/L chlorine addition and a hold-time of 4 hours.

Results and Conclusions

Percentage reduction of DOC after standardized treatment using alum (%DOC_{Rem}) and the alum dose rates (mg alum per mg DOC removed, Al/DOC) are presented in Figure 1. Average percentage removal of DOC from river water (58 ± 10%) was higher than from reservoir water (53 ± 3%), while the Al/DOC ratio for the river water (13 ± 3 mg/mg DOC removed) was similar to that for reservoir water (13 ± 1 mg/mg DOC removed). For river water, the %DOC removal by alum treatment was greater for water samples collected during wet seasons (64 ± 5.4%) than waters collected during the dry seasons (53 ± 10%). The Al/DOC data showed a consistent trend with values lower for waters collected

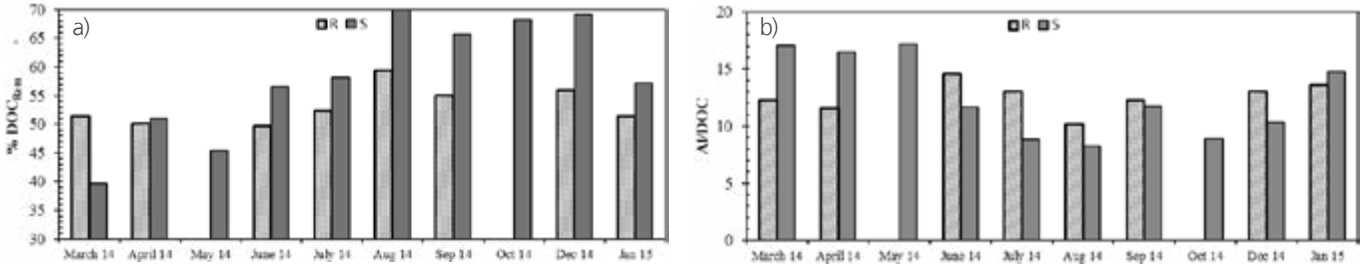

Figure 1. (a) %DOC_{Rem} and (b) Al/DOC from jar tests of river and reservoir waters. R refer to reservoir and S refer to river

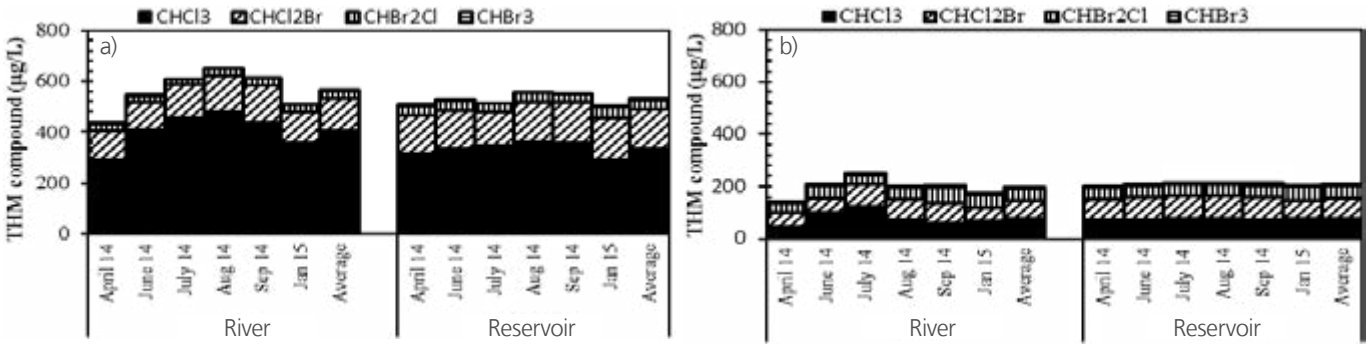

Figure 2. Constituent THM compounds for raw (a) and ED alum treated (b) waters from Myponga River and Reservoir

during wet seasons (10 ± 2 mg/mg DOC removed) than waters collected during dry seasons (15 ± 3 mg/mg DOC removed). This indicates that organic compounds in the surface waters collected during wet seasons (with higher aromaticity and AMW) were more amenable to removal by coagulation than the waters collected during dry seasons. In contrast, water samples collected from the reservoir during wet seasons exhibited similar %DOC removal and Al/DOC values compared to those collected during dry seasons (%DOC_{Rem}: 54 ± 4% for wet seasons vs 52 ± 2% for dry seasons; Al/DOC: 13 ± 2 mg/mg DOC for wet seasons vs 13 ± 0.8 mg/mg DOC for dry seasons). This may be attributed to storage of larger water volumes within the reservoir (average retention time ~4.6 y) enabling mixing of influent waters and stabilization of water quality.

Surface water samples collected from Myponga River had DOM of higher total THMFP ($\bar{x}$ ± SD: 560 ± 73 µg/L) than samples of reservoir water (527 ± 22 µg/L), as shown in Figure 2a. However no apparent difference was found in the mean specific THMFP values (the ratio of THMFP to DOC concentration) between waters collected from Myponga River and Reservoir. Total THMFP was higher in waters collected in the wet seasons ($\bar{x}$ ± SD: 603 ± 38 µg/L for river waters and 539 ± 18 µg/L for reservoir waters) than in the dry seasons ($\bar{x}$ ± SD: 472 ± 39 µg/L for river waters and 504 ± 3 µg/L for reservoir waters). Average total THMFP for alum treated waters (Figure 2b) collected from Myponga River ($\bar{x}$ ± SD: 202 ± 26 µg/L) was similar to that for treated waters collected from Myponga Reservoir ($\bar{x}$ ± SD: 209 ± 8 µg/L). Further, for treated reservoir waters, no significant difference was found between waters collected during dry and wet seasons (mean 212 ± 10 µg/L for dry seasons vs mean 208 ± 7 µg/L for wet seasons). These results show that DOM present in river water is highly impacted by the timing and volume of catchment runoff and seasonal variation. However DOM in reservoir waters is less variable over different seasons.

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Developing hydrological restoration options for Glenshera Swamp, Stipiturus Conservation Park

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Presenter: Mark Bachmann

Glenshera Swamp, within Stipiturus Conservation Park, is one of the most important remnants of a nationally threatened ecological community – the Swamps of the Fleurieu Peninsula. The site has managed to retain a suite of important biodiversity values, despite attempts over a 50 year period (up to its reservation in 2003) to make the area more suitable for agricultural production through drainage, clearance and grazing activities.

Consistent with a current trend of growing concern surrounding the availability and sustainable management of water resources in the Adelaide and Mt Lofty Ranges NRM region, there is considerable interest in the eco-hydrology Glenshera Swamp. With this in mind, Nature Glenelg Trust was asked to undertake an assessment of the site for DEWNR, to review the feasibility of different hydrological restoration options, with a goal of ensuring the future sustainability of the wetland ecosystem.

The assessment, which occurred from September 2015 until January 2016, involved: site visits, LiDAR and aerial imagery acquisition, historical research, and, detailed discussions with a wide range of people that have an intimate knowledge of the site. The work culminated in the production of a report with six key recommended on-ground actions for proposed implementation, with the first (inexpensive) step proposed being the installation of trial structures to reinstate surface flows to the swamp in time for winter 2016.

This project is a detailed and complex case study, ideal for exploring the logic of different hydrological restoration methods on public land, with broad application to those interested in improving modified wetland ecosystems elsewhere.

Groundwater management and mining development in South Australia

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Presenter: Rohan Baird

Mining has the potential to generate significant wealth for the State, however, careful regulation is required to protect water resource availability and quality for existing users and the environment. The Department of Environment, Water and Natural Resources (DEWNR) along with the Department of State Development (DSD) are responsible for regulating water related impacts associated with the mining industry. Significant volumes of water are generally required for mine site operations for mineral processing, dust suppression, camp supplies and amenities. The main water supply for mine sites in South Australia is groundwater which is extracted through dewatering wells or from dedicated water supply wellfields. Groundwater extraction and other mine site activities such as mineral processing need to be carefully managed to ensure existing users and water dependent ecosystems are not adversely affected.

Mining operations which have been assessed as having the potential to interact with groundwater are required to be supported by a groundwater impact assessment within a mining lease proposal. Impacts may include groundwater quality changes, drawdown causing groundwater level declines, seepage causing groundwater mounding and changes to surface water flow regimes. Assessment of impacts is guided by existing legislation, data, research, industry standards, community expectations and government and industry experts. DEWNR plays a key role in ensuring that approval and operation of South Australian mines is based on assessment of all available data and resources and is underpinned by defensible science. This is achieved through review of mining proposals, validation of data and technical work and consultation with other government agencies and mining proponents. If approval is granted, mine sites are subject to lease conditions and ongoing monitoring is used to ensure lease conditions are met. This talk presents an overview of the requirements of a mining lease proposal relevant to groundwater and the common approaches used to assess and monitor impacts.

Botany 2016 — Past, present and future

Algal Advocacy

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Algae – why important, especially those of southern Australia?

Algal studies in southern Australia: where they have come from, where they are now, and, have they a future? with an emphasis on the future and the relevance to NRMs

- The exploration era, Terra Australis and competition between the French and English (1791-1850). See: Womersley H.B.S. (1984) *The marine benthic flora of southern Australia*. Part I. Adelaide, Government Printer
- The founding of European Australia with interest in the west and east, but, sadly, South Australia is passed over

- The coming of W. H. Harvey the Dublin Doctor and a swell of interest in natural history
- Local amateurs and the Scandinavian connection – Jessie Hussey, Reinbold, and a Geelong Grammar School Head; a period of fascination with natural diversity
- A lull of 50 years, then the S A handbook era with Mrs. Florence Perrin and A.H.S. Lucas largely transcribing De Toni's lists and descriptions
- The golden age, with Adelaide University an international algal centre, headed by H.B.S. Womersley, and the advent of entrepreneurial SCUBA divers
- A period of consolidation with the writing of the 6 volumes of the marine benthic flora, the description of marine bioregions and applying terrestrial notions of ecology to marine ecosystems
- The contraction of government interest in pure research and pre-eminence of commercial priorities; molecular techniques for analysing diversity and the decrease in specialists on algal morphology; conversion of archival information using computer technology; regulations that inhibit fieldwork.

So what is the future of algal studies and in particular, the algal side of the State Herbarium?

- The public still has an interest in marine life including algae. How can this be fostered? Some website attempts are already available
- Marine biosecurity crises are likely to increase. These require access to validated specimens for identification if suitable responses are to be implemented.
- Ecological studies need validation of species if they are not to be criticised as subjective and "un-scientific".

Does release method matter when reintroducing brushtail possums to the semi-arid zone?

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Presenter: Hannah Bannister

Reintroductions are an increasingly common conservation tool used to reverse the decline of threatened species. Brushtail possums (*Trichosurus vulpecula*) were historically distributed across most of Australia, including arid and semi-arid regions, but have disappeared from more than 50% of their historical range over the past 200 years. In South Australia the species is listed as 'Rare', and is declared regionally extinct across much of the state. Previous attempts to translocate or reintroduce brushtail possums have encountered poor post-release survival and hyperdispersal away from release sites, while others have failed to undertake adequate post-release monitoring, with the fate of released possums remaining largely unknown. We tested whether alternative release methods combined with intensive post-release monitoring could improve reintroduction success for brushtail possums. We trialled three release methods during a reintroduction to the semi-arid Ikara-Flinders Ranges National Park in South Australia: soft-release (delayed release with supplementary food and shelter), hard-release (immediate release without supplementary food or shelter) and nest-box-release (supplementary food and shelter). Brushtail possums were last recorded in the area around 70 years ago. Successful fox control through DEWNR's *Bounceback* program facilitated the trial reintroduction of brushtail possums to the park. We monitored the survival, weight, dispersal distance and retention of pouch young (females only) for 48 radio-collared possums divided into the three release treatment groups.

Soft-release and nest-box release methods did not confer any reintroduction benefit. Soft-release possums took the longest (6 weeks) to maintain a stable distance from their release site, whereas hard-released possums did so the fastest (3 weeks). After three months, possums were residing between 0.9 km and 9.7 km from their release site. Soft-release and nest-box release methods did not prevent hyperdispersal, with three soft-released possums, three nest-box release possums and one hard-release possum dispersing more than 3 km from their release site. The mean distance from release site after 12 weeks was 1.1 km (range 0.9 - 3.7 km), 1.8 km (range 0.4 - 9.7 km) and 1.6 km (range 0.7 - 5.3 km) for hard-released, nest-box-released and soft-released possums respectively. Possums did not use nest boxes for shelter post-release, despite occasionally visiting them to eat the supplementary food provided. There was no difference in post-release weight, reproduction or survival between treatment groups. Possums in all release treatments had lost weight 10 days after release but most had regained it after 20 - 30 days, with almost all possums heavier than their translocation weight 60 days after release. Survival was high, with only one death of a hard-released female potentially attributable to release methods, although the cause of death remained unclear. All pouch young were retained post-release and additionally several females with empty pouches conceived joeys shortly after release, regardless of their release treatment. By 90 days after release, many females across all treatments had both a joey at foot and a second joey in the pouch. As reintroductions are financially and logistically expensive, determining cost-effective, successful release methods can inform future reintroductions for this and other related species. When post-release predation risk is low and shelter sites are plentiful, we recommend hard-releases for reintroduced brushtail possums.

A Heritage of Innovation: biocultural narratives in the McLaren Vale, South Australia

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Presenters: Douglas Bardsley and Elisa Palazzo

The McLaren Vale has been a highly successful region for agriculture since colonial settlement in the late 1830's. The region has experienced waves of dominance of particular agricultural activities from mixed farming, including dairy, grazing and cropping, through horticulture, especially apricots and almonds, through the current dominance of the modern viticultural systems. Throughout those eras, the local ability to adapt to external drivers has enabled successful businesses and communities. We present the contemporary stories and map the complexities of landowners' responses to risks and opportunities. Narratives of the values of agrobiodiversity and associated biocultural heritage are developed at field, farm and regional levels for the McLaren Vale. We contend that constructed divisions between the natural and the anthropogenic have often been artificial, limiting opportunities for holistic examinations of the biocultural heritage that is in regional agroecosystems. As the multifunctionality of agriculture becomes more marked, with history, tourism and associated landscape values becoming as important for many landholders as the commodities they produce, we argue that agrobiodiversity values within the landscape need to be recognised holistically. The recognition of the biocultural heritage linked to that agrobiodiversity could help to inform a World Heritage Listing application that wishes to protect landscape values in the Mt Lofty Ranges.

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Bushfires, biodiversity and peri-urban planning in a second modernity: the example of the Mt Lofty Ranges

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Presenter: Douglas Bardsley

Catastrophic fires in uplands on the periphery of Australian cities are reframing perceptions of what constitutes effective landscape planning and vegetation management. The emerging governance challenge to simultaneously mitigate bushfire risk and support improved conservation practices in peri-urban areas is reviewed within the context of historical and contemporary cultures of place within South Australia's Mt Lofty Ranges. The analysis suggests that anthropogenic burning of landscape has been a vital historical component of the management of risk. During the first modern era however, improved capacities to manage bushfire risk led to complacency in light of the hazard, which in turn has led to urbanization that has not sufficiently accounted for fire risk. A planning conflict is emerging as there is renewed interest in bushfire risk, which is reflected in new state policies increasing prescribed burning of remnant vegetation and providing greater allowances for land owners to clear around dwellings. Although attempts have been made to constrain urban growth around the city of Adelaide, recent workshops with key stakeholders suggest that urbanization continues within the Mt Lofty Ranges in areas that are both highly vulnerable to fire and are of great importance for biodiversity conservation. Planning could explicitly take such risks and values into account to effectively respond to the changing nature of future environmental hazards and development needs in Australian peri-urban uplands.

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Climate change adaptation in the Alinytjara Wilurara region of South Australia

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Presenters: Douglas Bardsley and Nathanael Wiseman

The application of comprehensive, caring policy to help guide sustainable futures for remote indigenous communities remains highly problematic in Australia. Now, climate change across Central Australia has the potential to make life more difficult in semi-arid environments and further weaken the traditional links between people and landscape. Work over the last five years with Natural Resources Alinytjara Wilurara suggests that institutional investment into spatial and temporal indigenous community monitoring and targeted adaptation management programs can generate employment while also providing a vital mechanism for monitoring, learning from, and responding to environmental change. Climate change generates the need for improvements in knowledge of environmental change and the management of the Australian rangelands, and so indigenous peoples' presence, biocultural knowledge and management activities become even more valuable for sustainable rangeland management. While there has been increased policy recognition of the importance of indigenous natural resource management in Australia over the last decade, the links between Indigenous Protected Areas, and the associated Working on Country Ranger program, and improved socio-economic outcomes for remote communities remain under-developed. New forms of institutional support could integrate remote indigenous communities into national environmental management goals while also improving livelihoods in remote communities.

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Botany 2016 — Past, present and future

How best do we sample a region's vascular plant diversity and how representative of a region is the State Herbarium collection?

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Scientific collections in herbaria are assembled in different ways suiting the purpose for which they are made. The main approach for assembling herbarium collections from the days of Linnaeus has been the general collecting expedition (field trip, foray) focused on geographical regions. The aim has been to gain a coverage of the plant, algal and/or fungal diversity encountered. Initially started by overseas institutions involved in voyages of discovery and followed by Australia's state and national herbaria in universities and government, the practice has continued into modern times. With the advent of resident Australian biological scientists, taxonomists specialising in particular groups and others needing plant identifications for botanical, biological and ethnobotanical studies enriched the collections, as have exchange programs between institutions. Such collecting is not "random" across a region's biodiversity, but should it be? A primary aim for regional herbaria such as ours should be to maximise coverage of diversity ecologically, seasonally and geographically.

The regular general flora surveys of different regions of the State have declined hugely, mostly through diminished staff and budgets, such that today they have fallen out of favour. Notable exceptions are the fungi (volunteer) and the naturalised vascular flora (special stakeholder funding), both recognised as substantially under-represented in the State Herbarium collection.

Since the definition of vegetation types across a broad region such as our State by analysis of floristic composition, ecological "vouchering" has been a major source of collections. Initiated the early 1970s, the Biological Survey of South Australia has contributed over 100,000 voucher collections, 78,000 incorporated into the State Herbarium's collections and associated database, a substantial portion of the 527,000 covering the State in the Herbarium. They are the specimen-backed ("vouchered") records of plants from thousands of "plots" across the State that augment a further 80% observational records that are not backed by specimens. The survey "plots" are of a size balancing efficiency of data gathering against level of diversity likely to be covered.

This paper compares the extent to which the results of plot-based and general survey cover known regional vascular plant diversity within the State Herbarium collection. Particular reference is made to Kangaroo Island, which is a floristically diverse geographical unit with marine borders. How well is its vascular flora represented in the State Herbarium collection?

Botany 2016 — Past, present and future

Tales from the type bay of the State Herbarium of South Australia

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Today whenever a new plant species is described the author is required to designate a holotype and list the isotypes (duplicates) and where they can be found; so there is usually no question about the identity and location of any type material. However, this is a relatively recent requirement and for older plant names, such as those described by Ralph Tate, J.M. Black and R.S. Rogers here in South Australia, types were not indicated. Instead there is just a list of specimens they had seen, or in some cases with Black, just a broad list of localities. Identifying those specimens which are types is a much more challenging process.

Most herbaria will have already made at least one pass through their collections to set aside their types and, in the case of the State Herbarium of South Australia (AD), assigned them to their red folders and placed them in the type bay. Once in the type bay they are readily identified and are then available to be worked on by visiting scientists or for loan to botanists working in Australian or overseas herbaria.

The advent of the JSTOR Global Plants initiative type digitisation project has led to the types in the bay being revisited and scrutinised before their images are captured and made available to the world through the web. What have we learnt about the collection in the State Herbarium from this process and how is the digitisation project affecting botanical practices?

Should I stay or should I go: The movement of mulloway (*Argyrosomus japonicus*) around the Great Australian Bight Marine Park inferred from satellite telemetry

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Presenter: Thomas Barnes

Very little information is available on the movement ecology of predatory demersal fish (i.e. fish that live near the bottom of the water column) likely due to a shortage of suitable tracking methods. This lack of information is concerning as many predatory demersal fish species provide important ecosystem services and support significant commercial and recreational fisheries. Consequently, improved information on movement of these species has the potential to underpin more informed environmental and resource management outcomes. Implementation of marine protected areas (MPAs) is increasingly being used as a management tool and has the potential to enhance the sustainability of demersal fish populations. Mulloway (*Argyrosomus japonicus*) is a large demersal fish species that could potentially benefit from MPAs as there are concerns that they may be declining in some areas. Although this is an iconic commercial and recreational species, little is known about spatiotemporal aspects of their movements. During the Austral summers and autumns from 2011 to 2014 we deployed 19 pop-up satellite archival tags (PSATs) on mature mulloway at an aggregation site in the Great Australian Bight Marine Park (GABMP), with the main objective to examine their spatiotemporal movement patterns. Approximately 58% of the tags transmitted useful data from deployments ranging from ~8 to 110 days. Pop-up location data revealed that the fish moved up to ~550 km from the tagging location. Nearly all tagged mulloway remained in the vicinity of the tagging location and hence MPAs over summer. However, relatively large horizontal movements were observed over autumn for most fish. Depths traversed by the tagged mulloway ranged from very shallow to relatively deep (0.0 to 56.5 m). Some tag data sets were incomplete due to rapid beaching of detached tags due to fish being relatively close to shore, consequently inhibiting the ability of tags to transmit data. In response to this problem and others we provide potential solutions for deployment of PSATs on predatory demersal fish species. In this study, we collected unprecedented information, which allowed us to determine and characterise the movement ecology of mulloway. The acquisition of movement information, which has been previously identified as the first step in enhancing conservation planning, will potentially support decision making for management of this, and other, predatory demersal fish species.

Overcoming constraints on sandy soils – amelioration strategies to improve resource condition and boost crop production

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Presenter: Brett Bartel

Up to 40% (4.1 million hectares) of the broadacre farming area of South Australia has soil constraints that could be overcome through the application of new advances in technology, machinery and soil management. These include water repellent sands with low fertility and low water holding capacity and heavier soils with poorly structured subsoils.

'New Horizons' is a South Australian Government funded program developed to capture an additional $800 million in agricultural production per annum in South Australia by addressing constraints to production on these soils. There is also the potential to offset greenhouse gas emissions through increasing soil organic carbon storage. In 2014, three trial sites were established on sandy soils on the Eyre Peninsula, Murray Mallee and South East; at Brimpton Lake, Karoonda and Cadgee respectively.

Crop biomass and grain yield data generated at the three New Horizons research sites in both 2014 and 2015 confirm that productivity can be substantially improved on infertile sandy soils when subsoil chemical, physical and biological constraints are treated. Despite the challenging climatic conditions observed, crop yields of the best treatments at each site exceeded the yields of the unmodified control by 110 – >300% in 2014 and 70 – >200% in 2015. The best treatments at all sites in both years included the incorporation of organic matter deep in the soil profile, with or without the inclusion of clay and additional fertiliser. The results indicate an increased resilience to climate variability and the challenges associated with reduced and erratic rainfall distribution.

Useful resources: http://pir.sa.gov.au/major_programs/new_horizons

Botany 2016 — Past, present and future

Bryological research in South Australia

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"Bryophytes" is the collective term generally used for three groups which traditionally have been considered together, although they are now known to be separate lineages, each being treated at the same level of separation as the flowering plants: the mosses (Bryophyta), liverworts (Marchantiophyta) and hornworts (Anthocerotophyta). These are often thought to be "wet area" plants, and are certainly more common in wetter areas, but some bryophytes are adapted to survive in quite arid parts of the world, not least in Australia. It is true that they require water for sexual reproduction and this limits and / or modifies their life strategies in some cases.

Due to its predominant aridity, South Australia is less diverse bryologically than the eastern States. Moss species are more numerous than liverworts, and hornworts are few and restricted. The liverworts can further be subdivided into two major groups: thalloid and leafy. The thalloid species are more robust and spread further into arid regions than the leafy species. Hence the major diversity in SA liverworts is in the thalloids. Leafy species become more diverse in wetter areas, and in the tropics become more dominant than mosses.

Apart from basic collecting, comparatively little work has been carried out on bryophytes in SA. The earliest records seem to date from the arrival of Ferdinand Mueller in SA in 1847. About 100 specimens of his are held in the Melbourne Herbarium, as he left SA in 1852 to become Government Botanist in Victoria. Apart from some scattered specimens collected by Tepper, Tate and a few others, not much was achieved until the work of Jim Willis in Melbourne almost a century later. David Catcheside came to Adelaide in the 1950s to start a Genetics Department at Adelaide University. As his hobby was collecting and identifying bryophytes (especially mosses), and he had been active in the British Bryological Society, he was able rapidly to increase the knowledge of bryophytes in SA with many new records. Although he worked elsewhere for 20 years, he retired to Adelaide and worked assiduously on the local bryophytes until his death. His 1980 handbook "Mosses of South Australia" is still of immense value, and came shortly after the first major publication on Australian bryophytes, Scott and Stone's "Mosses of Southern Australia" (1976).

From the 1950s onwards, there have been many collectors of bryophytes, but few serious taxonomists throughout Australia. Hence, whilst there are large numbers of collections in herbaria, there are still major deficiencies in our knowledge of many bryophyte genera. The "Flora of Australia" project and now "Mosses Online" have meant some progress has occurred, but there is still much to achieve.

Botany 2016 — Past, present and future

History and collections of the State Herbarium

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The State Herbarium of South Australia (AD) is a significant national collection, currently containing more than a million specimens and thus ranking amongst the four largest Australian herbaria. Its diverse holdings include native and naturalised species, an estimate giving figures of around 84% angiosperms, 8% algae (mostly marine), 3% bryophytes, 2% fungi, 2% lichens, and 1% pteridophytes and gymnosperms. These holdings include the bulk of herbarium specimens collected in SA after about 1870 – older collections are largely held elsewhere.

The earliest known preserved plant specimens collected from SA date from 1802. These were made by Robert Brown, the botanist accompanying Matthew Flinders' expedition on the *Investigator*. French explorers with Baudin's expedition also made collections the following year on Kangaroo Island. Some collections were made by early visitors to SA, after European settlement (in 1836) and these collections were sent back to Britain.

The first serious botanist resident in SA was Ferdinand Mueller, a German migrant who arrived in 1847. In 1852 he was appointed Government Botanist of Victoria, and his collections, along with those of other residents of SA, who later collected for him, are now held by the National Herbarium of Victoria, Melbourne. Another distinguished early botanist was George Francis, who arrived in South Australia in 1849 and became the first Director of the newly established Adelaide Botanic Garden in 1855. Unfortunately, little is known about the contents of the herbarium he formed. It is recorded that some material from early expeditions, such as that of Babbage in 1858, was given to Francis, and it is known that these were sent to George Bentham at Kew Gardens (UK) to examine them for his work on the first flora of Australia. The current whereabouts of most of Francis' herbarium is, however, unknown.

Extant institutional collections within SA began with two significant events: Richard Schomburgk's appointment as the Director of the Adelaide Botanic Garden in 1865 and Ralph Tate's appointment in 1875 as the first Professor of Natural History at the University of Adelaide. These institutions became focal points for the retention of specimens in SA rather than their being sent to interstate or overseas herbaria. The Waite Institute of the University of Adelaide established a collection in 1933, concentrating on plants of agricultural and economic importance.

From the time of his appointment as Botanic Garden Director in 1948, Noel Lothian agitated to establish a true State Herbarium. With agreement from the other main collection holders and limited Government funding the State Herbarium of South Australia was established at the Botanic Garden in 1954, under the acting leadership of Edward Stirling Booth. The foundation collections of the new State Herbarium were initially those held by the University of Adelaide Botany Department, and a little later those held by the Museum were added. An active collecting program was undertaken by early staff led by the first Keeper, Hansjoerg Eichler.

Over the subsequent decades, virtually all significant plant, algal and fungal collections in the State have been amalgamated into the State Herbarium. Especially significant additions include the large collection formerly held by the Waite Institute (around 57,000 transferred in 1985), and the marine algae from the Botany Department of the University of Adelaide (around 70,000 in 1990).

Significant collections within the Herbarium holdings

Important collections came from both the Museum and the Botany Department herbaria. From the larger University collection came some of the earliest specimens retained within the State. Tate collected widely and also acquired many valuable records; among these are specimens from early scientific expeditions to the interior regions of northern and western Australia: the Elder Exploring Expedition (1891-2) [principal collector Richard Helms]; the Horn Expedition (1894) [principal collector Tate] the Calvert Expedition (1896-7) [collector George Keartland]. Important material from later expeditions added to this foundation; notably the Simpson Desert Expedition of 1939 and the Arnhem Land Expedition of 1948.

Schomburgk, second Director of the Botanic Garden, was not a practising taxonomist but was extremely active in horticultural and agricultural pursuits, and prominent within the Plant Acclimatisation movement sweeping Australia at the time. The economic uses of plants were of prime interest, and the building of the Museum of Economic Botany in 1881 demonstrates this commitment. Schomburgk's herbarium was housed in a dedicated room at the eastern end of the Museum. The collections that comprised the Schomburgk Herbarium were eventually transferred to the University of Adelaide Botany Department in 1940, as subsequent Directors had different interests and the collections were at risk of destruction by insect damage. The University and Botanic Gardens collections both contained Australian and overseas material of considerable interest; the breadth of which is still to be fully appreciated. John Burton Cleland had contributed his large collection of NSW plants to the University in 1920; Richard Sanders Rogers bequeathed his large orchid collection in 1942, and John McConnell Black's private collection, on which his landmark "Flora of South Australia" was based, had been donated by his family in 1951.

Amongst material acquired from the Museum was the herbarium formed by the Field Naturalists Society, which had come to include the significant private collection of Otto Tepper. Ernst Ising had donated his considerable private collection to the Museum in 1945, and Alison Ashby contributed hers in 1949. The latter included considerable material from her father, Edwin, whose estate "Wittunga" is now included within the Botanic Gardens portfolio. Samuel White's collection had also been incorporated within the Museum holdings. Cleland's later plant collections and his highly important collection of fungi had also been part of the Museum collection, although the fungi were later transferred to the Plant Pathology Department of the Waite Institute. The main part of this fungal material is now in the State Herbarium. Important collections of ethnobotanical material from Norman Tindale and others also came from the Museum.

The Waite Institute's plant herbarium, administratively separate from the fungal herbarium, had grown to about 57,000 specimens by the time of its transfer to the State Herbarium in 1985. This merger produced a far more comprehensive State Herbarium, given the Waite's previous emphasis on weeds. In the 1940s, the Waite collection had also received the private herbarium of Albert Morris from Broken Hill. Its various past curators (C.M. Eardley, N.T. Burbidge, E.L. Robertson and especially D.E. Symon) all contributed significantly to the Waite collection. Burbidge's eucalypt collections and Symon's Solanaceae are of particular significance.

Almost all substantial South Australian plant collections from the 20th century are now held within the State Herbarium; later incorporations have included the eucalypt collections of C.D. Boomsma from the Woods and Forests Department, as well as collections formerly held by the University of South Australia and the Animal and Plant Control Commission.

Apart from flowering plant material, the State Herbarium holds important collections of other groups: the internationally significant collection of marine algae gathered by Professor Bryan Womersley was transferred from Adelaide University in 1990; the non-pathogenic part of the Waite Institute collection of fungi (including the J.B. Cleland material) was transferred in 1978 and 1997; historic lichen collections from the Mawson Antarctic expeditions were received from Adelaide University, as well as large student collections of arid-zone lichens from R.W. Rogers and liverworts from R.D Seppelt. A large private collection of worldwide mosses and lichens was bequeathed by Professor D.G. Catcheside.

These collections have all added to the breadth of the State Herbarium's vast information store. However, the historic collections tell only part of the story, and the collection still continues to expand our knowledge base. Current staff and Associates still contribute new and highly significant records, and at least 10% of the total specimen holdings have been contributed since 1984 through the Biological Survey of South Australia project.

The State Herbarium of South Australia holds an internationally significant collection of plants, algae and fungi. These collections continue to be used in the discovery of new species, in analysis of changing climatic conditions and as evidence for changing biodiversity. The collections enable the detection of new weed incursions and understanding of the distribution of species within and beyond this State. The ongoing work of the Herbarium, with support and collaboration from the South Australian community, will maintain and develop this important historical reference collection.

Parsimonious simulation of daily rainfall fields

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Presenter: Bree Bennett

The spatial distribution of rainfall has a significant influence on catchment dynamics and streamflow generation. However, there are few stochastic models that can simulate long sequences of stochastic rainfall fields continuously in time and space. To address this issue, this paper presents a continuous daily spatial rainfall model which employs a latent variable approach. The use of a latent variable approach is parsimonious as it utilises a single distribution to model both the rainfall occurrence and the amount. A comprehensive evaluation approach was developed that uses a performance classification scheme to systematically evaluate model performance over a range of temporal and spatial scales. The evaluation of the model performance using the Onkaparinga catchment in South Australia showed that the model is able to reproduce the majority of statistics at individual sites within the region as well as realistic patterns of spatial rain fields. These statistics included rainfall occurrences/amounts, wet/dry spell distributions, monthly/annual volumes, extremes and spatial patterns, which are important from a hydrological standpoint. One of the few model weaknesses was that the total annual rainfall in drier years (lower 5%) was over-estimated by 15% on average over all sites. An advantage of the comprehensive evaluation was that it was able to attribute the source of this over-estimation to the poor representation of annual variability in rainfall occurrences. Given the strengths of this continuous daily rainfall field model it shows considerable promise for hydrological applications such as distributed catchment modelling.

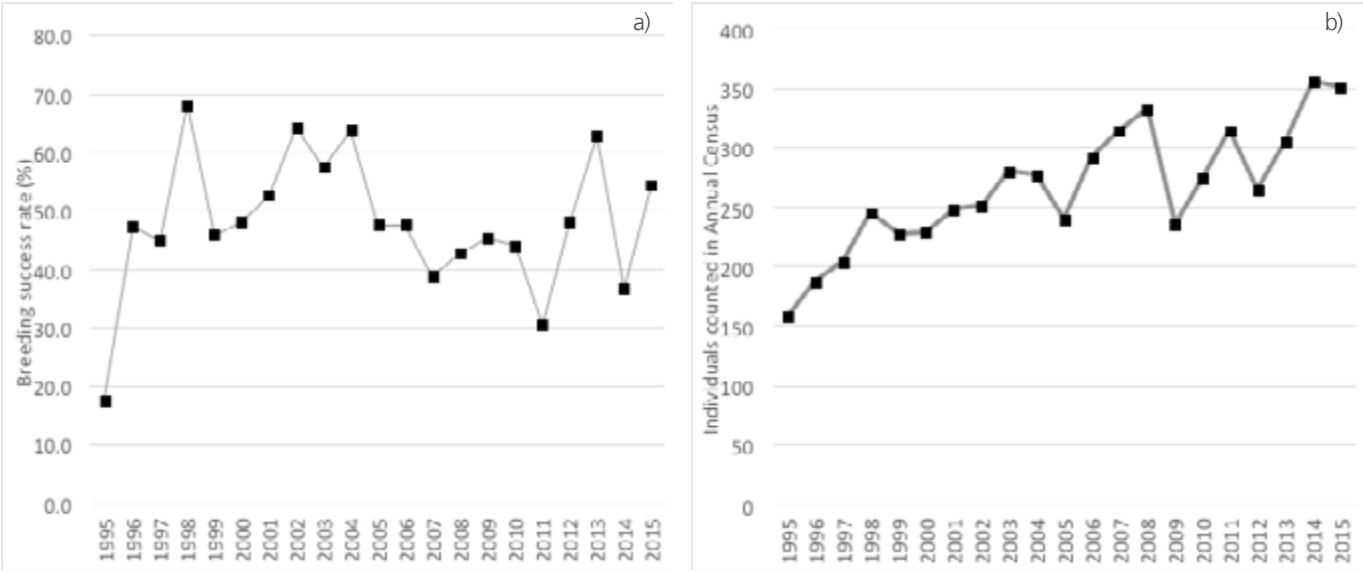

*Figure 3. Data collected by the GBC Recovery Program on (a) the breeding success rate of the Kangaroo Island population since 1995 (*note – protection of nest trees from possums commenced in 1996) and (b) total individuals counted during the annual census 1995-2015.*

Factors influencing the use of artificial nest hollows by the endangered South Australian glossy black-cockatoo

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Presenter: Karleah Berris

The South Australian subspecies of the glossy black-cockatoo (*Calyptorhynchus lathami halmaturinus*; GBC) is found only on Kangaroo Island, and is classed as *Endangered* under the *Environment Protection and Biodiversity Act* 1999. The population has been intensively managed since a Recovery Program commenced in 1995 to identify and mitigate threats to survival of the species. GBC's nest in hollows in large mature Eucalypts, and also require significant areas of drooping she-oak (*Allocasuarina verticillata*) woodland within a 12 km radius of nests for feeding, as they feed solely on the cones of this she-oak species. Loss of both of these habitat types has contributed to the wide-scale decline of this species following European settlement. Luckily stands of drooping she-oak woodland remain on Kangaroo Island. However research in the 1990's found that the breeding success of this species was particularly low, and this was found to be primarily due to the high rates of predation on GBC eggs and nestlings by common brushtail possums (*Trichosurus vulpecula*). Predation on GBC nests is believed to have intensified following increases in brushtail possum numbers since European settlement on Kangaroo Island. The mosaic of cleared agricultural land and high quality remnant vegetation that exists on the island appears to support larger numbers of possums than natural vegetation alone. Between 1990 and 1995 the GBC population was estimated at around 150 individuals and listed as *Critically Endangered*.

To increase breeding success rates, all known natural nests are now protected from possum access with corrugated iron tree collars. Since this management action was implemented, breeding success rates have generally been above 45% (Figure 3a), which is approximately double the breeding success rates recorded prior to management. The population size recorded in annual census counts has increased significantly since 1995 (Figure 3b).

To increase the amount of suitable nesting habitat, the GBC Recovery Program has installed over 100 artificial nest boxes across Kangaroo Island, which are placed in trees we can easily manage and prevent possums from accessing. We investigated how successful the installation of artificial nest boxes has been, and what factors influence the use of artificial nests by GBC's. As the Recovery Program is aiming to install an extra 40 artificial nests in 2016, it is important to determine whether there are factors we should consider when deciding on where to locate these nests.

Long-term breeding data collected by the Recovery Program shows that GBC's readily used artificial nests once they became available, and since 2007 over half of all monitored breeding attempts have taken place in an artificial nest. When comparisons are made between the usage rates of natural and artificial hollows, it seems that GBC's are now preferentially using artificial nest boxes over natural hollows.

Trends in artificial nest box use was investigated in further detail. Natal nest type does not appear to influence the hollow choices of female GBC's when they reach breeding age, as females raised in artificial nests are no more likely to use them once they reach breeding age than females raised in natural hollows.

Although most artificial nest boxes have been used multiple times since installation, there are a small portion that have never been used, despite being located close to GBC feeding habitat. As the Recovery Program invests significant resources each year to maintain artificial nests, we investigated what factors may be causing some nests to be ignored by breeding pairs prospecting for hollows. Two factors seem to be important in choosing where to install nest boxes to maximise their chances of being used.

Firstly, spatial analysis has shown that artificial nests located in regions with a lesser amount of available natural nesting habitat are more likely to be used. In addition to this, placement within the flock's home range is also important. Artificial nests that are located close to regularly used natural nests are more likely to be used by GBC's than those placed in areas with no nearby natural nests. Most natural nests tend to be clustered in the landscape, indicating GBC's have a tendency to nest communally. Therefore when planning future nest box installations, placing them within 1 km of existing natural nest hollows within a region with a low amount of remaining nesting habitat is predicted to increase the likelihood of them being utilised by the population.

Freshwater benefits a marine fish: evidence for providing environmental flows to the Coorong for productivity benefits

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Presenter: Chris Bice

Freshwater flow transports nutrients and carbon of riverine origin downstream to estuarine and marine environments, and assimilation of these elements by biota subsidises food webs. Consequently, river regulation and reductions in freshwater discharge typically have a detrimental impact on estuarine and marine productivity. The current study investigated the influence of freshwater discharge on productivity and trophic subsidy in the Murray estuary region of the Coorong in 2014/15. The study utilised a range of traditional (e.g. netting, abundance/biomass estimates) and novel techniques (e.g. stable isotope analysis, molecular fingerprinting) to investigate: 1) phytoplankton community structure and biomass; 2) zooplankton community structure and abundance; and 3) the abundance, diet and assimilation of organic matter of freshwater origin by sandy sprat (*Hyperlophus vittatus*). Sandy sprat is an abundant small-bodied (<100 mm), zooplanktivorous, marine fish, which is an important prey item for higher trophic levels in estuarine and marine ecosystems of southern Australia, including the Coorong. Freshwater discharge diminished over the study period and was reflected in changing patterns of salinity, phytoplankton and zooplankton community structure. Freshwater derived zooplankton were present in the Murray estuary during freshwater discharge, particularly in proximity of the Murray Barrages, and when present, were preyed upon by sandy sprat. In support, stable isotope analyses indicated substantial assimilation of matter of freshwater origin by sandy sprat and a gradual decline of freshwater trophic subsidy with declining discharge. This study presents empirical evidence that organic matter and biota exported to the Murray estuary with freshwater flow materially support productivity. The findings provide a robust basis for the delivery of environmental water to the Coorong to enhance productivity.

Botany 2016 — Past, present and future

The next generation of molecular botany in South Australia

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Presenter: Ed Biffin

Recent advances in DNA sequencing technology have revolutionised botanical research. In particular, both cost and DNA sequencing capacity have dramatically improved allowing the routine generation of large genomic data sets for taxa that have few or no existing genetic resources. Consequently, we can address a range of questions for relatively poorly known South Australian plants that were difficult or intractable less than a decade ago. Here, we discuss recent developments in DNA sequencing and the impact on molecular research at the State Herbarium of South Australia. Using case studies, we illustrate the potential of these new data sources to address questions ranging from the identification of specimens and their evolutionary relationships through to population and conservation genetics, and how the boundaries between these traditionally disparate research disciplines are increasingly blurred by new sources of data.

What are flying foxes doing in Adelaide? Researching the disease and ecological implications of Grey-headed flying foxes in South Australia

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Presenter: Wayne Boardman

Grey-headed flying foxes (*Pteropus poliocephalus*) arrived in Adelaide in 2010, outside their normal distribution range. Since then, despite pup mortality each summer due to heat stress, the population has continued to increase to ~ 3,600 bats. Within this population, Australian bat lyssa virus (ABLV), known to cause disease in horses and people, has been isolated, and a unique, as yet untyped Hendra-like virus of unknown pathogenicity have been discovered.

Why have the bats made Adelaide home? What do they feed on and where do they go? Can they survive in Adelaide and are they shedding HeV and other viruses which may pose a risk to horses and people in South Australia?

The presentation will give an overview of Grey-headed flying fox biology, disease ecology and provide initial movement and foraging data using solar powered GPS collars.

How to capture emerging diseases of wildlife! Wildlife Health Australia and Wildlife Disease Surveillance at the University of Adelaide

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Presenter: Wayne Boardman

Wildlife Health Australia (WHA - www.wildlifehealthaustralia.com.au) is the peak body for wildlife health in Australia and manages the existing national framework for wildlife disease surveillance in Australia. WHA was established as the Australian Wildlife Health Network (AWHN) in 2002 as a national government initiative, and its work continues following incorporation as an independent not-for-profit association WHA in 2013

Australia's general wildlife health surveillance system relies on the detection, submission, investigation and reporting of sick/dead captive or free-living wildlife. Key elements of the existing national wildlife health surveillance framework include a network of state and territory WHA coordinators (appointed by their Chief Veterinary Officers), veterinarians at zoo-based wildlife hospitals and large private wildlife clinics, in addition to targeted projects and a number of focus/working groups. Through WHA's network and projects, wildlife health information is consolidated into a national database to inform decision making.

Launched in December 2015, WHA coordinated a new University Based Wildlife Disease Surveillance Pilot Program which aims to boost Australia's wildlife disease surveillance capacity. The one-year Program enlists the participation of seven Australian universities including the School of Animal and Veterinary Sciences at the University of Adelaide is supported by funding from the Commonwealth Department of Agriculture and Water Resources.

The presentation gives an outline of the program and the University of Adelaide's School of Animal and Veterinary Sciences contribution.

The Roseworthy Wildlife Health Research Centre: Proposing a new hub to support the 'One health' concept in South Australia

Boardman, W., Woolford, L., O'Handley, R., Speight, N., Rasmussen, B., Funnell, O., Caraguel, C.and Trott, D.

School of Animal and Veterinary Sciences, University of Adelaide, Roseworthy

Presenter: Wayne Boardman

Over the past 30 years, there has been a significant upward trend in the appearance of emerging infectious diseases (EIDs) which have had a significant effect on public health (1) and biodiversity. EID events are dominated by zoonoses (60.3% of EIDs): the majority of these (71.8%) originate in wildlife (for example, in Australia; Hendra virus and Australian bat lyssavirus), and are increasing significantly over time (Jones et al. 2008). EID events affecting biodiversity include the emergence in Australia of chytridiomycosis in amphibians, dolphin morbillivirus infection, devil facial tumour disease in Tasmanian devils and koala retrovirus and chlamydiosis in koalas.

In support of the aforementioned issues and planning to work cooperatively with statutory organisations, the School of Animal and Veterinary Sciences at the University of Adelaide based at Roseworthy is proposing to establish a collaborative wildlife health research centre based on 'One health' principles to serve the community of South Australia. Utilising its first rate facilities, the primary aims are to conduct research into emerging diseases of wildlife, wildlife and ecosystem health,

establish training opportunities in wildlife population health for undergraduate and post graduate students, conduct wildlife disease surveillance in conjunction with Wildlife Health Australia (www.wildlifehealthaustralia.com.au).

This presentation will give an overview of the research conducted to date at the School of Animal and Veterinary Sciences in wildlife health research and the proposed wildlife health research centre.

Reference:

(1) Jones KE, et al. (2008) Global trends in emerging infectious diseases. *Nature* 451(7181):990–993.

Living with dolphins in an urban environment

Bossley, M.[1], Steiner, A.[2], Rankin, R.[3] and Bejder, L.[3]

[1] Whale & Dolphin Conservation

[2] Bressaucourt, Switzerland

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Presenter: Mike Bossley

An observational study of bottlenose dolphins (*Tursiops aduncus*) was commenced in the Port River estuary in 1988. Systematic surveys were undertaken beginning in 1990 and are ongoing. Over the twenty-four year period of the study boat-based surveys were conducted (n=735) for dolphin groups (n=3,634) along a pre-determined route in the inner and outer parts of the estuary.

The estuary has experienced environmental impacts from coastal engineering, industrial pollution, sewage discharges and storm water run-off since European settlement. The inner parts of the estuary have suffered the most environmental impacts compared to the outer areas. In recent years, the amount of pollution, particularly total nitrogen, entering the system has reduced and this has mitigated eutrophication effects such as excessive growths of algae. The establishment of the Adelaide Dolphin Sanctuary (ADS) in 2005 and the consequent employment of ADS rangers has provided better protection from harassment and deliberate attacks.

The estuary remains an industrial area with a busy port but is also increasingly popular for recreational fishing, kayaking, sailing and other water based activities, some of which pose potential risks to the dolphins. In addition, residential and industrial developments in adjacent areas could have negative impacts on the dolphins' habitat.

Dolphin numbers in the inner parts of the estuary increased during the course of the study while those in the outer areas did not change. These increases were likely the result of improved water quality, augmented by surveillance and education arising from the proclamation of the ADS.

This study highlights the importance of collecting long term data sets to establish baselines and track changes to target species over time. The study also has implications for dolphin conservation in heavily impacted urban areas and their protection via marine protected areas. It also seems likely that an increase in numbers will have the paradoxical effect of requiring more rather than less management.

Identifying cost-effective reforestation approaches for biodiversity conservation and carbon sequestration in southern Australia

Bradshaw, C.J.A.[1], Horner, B.[2], Mayfield, M.M.[3]

[1] University of Adelaide

[2] Succession Ecology, Adelaide

[3] University of Queensland

Presenter: Corey Bradshaw

As the extent and contiguity of Australia's native vegetation declines and the extinction risk to native animal and plant species increases as a result, viable and cost-effective reforestation approaches are becoming more important. Increasing forest cover will not only reduce the number of future extinctions, it will lead to a higher sequestration of anthropogenic carbon that is contributing to global climate disruption. Despite this necessity, few experimental data exist to provide guidance on the most effective reforestation approaches to maximise biodiversity, minimise costs and maximise carbon sequestration. Our aim was therefore to determine the reforestation approach that maximises the native biodiversity found in Mallee bushland regrowth in South Australia, while simultaneously maximising carbon sequestration. We implemented a long-term reforestation experiment testing six approaches (3 biodiversity treatments: 1. monoculture, 2. low diversity, 3. high diversity; and 2 planting densities: 1. high and 2. low) for reforesting deforested land into secondary shrubland and woodland complexes at Monarto Zoo, South Australia. To assess goals, we are monitoring indicator taxa (vegetation, invertebrates, small mammals, reptiles) and carbon pools prior to reforestation and throughout the regeneration process. Our study is unique in its experimental assessment of temperate Australian reforestation for biodiversity conservation and in the collection of baseline data. This study will eventually result in guidelines for woodland/shrubland reforestation as an economically viable land use for landholders. Preliminary results suggest a slightly elevated survival and growth rate of planted seedlings in the low-density plots, and higher survival in the low-diversity plots due to the exceptional survival rate of species such as *Enchylaena tomentosa* and *Eucalyptus porosa* (Mallee box gum) in particular. Invertebrate densities and diversity increased in the highest-diversity plots quickly after seedling establishment and spread. Ongoing monitoring will continue to provide insight into the longer-term effects of variable planting densities and diversities.

Assessing herbivore impact to inform herbivore management programs – a rapid method for managers of grassy and chenopod shrub dominated vegetation communities

Brandle, R.and Mooney, T.

Natural Resources, SA Arid Lands, Department of Environment, Water and Natural Resources

Presenter: Robert Brandle

In arid South Australia conservation land managers have usually inherited ex-pastoral leases that include altered and degraded vegetation communities. Management aims usually include recovery or improvement of degraded landscapes/vegetation communities, which is often compromised by native and/or introduced herbivore grazing. The management response is usually to remove as many of the introduced herbivores as they can afford and native herbivores are ignored.

Managers need a practical and affordable method of distinguishing when herbivores are negatively impacting remaining vegetation and preventing recovery in damaged or degraded systems and separating this from historic impacts. Whilst herbivore exclusion plots are a great way to visually demonstrate improvement potential compared with non-exclusion, the associated research inspired data collection that is used to investigate these changes is generally time consuming and generates large amounts of noisy data, primarily because it is explorative rather than impact focused data. Other science based criticisms of this herbivore-exclusion comparative approach is the small area sampled, lack of replication and the cumulative effect of zero grazing over time. Manager based criticism is that data analysis takes too long and "how can we use the results to inform into annual management cycles".

We present a simple and quick method for data collection and analyses for perennial grass and chenopod shrublands, which when applied at sites spread geographically across a property and stratified for vegetation types can provide timely feedback to managers on grazing pressure impact. Presence/absence of key indicators within multiple small plots (≤ 1 m^2) separated by 10 m intervals along transects defines the approach. The key indicators rely on easily identifiable utilization-states for perennial functional plant forms (native grasses and woody shrubs), and presence of common weed species. Categorised presence data for different herbivore types is also collected at all plots to assist with determining which herbivores are most likely to be having the greatest impact and therefore in need management consideration. Collection of data post growing season is an important consideration for determining if impacts are leading to perennial plant decline, for South Australia this means late summer and autumn.

Analyses use frequency of occurrence of utilization-states for grasses and shrubs plus presence of common weed species, based on a minimum of 30-50 replicate plots per site depending on variability. Graphical representation of the plant utilization state results clearly show at which sites impacts are likely to prevent perennial plant recovery and resampling across time will indicate trends.

Data from public conservation reserves is used to illustrate data collection, analysis and interpretation for management, including setting triggers for increasing management intensity. The method is also useful for evaluating responses across the standard fenced herbivore exclosures that are common in SA conservation reserves, and can provide benchmarks for ungrazed vegetation. This is particularly useful for assisting interpretation during drought periods.

Micro-organism triggers widespread small mammal recovery in arid South Australia; Rabbit Haemorrhagic Disease Virus maximises bang for conservation buck

Pedler, R.D., Brandle, R., Read, J.L., Southgate, R., Bird, P. and Moseby K.E.

Natural Resources, South Australian Arid Lands, Department of Environment, Water and Natural Resources

Presenter: Robert Brandle

Funding for species conservation is insufficient to meet the growing challenges facing biodiversity, yet we often focus on expensive single-species recovery actions with limited gains, while neglecting broader management that addresses threatening processes. In arid inland Australia the small mammal fauna has suffered the world's worst extinction rate, attributable largely to competition from introduced rabbits and predation by feral cats and foxes. The biological control agent Rabbit Haemorrhagic Disease Virus (RHDV) was introduced into Australia in 1995; dramatically supressing rabbit populations, with linked reductions in populations of their main predators, cats and foxes. We examined the effect of this cheap and wide-reaching ecosystem management tool on threatened small mammals in the SA arid zone. Despite low rainfall conditions over the first 14 years following the spread of RHDV, two IUCN-listed native rodents (the Dusky Hopping-mouse and Plains Mouse) increased their extent of occurrence by 241-365%. The Crest-tailed Mulgara, a threatened marsupial micro-predator, underwent a seventy-fold increase in extent of occurrence and a 12-fold increase in area of occupancy. These recoveries are indirectly attributed to RHDV via decreased competition for food resources and the linked decline of rabbit-dependent introduced predators. These three previously threatened species now qualify for downgrading from the IUCN Red-List; recovery on a scale rarely seen in any mammal and unprecedented in modern Australian

history. The use of rabbit bio-control as a tool for reducing cat and fox predation on threatened small mammals is a demonstration of the wide-reaching benefits created by conservation actions that take a big picture approach to addressing threatening processes over large spatial scales. Further, this work highlights the value of landscape-scale long-term ecological monitoring, a critical tool in detecting and understanding complex ecosystem change.

Integration of ecosystem service metrics into product based environmental studies

Bricout, J.[1], Grant, T.[1] and Eady, S.[2]

[1] Life Cycle Strategies

[2] CSIRO Agriculture

Presenter: Jodie Bricout

Introduction

There is a disconnect between the consumption of goods and services and the environmental pressures applied to the natural land systems that produce. Consumers demand goods at high quality and low prices and these pressures are used to justify land management practices that may compromise environmental quality.

The link between farm practices and environmental consequences are often not made, as the relationship is not obvious or direct. An exception to this is in Queensland where the impact of the sugarcane industry on the Great Barrier Reef is directly visible. The Smartcane BMP (Best Management Practice (BPM) standards have been established to create incentives for better practice not driven purely buy short term economic priorities of the farm.

While natural resource management is often addressed locally or regionally, there is considerable interest to include indicators related to natural resource management into product based assessments using Life Cycle Assessment (LCA).

LCA is a systematic approach to evaluating the environmental impacts of product systems. LCA typically covers a broad range of environmental impacts to avoid environmental burdens being unknowingly displaced to other environmental aspects. Based on this approach, any environmental aspect not included in the LCA risks being compromised in product based decision making.

Representing the impacts and benefits of agriculture production on ecosystem services has significant challenges. These include defining the nature of these ecosystem services, and dealing with the spatial and temporal variations in agriculture systems.

A project by Life Cycle Strategies and CSIRO is developing a range of impact metrics based on soil quality as one of these key ecosystem service indicators.

Methodology and initial results

The project begins with the structure defined by Mila Canals shown in Figure 4, which shows the connection between land use, soil processes and los of ecosystem services.

For modern Australian agriculture we have identified the following four key impacts to be incorporated into LCA:

1. Soil acidification
2. Soil erosion
3. Soil organic carbon
4. Biological production potential

Other important impacts include salinity, however a clear link between current agricultural practice and the ongoing instance of salinity is not clear. Compaction is important, but less so in broad acre agriculture with the influence of minimum and no-till agriculture.

The model for soil acidification consists of a full hydrogen ion balance for the cropping and/or grazing system. The net acid addition rate (NAAR) from the system is mapped against the buffering capacity in different regions to determine if the area is approaching critical PH levels, comprising plant growth.

For soil erosion, improvements are being made to the universal soil loss equation that describes the dynamics for water erosion. Similar modes are being examined for wind erosion. The implementation of reduced and minimum till agriculture are important factors in reducing overall soil erosion.

Changes in soil organic carbon (SOC) are being examined through thousands of simulation runs in crop modelling software (APSIM), with local spatial data for 30 different agro-ecological regions across Australia that grow significant crops. SOC is expected to be affected by crop rotation, nitrogen management, stubble management and tillage practice.

Next steps

The LANDLCI project to develop the indicators will be completed by mid-2016 and will be trialled in an LCA assessment of grain crops across Australia over the following year. This is merely the beginning of the journey to better represent soil in product based assessment and not the end.

The LANDLCI project is being supported by the Australian Government through the National Landcare Programme Innovation Grants for the project "AusAgLCI – enabling continual improvement of sustainability by life cycle impact assessment (INNOV-033)" which is being undertaken by CSIRO Sustainable Agriculture Flagship and Life Cycle Strategies from 2014-2016.

The LCA assessment of grain crops project is supported by the Grains Research and Development Corporations as part of the project "Identifying National Opportunities for Grains Emissions Mitigation and other Environmental Improvement" which is being undertaken by NSW Department of Primary Industry, CSIRO Sustainable Agriculture Flagship and Life Cycle Strategies from 2014-2017.

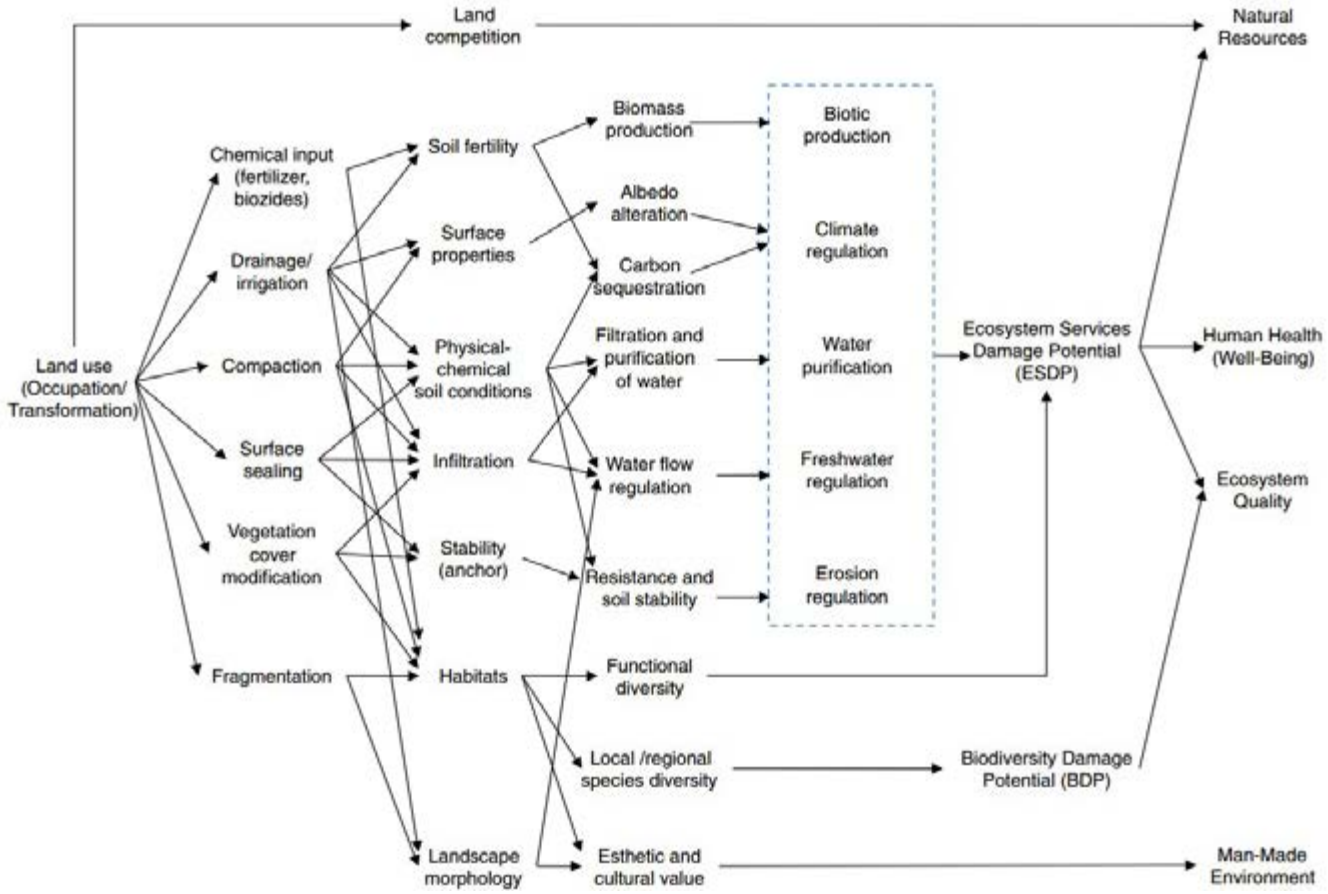

Figure 4. Connection between land use, soil processes and loss of ecosystem services (Source: Brandão and Milà i Canals 2013)

References:

About Smartcane BMP: www.smartcane.com.au

Brandão, M. and L. Milà i Canals (2013). "Global characterisation factors to assess land use impacts on biotic production." *The International Journal of Life Cycle Assessment* 18(6): 1243-1252.

Cameras and eyes – complimentary approaches to counting fish in Marine Parks

Brock, D., Miller, D., Colella, D., Holland, S.and Armstrong, D.

Science, Monitoring & Knowledge, Science, Monitoring & Knowledge, Department of Environment, Water and Natural Resources

Presenter: Danny Brock

One of the main objectives of South Australia's network of Marine Parks is to protect and conserve marine biodiversity and habitats. To measure how well the park network is at achieving these objectives requires a rigorous ecological monitoring program. Baited remote underwater video systems (BRUVS) and underwater visual census (UVC) by scuba divers are two common techniques used for monitoring in the marine environment. Like all sampling techniques both have advantages and disadvantages, however, for BRUVS and UVC the respective limitations of each tend to be somewhat compensated by the other due to their complementarity. Among the advantages of BRUVS are that they can be deployed at most depths, are good at capturing species targeted by fishers and provide accurate length measurements, however, they only capture information on fish communities and can be biased by the use of bait to attract fish. The main strength of the UVC method employed by divers is that more trophic levels are assessed as in addition to fish, invertebrates, including commercially important species such as lobster and abalone that, and macroalgae communities are sampled. Application of the UVC method is limited by depth, level of diver training and several fish species are "diver shy", and thus often under-represented in counts. Numerous studies have demonstrated that recovery of ecological communities following implementation of Marine Park networks can be highly variable and develop over long time frames. UVC and BRUVS, when used in conjunction, capture a large suite of biological indicators across several trophic levels that can provide multiple lines of evidence to help understand and assess the effectiveness of the SA Marine Park network in protecting and conserving marine biodiversity and habitats.

Have shorebirds been adequately considered with the expansion of the south-east beach-cast macroalgal fishery?

Brook, J.[1] and Christie, M.[2]

[1] Conservation Council of South Australia

[2] Friends of Shorebirds SE Inc.

Presenter: James Brook

The Limestone Coast contains seventeen sites of international importance for seven migratory shorebird species which nest in the northern hemisphere and migrate south each summer. The area is also important for several resident, beach-nesting, shorebirds, including plovers and oystercatchers. All of these species depend on the beach-cast macroalgae for food and shelter.

In May 2014, China's second-largest processor of seaweed purchased the single license to harvest macroalgae, with plans to invest $21 million over the next three years and increase in the level of harvest by tenfold. In order to export their products, they sought approval as an ecologically sustainable fishery under the EPBC Act. This process required two rounds of consultation and resulted in greater protection of shorebirds, through spatial and temporal closures. However, adjustment to the closure period is needed to prevent harvesting effort from becoming focussed on the most important month for migratory birds.

Harvesting is also proposed for Habitat Protection Zones in the Upper South East Marine Park. This currently possible due to an artefact of the *Marine Park Regulations* 2012 that if not addressed would call into question the ability of the marine parks to deliver on their conservation goals.

Conservation concerns about common dolphin interactions in the South Australian Sardine Fishery

Brook, J.and Warhurst, K.

Conservation Council of South Australia

Presenter: James Brook

An assessment of the ecological sustainability of the South Australian Sardine Fishery in 2004 under the EPBC Act 1999 recommended that interactions with marine mammals be reported accurately. An observer program in 2004/05 estimated nearly 500 common dolphin mortalities, compared with 7 reported in logbooks. Following the closure of the fishery, industry and government worked hard to develop and refine a code of practice for mitigation of wildlife interactions. A combination of searching for dolphins prior to setting nets, and release of encircled dolphins by dropping the net, is clearly capable of reducing dolphin bycatch to negligible levels. But how often is the Code of Practice (CoP) actually been applied?

In most years during the decade since the CoP was developed, observer data have suggested that only 4–34% of dolphin interactions were being reported. In the other years, sardine catch rate data suggest that fishing behaviour differed depending on whether observers on board. Other changes in fishing behaviour in response to changes in the observer program also raise concerns about the integrity of the observer program. The most recent assessment of the effectiveness of the CoP concluded that existing data cannot be used to calculate how well it is implemented in the absence of an observer. This creates uncertainty over the estimated total number of dolphin interactions.

It has been suggested that deficiencies in the observer program could be addressed by ensuring representativeness of fishing effort by month, vessel and region. However, after a decade of tolerance by management of underreporting, and increasing concern over the integrity of the observer program, CCSA has recommended that observer coverage be increased to 100% for two years to ensure that, a decade on, the level of dolphin bycatch in the sardine fishery can be quantified with confidence.

From the ashes: the role of Natural Resources Management in personal and property recovery after the Sampson Flat Bushfire.

Brookman, T., Mangelsdorf, T., Madigan, C.and Fox, A.

Natural Resources Adelaide & Mt Lofty Ranges, Department of Environment Water and Natural Resources

Presenter: Tom Brookman

The Sampson Flat bushfire started on Friday the 2nd of January 2014 and was declared a major emergency the following day. It burned for six days within a 222 kilometre perimeter before it was controlled. It covered over 12,500 hectares consisting primarily of native vegetation, plantation forestry and grazing and lifestyle properties. The ongoing bushfire response highlights the need for Natural Resources Management organisations to be prepared to respond to landscape scale events in order to minimise post-disaster environmental damage.

The Sampson Flat experience shows that multiple levels of engagement are required to cater to community demand for resources at different stages of their recovery journey. A range of engagement strategies and information materials are being employed, including media releases, fact sheets, web content, community events and individual property visits. Each method of engagement is designed to move landholders through stages of attitudinal change; in some cases simply making individuals aware of information is the goal, while in others engagement aims to result in changes to, and maintenance of, land management practices.

The diversity of information across various platforms ensures easy access for the community and caters for different levels of ability and interest. However, particularly early in the recovery process, information delivery needs to be as simple and targeted as possible to convey key messages and avoid an information overload.

Similarly, engagement strategies must be tailored to different demographics within the fire scar including industry and agriculture groups. Land management engagement after Sampson Flat primarily focuses on lifestyle landholders, many of whom are new to the area and have minimal land management knowledge. Many of these landholders are not associated with community or industry groups. Consequently, they lack peer group support regarding land management, making individual engagement and education critical.

Case studies from properties in the Kersbrook area highlight how natural resource management bodies can support post-fire landscape recovery through effective engagement. The same case studies also demonstrate how land management advisors can play an important role in the psychological recovery of those affected by bushfires, particularly if staff receive training in disaster management and Psychological First Aid.

Futures for Australian land use and ecosystem services

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CSIRO

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Presenter: Brett Bryan

Futures for Australian land-use and the ecosystem services they provide depend on interactions between global drivers and domestic policy which influence individual land use decisions over time. The introduction of climate (e.g. a carbon market) and energy policy may provide significant opportunities for landholders to adopt a range of land use and management options (e.g. bioenergy, carbon forests, minimum tillage, livestock management) for greenhouse gas (GHG) mitigation. However, these changes may generate collateral impacts (positive and negative, direct and indirect) for regional development, energy security, food production, land and water resources, biodiversity conservation, and other ecosystem services. There is a need for the ex-ante evaluation of the impact of alternative policy options under a range of biophysical and economic scenarios on ecosystem services in Australia's agricultural landscapes. Consideration of the uncertainty underpinning the range of input data and models and the impacts of future scenarios is essential to understand the robustness of decisions and outcomes. This information is required to inform decision-making for Australia's transition to a low carbon economy.

We present some outcomes of land use scenarios from the Land Use Trade-offs (LUTO) model, undertaken as part of CSIRO's Australian National Outlook (www.csiro.au/nationaloutlook). Global economic and climatic trends were taken from an integrated assessment model. LUTO itself integrates a wide range of biophysical and economic data and models in a high-resolution spatio-temporal model of potential land use change in Australia's intensive agricultural zone out to 2050. Via a partial equilibrium model of the agricultural sector, LUTO allocates land use including agriculture and a range of new land uses such as environmental plantings, carbon plantings, woody perennials and cereal crops for bioenergy and biofuels. We quantified the implications of policy options and changes in external drivers on land use and the impact on across a range of ecosystem services including food and fibre production, carbon, water, energy, and biodiversity. We linked to a global integrated assessment model to provide internally consistent outlooks for Australian land use under alternate futures. We analysed four global scenarios—one low emissions, two medium emissions, and one high emissions pathways—with climate change projections from three GCMs. Also, assessed are three biodiversity payment policies, three productivity scenarios, and three land-use change adoption rates. The modeling is a quantum leap beyond any other models in use globally. Selected outcomes from these national land use outlooks will be presented. The full paper can be downloaded at http://dx.doi.org/10.1016/j.gloenvcha.2016.03.002.

SA's Marine Parks – how will we know if they are working?

Bryars, S., Wright, A., Morcom, R., Eglinton, Y., von Baumgarten, P., Waycott, M.and Scholz, G.

Department of Environment, Water and Natural Resources

Presenter: Simon Bryars

In October 2014, South Australia's network of 19 marine parks and associated 83 sanctuary zones were fully implemented. The monitoring, evaluation and reporting program of the Department of Environment, Water and Natural Resources will assess the effectiveness of the marine parks network against a number of evaluation questions. To enable the assessment, monitoring is occurring on six inter-related components: ecological values, socio-economic values, physical drivers, socio-economic drivers, pressures and marine park management. Within each component a number of indicators will be measured to track changes that may be attributed to marine parks. For example, indicators of change to ecological values include the size/abundance/diversity of reef communities and the spatial extent of seagrass habitats inside and outside of sanctuary zones. Baseline information, conceptual models, predicted changes and monitoring activities in the Gulf St Vincent bioregion will be presented. Monitoring techniques being used to collect data for these ecological indicators

include remote benthic video habitat mapping, baited remote underwater video systems, and underwater visual census. A range of monitoring activities is currently underway in the Gulf St Vincent bioregion, which has been a focus for activity in 2015/16.

Translocation to save the endangered pygmy bluetongue lizard

Bull, M.

School of Biological Sciences, Flinders University,
Presenter: Mike Bull

The pygmy bluetongue lizard, *Tiliqua adelaidensis*, was considered extinct until its rediscovery in 1992 near Burra. It is now known from a few isolated remnant patches of the once much more extensive native grassland habitat in a small area of the mid-north region of SA. In those patches it occupies single entrance spider burrows, with little movement beyond the burrow entrance. Burrows are in short supply, and adding extra burrows allows populations to grow, but that will not resolve threats from climate change or land development (e.g. wind farms).

A potential solution is to move lizards to establish them in new sites, further south. The known historical range included Adelaide and Gawler, so there are potential sites to consider where lizards used to live a century ago. And unlike many conservation issues we have the luxury of a short time still available before immediate decisions must be made. We are addressing this problem with a three pronged approach.

First we have explored within simulated releases, the conditions that will best encourage lizards to remain at the place where they are released. Second, we have started a trial to assess the risks of a translocation. We will release translocated lizards into fenced enclosures and follow the ecological consequences for the other reptiles in the community, the probability of producing novel non-adaptive parasite host interactions, and genetic risks from interbreeding for instance if lizards are moved from a development site into an existing population. If any of these risks proves to be real and likely to have detrimental impacts, our translocations are contained and can be terminated. Our third approach has been to build community awareness and involvement of the mid north community so that ultimate conservation decisions will have informed local community support in the future.

Marine Park Compliance – Implementation of a new responsibility

Burnell, A.

Department of Environment, Water and Natural Resources

Marine Parks are relatively new to South Australia. For the community and for DEWNR there are new responsibilities, complying with unfamiliar regulations and encouraging compliance with those new regulations. Eighteen months in from the implementation of fishing restrictions, what have we done and what have we learnt.

Three guiding principles underpin the Compliance Strategy for marine parks:

1. Maximise voluntary compliance through communication and education to improve awareness.
2. Create effective deterrents through the optimal use of enforcement action which is proportional to the severity of offending.
3. Monitor and review compliance activities to inform improvements.

Communication and education were a focus in the two year period before fishing restrictions took effect and continue to be integral to an effective approach. Signs, printed materials, internet and mobile phone applications have all been developed and widely shared.

When considering enforcement it is important to focus effort on areas that are most vulnerable or where significant risks exist, so we evaluate and define compliance priorities for each park and develop regional compliance plans utilising a risk assessment process. This annual process considers potential non-compliant activities, frequency and consequence. It also incorporates consideration of key monitoring sites as identified by the DEWNR Performance Program, visitation, and now that data is available, has been updated to include prior year compliance incidents.

Patrolling follows planning for deterrent and detection reasons and has been implemented state wide by primarily DEWNR regional staff with some assistance from other Government agencies and is reported on monthly. With limited resources and assets it is pleasing to be able to report considerable shore-based (2723), boat-based (187) and aerial patrols (39) conducted and we are also developing our capacity for digital surveillance.

Voluntary compliance has been good statewide with the exception of several specific locations. To date (end of Feb 2016) we have logged 350 incidents, issued 170 formal warnings as required by the Act, five expiations and in addition successfully prosecuted 20 cases under the Historic Shipwrecks Act at the *Zanoni*.

Zanoni is an interesting case study of a location with biodiversity and cultural values that has had considerable non-compliance. Targeted effort to establish a deterrent has successfully reduced but not eliminated non-compliance.

We have learnt about specific locations, regional differences, challenges related to shore, boat and aerial work. We have established a foundation for encouraging compliance based on the compliance strategy and are monitoring and reviewing to inform continual improvement.

An Isotopic TREND: Water stress in South Australian flora

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School of Biological Sciences, The University of Adelaide

Presenter: Stefan Caddy-Retalic

Our limited understanding of how plants respond to stress caused by a changing climate is a major barrier to predicting the future composition and distribution of Australian flora. Measurement of stable carbon isotope ratios in leaves is an established methodology for detecting water stress but is seldom applied at a landscape scale. Stable carbon isotope ratios were measured in the 161 species found at ≥4 of the 42 TRansect for ENvironmental monitoring and Decision making (TREND) sites established by the Terrestrial Ecosystem Research Network, covering a strong bioclimatic gradient of >700km from the South Australian coast to the arid interior. Species tested reflect the diversity of the Australian flora, including trees, shrubs, forbs, yakkas, grasses, sedges, vines, chenopods, mistletoes and ferns; as well as native and introduced species. Correlations between water availability and carbon isotope ratios were found within most C3 plants and as a whole across the 800km gradient.

Potential utility for this data will be discussed, including combining isotope data with species distributions to improve predictive vegetation mapping under future climate change scenarios.

Prescribed burn intensity affects on pollinator interactions in the Narrow-leaved Mallee (*Eucalyptus cneorifolia*) woodland community of Kangaroo Island

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[1] Flinders University, South Australia

[2] State Herbarium of South Australia, Department of Environment, Water and Natural Resources

[3] Department of Environment, Water and Natural Resources

[4] Nature Foundation South Australia.

Presenter: C. Cannizzaro

Pollination is an important ecological process and contributes considerable diversity to a variety of ecosystems worldwide. Given the importance of pollinators in maintaining genetic viability and assisting with sexual reproduction of the majority of higher plants, there is a need for good conservation strategies that preserve pollinator interactions. In the Narrow-leaved Mallee (*Eucalyptus cneorifolia*) woodlands of Kangaroo Island, endemic communities are under threat from a loss of fire-stimulated germination from the soil seed bank and over story suppression. To address this issue biodiversity burns were administered in 2008 by DEWNR as part of the Eastern Plains Fire Trial to 36 sites across eastern Kangaroo Island. While successful regeneration of understory plant communities is important, perhaps equally important is successful pollination to ensure subsequent generations persist after burn treatments. In this study I use a replicated block design to investigate plant-pollinator interactions and pollen loads in 8 sites treated with high intensity or low intensity prescribed burns. Data from observations and captures was transformed into quantitative matrices to construct network graphs. Various network parameters were analyzed to test for variation in pollinator interactions between treatments. Results show high intensity treated networks were highly nested compared with low treatments. Marginal increases in specialization of interactions and robustness to extinction occurred in low intensity treatments compared with high treatments. Results from this research provide evidence suggesting that the intensity of fire induced disturbances influence pollinator interactions in ecological communities that require fire for regeneration.

DEWNR's Big Science: multi-year, cross-discipline investigation programs delivering targeted advice

Carrangis, T.

Science, Monitoring & Knowledge, DEWNR

uses coordinated multi-discipline programs to deliver investigations to support decision-making. In recent years the agency has completed three such programs to support significant decisions in South Australia.

The Coal Seam Gas and Coal Mining Water Knowledge Program was delivered as part of the Australian Government's Bioregional Assessment Programme to improve the information used to assess potential water-related impacts of resources developments. The program investigated surface and groundwater resources and the habitats dependant on these resources, analysing the risk and vulnerability of these to future water regime impacts that may follow a development.

The Climate Change Adaptation Program delivered a collaborative state-wide program of region specific and cross-regional projects to support the NRM Boards to incorporate climate change mitigation and adaptation measures and to build landscape resilience within regional Natural Resources Management Plans throughout South Australia.

The South Australian Riverland Floodplains Integrated Infrastructure Program (SARFIIP) Science and Investigation Program is currently informing an Australian Government (through the MDBA) investment program to improve the watering and management of River Murray floodplains in South Australia's Riverland. The investigations program is informing floodplain and salinity management options through an integrated program that included

data management, field investigations and modelling. Integrated floodplain response modelling will combine the outcomes of the dedicated investigations and analysis of ecology, surface water and groundwater to inform the investment decisions.

Each of these investigations programs led by DEWNR brought together technical and policy staff with regional knowledge, other SA Government Agencies, Australian Government and interstate agencies, and university and private sector researchers to inform complex regulatory, development and investment decisions.

The scale of these programs has advanced DEWNR's ability to focus complex programs to inform specified policy requirements, collaborative cross-discipline delivery, and associated data and knowledge management.

The on-shore biosecurity threat from the domestic cage-bird trade

Cassey, P. and Vall-llosera, M.

School of Biological Sciences, The University of Adelaide

Presenter: Phillip Cassey

The global pet trade is a major source of new introductions for alien vertebrate species. Understanding the traits driving the demand for exotic pets is crucial for preventing the introduction of new invasive alien species. We investigated the factors influencing species availability and at-large escapes within the Australian cagebird trade.

357 bird species are present in the private Australian cagebird trade, of which over half (55.2%) are alien. We collected information on over 5,000 bird escapes, from captivity in mainland Australia, which were reported by their owners to missing animal websites during the last 15 years. Most reported birds were parrot species (>90%), and the frequency of parrot escapes was best predicted by factors related to human presence and socioeconomic factors. Cheaper parrot species, Australian natives, and docile parrots were more frequently reported to missing animal websites than other captive species.

Accidental pet introductions have been overlooked as a source of new animal incursions. Online information on pet bird escapes may provide a useful tool for passive surveillance of some alien pet species, particularly for species with low detectability and high risk of establishment.

Botany 2016 — Past, present and future

Fungi and mycological research in South Australia

Catcheside, P.[1,2]

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pam.catcheside@sa.gov.au Presenter: Pam Catcheside

Mycology covers a very broad range of topics and includes not just the fungi themselves, but fungal ecology, medical mycology, plant and animal pathology, fungal physiology. Only the larger fungi will be covered here of which it is estimated there are 10,000 to 15,000 in Australia.

Amongst the earliest records of fungi from Australia were ones made by the naturalist Robert Brown during Matthew Flinders' voyage in the ship *The Investigator*. The expedition sailed along the now South Australian coast in late January to early April 1802, from Fowlers Bay to Kangaroo Island. During the Australian voyage, Brown recorded ten species of fungi, some of which may have been seen in SA, but it is not known if collections of the fungi were made.

Less tenuous are the collections of J.G. Otto Tepper. He listed 18 species of fungi "in the neighbourhood of Clarendon" in 1883. Some of his collections of fungi are in the State Herbarium of South Australia (AD), though most were sent to Germany, a few to Melbourne. Most of Tepper's extant collections in Australia seem to be of pathogenic fungi.

By far the greatest debt is due to Prof. Sir John Burton Cleland for his work on fungi. AD houses his approximately 16,000 fungal collections. Most of those from SA were made from 1920 to 1935. His Handbook, "Toadstools and Mushrooms and other Larger Fungi of South Australia", published in two parts in 1934 and 1935, is a major monograph on Australian fungi and the first work covering the larger fungi in this country since M.C. Cooke's "Handbook of Australian Fungi", published in 1892. Cheryl Grgurinovic revised Cleland's handbook, updating scientific names and expanding the descriptions. Her invaluable revision, published in 1997, includes expansion and illustrations of microscopic characters.

Until 1978, the Waite Institute held most of the fungal collections which included pathogenic and non-pathogenic taxa. An agreement, facilitated by Dr Pat Talbot, started the transfer of pathogenic fungi to DAR (the State Plant Pathology herbarium in Orange, NSW) and non-pathogenic specimens to AD. The vast majority of the latter consisted of the collections of J.B. Cleland, including over 230 type collections for most of the new taxa he described. The bulk of his significant collection of watercolour paintings, commissioned to document his collections, was also transferred. Cleland's collections are a magnificent resource: many are requested for loan by mycologists around the world. Cleland was a remarkable naturalist as well as holding the position of Marks Professor of Pathology at the University of Adelaide from 1920 to 1948. He was instrumental in the establishment of national parks and reserves including Belair and Flinders Chase National Parks (FCNP). It is arguable that, without his intervention, we may not have FCNP in its present state. As a very large area of remnant vegetation it is a refugium for a rich and diverse mycota of over 500 species of larger fungi.

Dr Jack Warcup was senior microbiologist at the then Waite Agricultural Research Institute from 1951 to 1986. He is known mainly for his work with orchid mycorrhizas but he also published

work on saprotrophic ectomycorrhizal fungi, notably after forest fires and was an excellent field mycologist. Warcup collaborated with systematic mycologist Talbot whose book "Principles of Fungal Taxonomy" remains a very useful text. He also worked with microfungal taxonomist Dr Clifford Hansford. The State Herbarium houses many of their collections, including a number of types, also Hansford's manuscript volumes of the makings of an apparent census of Australian fungi (macro and micro).

Lindley Williams published works on arid lands ecology and collected fungi, mostly in the Meningie region. He was particularly interested in Ascomycetes and Slime Moulds. Some of the Ascomycete collections he sent to Kew were described as new species.

Many others have contributed to the collections of fungi in the State Herbarium of SA. Some have added collections, others have consulted and researched the collections in AD, adding to our knowledge and understanding of South Australia's fungi.

I was appointed Honorary Research Associate at the State Herbarium in 2002. Since retirement in 1998, I have been collecting the larger fungi, mostly in National and Conservation Parks and Reserves in many areas throughout SA. These areas extend from the dryland parks of the Murray, the Flinders Ranges, the Upper and Lower Eyre Peninsula, the South East, the Mount Lofty Ranges and Kangaroo Island. With my husband David as photographer, I have made over 4000 fungal collections, all of which fully described prior to their being accessioned into AD. This is necessary because of the transitory nature of characters such as colour and texture.

Among the collections are new species. The first of these to be published, with Dr Teresa Lebel, Senior Mycologist at the National Herbarium Melbourne, was a rare stalked truffle, *Cribbea turbinispora*. Ours was the first and only collection of this genus for SA. A rare species of a small white gilled fungus from Kangaroo Island, *Entoloma ravinensis*, is shortly to be published with David Catcheside and Helen Vonow, Collections Manager at the State Herbarium. In recent years I have concentrated on collecting discomycetes with David carrying out molecular work on my collections. A paper on a new species of small black disc fungi is in preparation.

Among our surveys has been an intensive study, over a number of years, of a small area in Deep Creek Conservation Park, Stringybark Walking Trail. We have identified this as a fungal hotspot. In a paper published in 2008, the conservation status of approximately 250 species of larger fungi was estimated. Since 2008 the number of fungal taxa recorded has been rising steadily.

We have been surveying in FCNP since 2002 and have recorded over 500 species of fungi there. We have a number of sites which enables us to compare fungal fruiting in the different years at those sites. Because of the unpredictable fruiting of fungi it is necessary to conduct multiple surveys over many years to obtain an idea of fungal incidence and diversity. The extensive and intense bushfires of December 2007 in the Chase burnt much of its vegetation. We have been monitoring post-fire recovery of the fungi and have both pre- and post-fire data for most of our sites. We intend publishing these data which will be an important addition to the scant knowledge of fungal fruiting patterns after fire.

Teresa Lebel, an expert on truffles, has accompanied us on two of our expeditions to Kangaroo Island. Her collections of truffles have added significantly to the knowledge of the incidence of these fungi. Teresa will be coming to KI again this year.

Members of the Adelaide Fungal Studies Group are carrying out their own research projects. Thelma Bridle has been collecting Earth Tongues in the under-collected genera *Geoglossum* and *Trichoglossum*. Julia Haska has been collecting Amanitas on Kangaroo Island. The island has been shown to have a rich diversity of species in this genus of gilled fungi.

The State Herbarium of South Australia not only has a valuable collection of over 20,000 species of fungi, but its supportive atmosphere encourages both practising and budding mycologists resulting in its being an important hub for mycological research.

Sucking the lifeblood out of major invasive weeds of Australia

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[2] Faculty of Health and Life Sciences, Northumbria University

Presenter: Robert Cirocco

Major invasive weeds cost Australians around 4 billion dollars annually in addition to incalculable costs to biodiversity. Native parasitic plants may have detrimental effects on performance of invasive weedy hosts by removing resources via suckers and thus contribute to their demise. Glasshouse studies have documented severe effects of parasites on invasive species, but the effects of parasites may be highly variable depending on environmental conditions. We conducted physiological measurements to investigate the effects of the native parasitic vine *Cassytha pubescens* on the major invasive weed *Ulex europaeus* (gorse) across three field sites in the Mt. Lofty Ranges of South Australia. Photosynthetic performance and nitrogen concentration of gorse were strongly decreased by *C. pubescens* consistently across sites. In addition, at two of the three sites, the parasite had a negative effect on the long-term water-status of gorse and there was also evidence of breakdown in the photosynthetic apparatus of the host in response to infection. The data indicate that the native parasite negatively affects photosynthesis of gorse by removing large amounts of nitrogen and likely water from the host. Thus, *C. pubescens* shows promise as an effective native bio-control against major invasive weeds in Australia and if successful, may be used to help restore our native biodiversity.

Climate projections at regional scales: adding value to Australia's national projections

Clarke, J.M., Wilson, L., Heady, C.and Erwin, T.

CSIRO Oceans & Atmosphere, Aspendale, Vic.

Presenter: John Clarke

CSIRO's climate projections group has developed, delivered and supported uptake of Australian climate change projections for 29 years, and in collaboration with the Australian Bureau of Meteorology (BoM) for the past ten years. Over the past six years, CSIRO and the BoM have also created and supported climate projections for the Western Tropical Pacific and Southeast Asia, including the development of downscaling to add regional detail. Lessons from this experience have been applied to the latest Australian climate projections, developed in partnership with NRM groups from across Australia, which were progressively released between January and April 2015. The principal means of disseminating the projections is the Climate Change in Australia website (www.climatechangeinaustralia.gov.au) – with 13 online tools tailored to the needs of a range of clients.

Over the past year, CSIRO has value-added these projections to meet the regional planning needs of State and Local governments. Projections were developed for six regions in Victoria for the Department of Environment, Land, Water and Planning to inform a set of "Climate-Ready" brochures and data-sheets that were launched in January (http://www.climatechange.vic.gov.au/). Similarly, we recently completed climate projections for the Sunshine Coast Regional Council (Qld) to inform the revision of their climate adaptation planning.

In both cases, regional projections were tailored to the spatial and temporal scales and impact sectors of interest to the clients. The information developed included: regionally averaged changes in key climate variables (e.g. rainfall, maximum and minimum temperature), climate analogues, future seasonal rainfall averages and, days above/below key temperature thresholds.

Regional climate projections pose a number of scientific challenges, including increased uncertainty and the risk of clients over-interpreting results (e.g. 'false precision'). These must be explained honestly and transparently to ensure decision-makers are using the best and most complete information.

SA Murray–Darling Basin citizen science program – taking it from the masses

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Presenter: Sylvia Clarke

A plethora of valuable environmental data is voluntarily collected by groups and individuals across the South Australian Murray Darling Basin but its potential for environmental impact and resource condition monitoring has not yet been realised. Data has been stored on a range of media, in various locations, with little sharing of information or data analysis and evaluation. Through the provision of equipment and training in data collection and analysis, and the development of on-line data portals, a vibrant and purposeful citizen science program is emerging. Current projects see the public collecting data on surface water quality and macroinvertebrates, as well as bird and bat species distribution across the region. Data is self-entered on-line, is vetted by a moderator, can be viewed and downloaded through the internet, and ultimately becomes part of the Biological Database of SA and commonwealth government databases including the Atlas of Living Australia and Bureau of Meteorology. This provides participants with instant feedback and awareness of their role in region-wide projects. Data is also analysed periodically and reports are sent to participants to review and decide on relevant actions. Systems are now being established with organisations such as the Environmental Protection Authority to enable participants to trigger authorities into action to protect their local environment. The level of interest and capacity for involvement in environmental monitoring in this region is staggering. The challenge is to ensure the projects deliver engagement and education, while also providing data of use to community members, the Natural Resource Management Board, and any other interested parties.

What drives the distribution of kangaroos in areas where they are harvested in South Australia?

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[1] Environment Institute, The University of Adelaide

[2] Department of Environment, Water and Natural Resources

Presenter: Leah Collett

Monitoring a species distribution and abundance is critical for wildlife managers to inform management. Red and western grey kangaroos in South Australia are managed as an abundant species, to reduce their grazing pressure in rangeland landscapes. The kangaroo management plan for South Australia outlines the need to conserve the red and western grey kangaroo populations, to mitigate damage caused by kangaroos through a commercial harvest and to ensure the harvest is sustainable. The management of these species takes the form of a managed commercial harvest, which is based on population estimates derived from aerial surveys done annually by the Department of Environment, Water and Natural Resources (DEWNR). Quotas for these species are then set using a proportional harvest quota. We used the past 37-years of survey and harvest data to create and test models that incorporated kangaroo population demographics, and environmental and climatic variables that were expected to influence the distributions

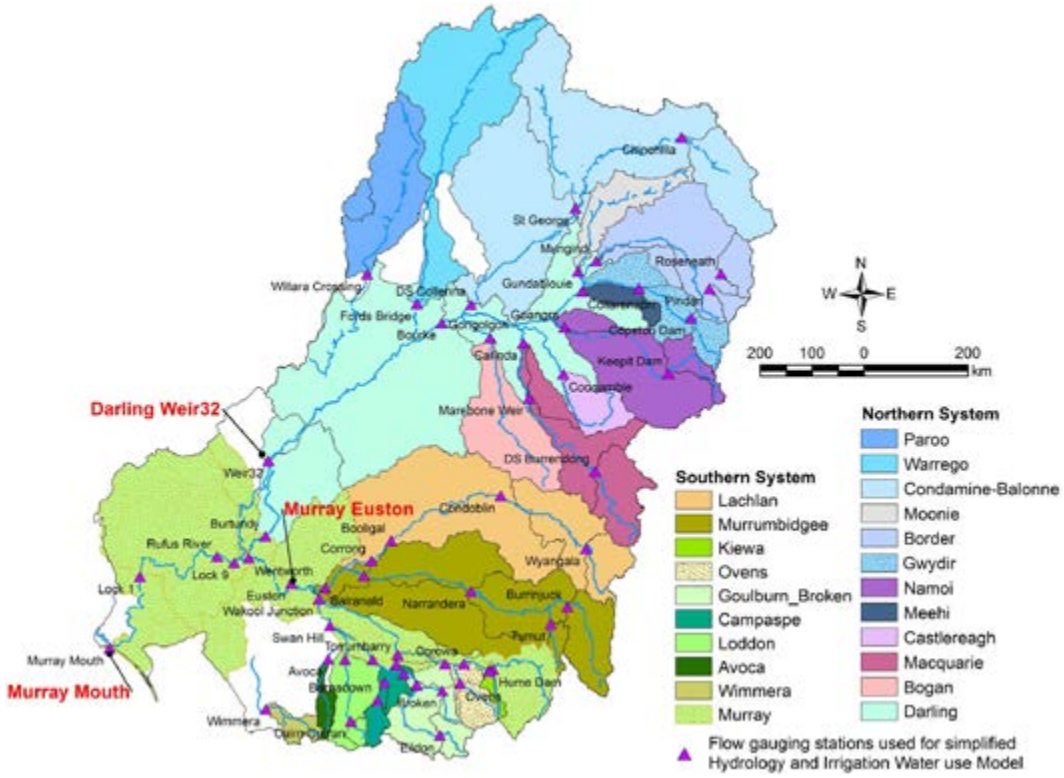

Figure 5. Murray–Darling Basin, subdivided into 58 catchments.

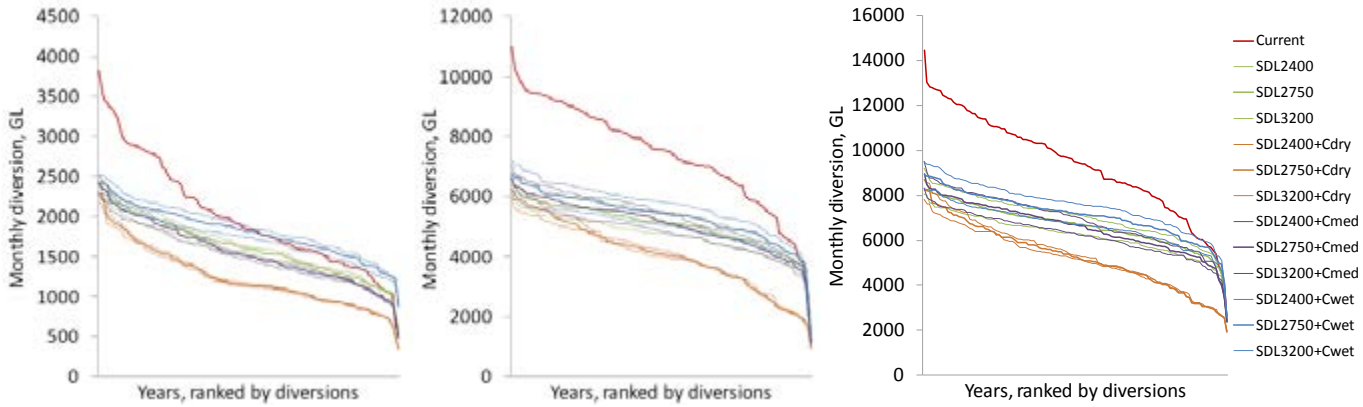

Figure 6. Results.

of kangaroos. We discuss the factors that appear to be driving the distribution of kangaroos and explore how our results might inform management, both in terms of population estimates and harvest quotas. This paper forms part of a study with DEWNR and the Global Ecology Lab (Environment Institute, University of Adelaide).

Climate change and environmental water reallocation in the Murray–Darling Basin: Impacts on flows, diversions and economic returns to irrigation

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Presenter: Jeff Connor

Introduction

Around the time that the Murray-Darling Basin plan was being implemented, a number of evaluations assessed diversion, flow and economic impact that might result. However, none of these assessments considered what the plan refers to as "risks" that could reduce future flows such as climate change. This presentation is an assessment of how climate change in combination with allocation changes under the plan could impact flows, diversions and the economic returns to irrigation. The focus is on potential of such risks to reduce the environmental flows which the plan was designed to enhance and additionally reduce irrigation allocations and thus exacerbate agricultural sector economic impacts from planned irrigation water re-allocation.

Methods

The framework underpinning the analysis is an integrated hydrology–economics model capable of simulating the year-to-year variability of flows, diversions, and economic returns. The hydrology component of the integrated hydrology–economic model is based on a simple, monthly water balance stocks and flows model of the Murray–Darling Basin, subdivided into 58 catchments shown in Figure 5.

The economics model is based on regressions of the observed areas and gross value of irrigated agricultural production as a function of water available, evaporation and rainfall, and crop prices, for 10 major commodity groups and for 17 regions and four recent years during the drought.

Scenarios

The presentation will present application to scenarios involving three levels of reallocation (2400, 2750 and 3200 GL) under the historical climate, and under a dry, a median and a wet climate change projection.

Results

Results shown in Figure 6 demonstrate that estimated river flows and diversions are more sensitive to the range of climate change projections than to the range of diversion reallocation scenarios considered. The projected median climate change more or less removes from flows the gains to the environment resulting from reallocation. Reallocations only in combination with no climate change, or climate change at the wetter end of the range of projections, is anticipated to lead to flows greater than those experienced under the water management regime prior to reallocation. The reduction in economic returns to irrigation is less than the reduction in water available for irrigation: a 25% reduction in the annual average water availability is estimated to reduce the annual average gross value of irrigated agricultural production by about 10%. This is consistent with expectation of economic theory (since more marginal activities are reduced first) and also with observations of reduced water availability and returns in the recent drought in the Murray–Darling Basin. Irrigation returns vary less across the range of climate change projections considered than across the range of reallocation scenarios considered.

A full length journal article reporting on this research can be downloaded at: https://www.researchgate.net/publication/265478734_Climate_change_and_environmental_water_reallocation_in_the_Murray-Darling_Basin_Impacts_on_flows_diversions_and_economic_returns_to_irrigation

Botany 2016 — Past, present and future

Weird and wonderful plants of South Australia

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Far from being just a saltbush-strewn desert, the South Australian flora contains a wide variety of plants with unusual biologies and evolutionary histories. Ranging from bizarre tiny waterlily relatives that mimic grasses so well, it took DNA to sort them out; hybrid tobaccoes that evolve by dropping chromosomes; diverse carnivorous and parasitic plants; and opportunistic desert dwelling lilies that can wait over a decade before carpeting the ground with masses of blooms then disappearing again in just a few weeks after rain. If you know where to look and when, the SA flora is anything but boring or uniform.

Botany 2016 — Past, present and future

Boolean logic and plant names

Cooke, D.

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Precise nomenclature is essential when plants are declared as pests under legislation. But synonyms, different names for the same plant, can cause confusion, as for example, when the declared weed *Polygala myrtifolia* is traded under the name *P. grandiflora*.

It may not be generally understood that declaring a taxon means that also has weedy biotypes.

Relations between names can be clarified by Boolean logic, linking entities with statements of the form "if A then B" (meaning A fits within the definition of B, but not the converse). Any relation that exists between entities can be expressed as a nested hierarchy of "if A then B" links. Biological taxonomy is such a hierarchy, especially phylogenetic classifications based on cladograms, which are topologically equivalent to Venn diagrams.

However, the codes of biological nomenclature were developed without reference to this. By the principle of priority the earliest published name is used when species are merged, although this may not be the name of the most inclusive set. Some garden plants were first named from variants selected for cultivation, but those names now apply to all wild populations of those species as well.

Implications of uncertain taxonomy for conservation management: case studies on bandicoots and gliders

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Presenter: Steven Cooper

It is often assumed that the taxonomy (species and subspecies classifications) and distribution of our native mammal fauna are now well established. However, even for very well-known species of conservation significance this assumption may be entirely wrong, with major issues for their conservation management. To illustrate this point we present some of our recent genetics research on southern brown bandicoots (*Isoodon obesulus*) and petaurid gliders from northern Australia.

Mitochondrial (mtDNA) and nuclear gene sequence analyses of *I. obesulus* revealed that there is a major phylogenetic split within I. obesulus, with the SA Mt. Lofty Ranges, Kangaroo Island and Franklin/St Francis Island populations grouping with populations of *I. obesulus* and *I. auratus* from Western Australia and a second group comprising *I. obesulus* from south-east SA, Victoria, NSW and Tasmania. MtDNA analyses further showed that all Tasmanian samples formed a distinct evolutionary lineage (monophyletic group of haplotypes) to the exclusion of all other mainland samples of *I. obesulus*. The level of sequence divergence among these lineages suggests that the Tasmanian population has been genetically isolated from the mainland population, potentially over hundreds of thousands of years, including multiple ice age cycles. Support from nuclear gene analyses for the distinction of the Tasmanian population was absent, possibly due to the low intra-specific variation in the nuclear genes used in our study. Taken overall, the results lend support for the separate sub-specific status of the Tasmanian population and further suggest that *I. o. obesulus* is limited in its distribution to NSW, Victoria and south-east SA. The latter represents a significant reduction in the known range of this subspecies.

Similar genetic analyses of petaurid gliders from the Northern Territory, previously thought to be a subspecies of *Petaurus breviceps*, revealed the existence of an entirely new evolutionary lineage of gliders that is likely to represent a distinct species, and preliminary evidence that an additional divergent evolutionary lineage may also exist in the Kimberley region of Western Australia. Morphological analyses are currently underway to further test the hypothesis of a new glider species in northern Australia. Together with recent genetic studies of other marsupials (e.g. rock wallabies of the genus *Petrogale*, *Sminthopsis griseoventer* from SA and *Petaurus australis* from northern QLD), it is apparent that there is still much to learn about the taxonomy and distribution of the Australian mammal fauna, particularly from northern Australia. The implications for their conservation management are further discussed.

Botany 2016 — Past, present and future

Conservation status of plants in South Australia: Challenges and trends

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Presenter: Peter Copley

The last revision of the threatened species schedules under the South Australian *National Parks and Wildlife Act 1972* were gazetted in February 2008, and the revision before that was in 2000. The changes incorporated in the revised schedules in 2008 arose from workshops held between 2002 and early 2003. Those workshops only reviewed species already listed as threatened and a limited number of others that had been documented as "of conservation concern". A discussion paper entitled "2003 Review of the Status of Threatened Species in South Australia: Proposed Schedules under the South Australian *National Parks and Wildlife Act 1972*" was then made available for public comment, and a significant number of responses were received. Further assessments were undertaken and the draft schedules were amended for several additional species. It then took a further three years to take the proposed revised schedules through government processes, including a sub-committee of Cabinet, to the final gazettal stage.

Between 2008 and 2014 the conservation statuses of all of South Australia's known native vascular plant and vertebrate animal taxa were assessed at IBRA sub-regional levels for each of the State's eight NRM regions. Assessments were made by panels of taxonomic experts and local naturalists who applied the widely-accepted, IUCN Red List criteria for deriving regional status. The panels drew on their own field knowledge and also accessed plots of vouchered records held by the State Herbarium of South Australia and data from the Biological Databases of South Australia (BDBSA).

This process served four main purposes. Firstly, it provided the first State-wide check of distribution data for all recognised native vascular plant (and vertebrate animal) taxa. It identified many likely database location errors that were then checked to ensure a "clean database" was available for all users. It also enabled workshop participants to gain a much better appreciation of what location (and other) information has been documented for each species and to identify "missing" or overlooked location

records and datasets. Secondly, the regional focus provided the first bottom-up assessment of plant (and animal) species statuses using IUCN criteria, at regional and sub-regional levels, across the State. Thirdly, the workshop process trained numerous people, including local regional staff and naturalists, in the application of IUCN Red List status assessment techniques. Fourthly, the regional assessments helped to identify those taxa for which there might be conservation concern at the State level, as well as those that were clearly of Least Concern.

During 2015 and 2016 more workshops involving many of the same experts have been re-assessing the native plant and animal species at the State level. Summary status statistics from these recent reviews will be presented and will be compared with previous listings. Implications for threatened species conservation in SA and the need for legislative reform will also be discussed.

Groundwater resource capacity estimates in the Barossa PWRA: Approach to risk and uncertainty

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[1] Department of Environment, Water and Natural Resources

Presenter: Roger Cranswick

The world-renowned wine industry of the Barossa Valley has historically developed with a dependence on the water resources of the region. Sources of fresh groundwater are found within a number of different aquifers and the relationships between key recharge and discharge processes are challenging to describe using simple water balance approaches. The development of a numerical groundwater model has enabled a more confident understanding of the likely impacts of both the historical and possible future changes to the climate and groundwater use. Subsequently this approach allows the development of water management policy to be tailored specifically for each hydrogeologically distinct area within the Barossa Valley in order to maximise the social, economic and environmental benefits from the use of groundwater resources.

As a background, important water resources in South Australia are protected and managed through a process called prescription. Once a resource is prescribed, users are issued with water licences and a water allocation plan (WAP) is developed to manage the taking and use of water from the resource in a sustainable manner. Ensuring that policies for management of water resources under a WAP are appropriate for balancing the environmental, social and economic needs for water in the area, requires a sound scientific understanding of the capacity of the water resource, the demands upon it, and the potential impacts of meeting these demands on an ongoing basis. This is required not only legislatively through the NRM Act, but also to give confidence to policy makers and the community about management decisions. The Barossa Prescribed Water Resources Area (PWRA) is highly dependent on water for irrigation and industrial use, most notably by its world-renowned wine industry, which is a significant contributor to the regional and state economy.

Traditionally, simple water balance approaches (e.g. estimates of long term recharge) are used as the basis for determining the resource capacity and sustainable levels of extraction, which are then used to inform policy decisions for water management. Although this may be fit-for-purpose in some systems where demands on water resources are low, the uncertainty of these estimates is not commonly quantified, which can result in a relatively low level of confidence in their adequacy for water managers. Additionally, using a single annual value for long term sustainable extraction may not be preferable in environments where the relationship between rainfall, groundwater use and the condition of water resources can vary greatly from year to year or is likely to change in the future. This approach may also potentially limit the adaptability of management decisions to provide flexibility for water users to respond to climatic variability and other factors.

For the Barossa PWRA, it was identified that a more rigorous and dynamic approach for determining resource capacity was required. To do this, a numerical groundwater flow model was created by integrating all available hydrogeological, hydrochemical and observation well data. The development and calibration of this model enabled a far greater understanding of how each type of aquifer has responded to the changing groundwater use patterns and climate variability over the last 25 years. Unconfined fractured rock aquifers were seen to be very sensitive to both climate variability and changes in groundwater pumping from year to year, while the deeper sedimentary aquifers were more robust and responded to stresses over longer time scales (see Figure 7). Model predictions were also made to investigate possible future stresses on the system and the likely impact on resource condition indicators (e.g. groundwater – surface water interaction and baseflow, groundwater salinity and groundwater levels). These include for example:

- an increased frequency of low baseflow years in the future if groundwater pumping increases in particular areas;
- an elevated risk of increasing groundwater salinity when groundwater extraction volumes increase; and
- an increased rate of groundwater storage decline in shallow aquifers as a result of reduced recharge predicted from climate change projections.

The added confidence provided by this level of analysis has been used to inform a risk assessment framework where likelihood and consequence of potential changes to resource condition over time are considered in a quantitative fashion. As such, policies for the management of the water resource can be more confidently developed to maximise benefits of extraction while ensuring risk is maintained within acceptable levels.

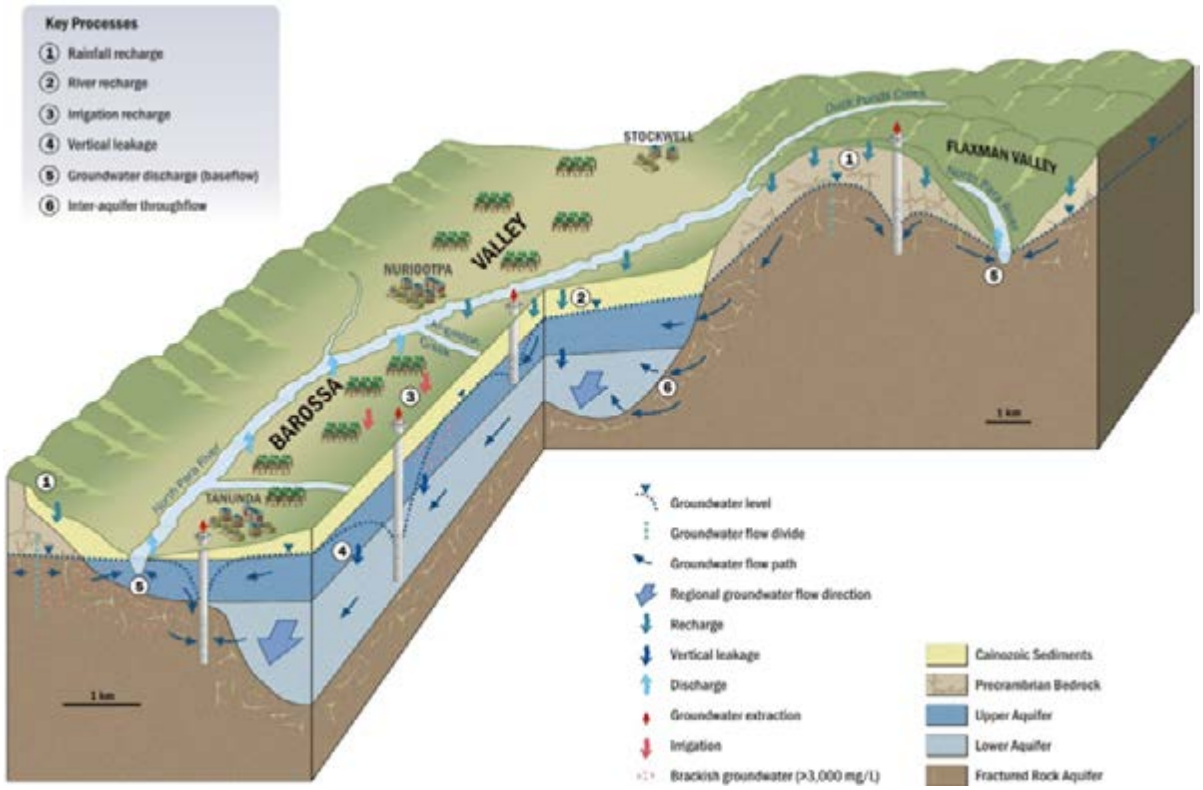

Figure 7. Conceptual model for the Barossa PWRA groundwater resources

Botany 2016 — Past, present and future

Mapping South Australia's pre-European vegetation cover

Croft, T.

State Herbarium of South Australia, Department of Environment, Water and Natural Resources

Presenter: Tim Croft

At time of formal European settlement in 1836, South Australia was covered by diverse vegetation, from temperate higher rainfall Forest and Woodland similar to adjacent south-eastern Australia; semi-arid and arid Shrubland and Low Open Woodland to the north and west; extensive areas of Mallee and unique Grassland vegetation; and even elements of semi-tropical species associated with the extreme north-east central drainage. Knowledge of the State's pre-European vegetation communities extent and coverage is an important step towards managing and conserving the State's remaining fauna and flora species and habitats, and if necessary rehabilitating some of these habitats. Some of these vegetation communities remain poorly conserved in the formal DEWNR reserves. This is particularly important in the southern agricultural district largely below "Goyder's Line", where this vegetation has been more severely impacted by 180 years of change.

Pre-European mapping has concentrated in the higher rainfall agricultural areas of the State, where vegetation change has been most significant. In some districts, this change has been dramatic. Determining the original vegetation cover back to the early 1800s involves considerable research and investigation from a multitude of sources, but ultimately relies on the perceived "landscape parameters" that led to the distribution of the various plant communities over a long time period. These landscape parameters include geology, soils, soil depth, aspect, drainage and hydrology, rainfall amongst other more minor factors, and are important in understanding why a particular vegetation community has evolved in a particular district in a particular part of the landscape.

Background research and investigation includes extensive literature research, tracing back as far as possible to original first hand observations of the vegetation by early navigators, explorers, pastoralists and settlers. As the pastoralists made way for agriculture in the 1860s, the State Government through Goyder's supervision, surveyed the land into Hundreds. And in the 1900s, more scientific papers were written for a number of agricultural districts, such as the "Ninety Mile Desert" (Specht 1951). These linked the vegetation communities to soil types and other landscape parameters. Biological surveys by DEWNR and the Nature Conservation Society of South Australia have supplied further information and refinement of the remaining native vegetation cover. And observing any remnant vegetation reinforces how the landscape works with regard to a particular vegetation community. In most cases, but not all, some remnant vegetation may be found on road or railway reserves, fencelines, scattered remnant trees, water reserves, even in heavily modified districts.

Using Eyre Peninsula as an example, Flinders and his scientists led by Robert Brown, landed in two sites (Coffin Bay and Port Lincoln), where Brown collected plants, some now residing in the State Herbarium. They also described the vegetation they observed (Flinders 1814). Formal settlement began at Port Lincoln in 1839, with the settlers rapidly spreading out again

describing the vegetation (Tod 1839, Eyre 1845, Neales 1844). George F. Angas visited the settlement in 1845, in addition to further vegetation description, sketched what he observed (Angas 1847). Some early settlers were also very interested in botany, sending plant specimens back to Adelaide, now to be found preserved in the Herbarium. These provide an invaluable idea of some of the vegetation in now the longest and most modified areas. With expanding agriculture, the land was divided into Counties, and surveyed into Hundreds and Sections, which frequently included rough description of the native vegetation present. Railway development brought further settlers and descriptions of the vegetation, but resulted in extensive clearance of the native vegetation to make way for exotic pasture and annual crops. It also resulted in widespread introduction of non-indigenous plants, loss of native animals and introduction of feral animals. All this changed the landscape, especially in the higher rainfall areas with better agricultural soils.

All the research and investigation comes together for the actual mapping. This applies biological survey point interpretation, soil mapping layers, digitised onto a background ortho-rectified enlarged aerial 1:40,000 scale imagery. With experience, species canopy and changes in underlying soil type can be detected, which in turn can be checked in the field. Such detailed mapping has been carried out for the South East, Murray Mallee, Mount Lofty Ranges, Yorke Peninsula and large areas of the Mid North. It has been a "first cut", but with additional information can be improved, with new agricultural districts also mapped. This is the proposed future for improving and extending the pre-European mapping to cover all the State's agricultural areas.

Preventing soil cracking, acidification and salinisation through improved irrigation efficiency and strategies

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Presenter: Michael Cutting

There is approximately 5,200 ha of land, comprising over 20 separate irrigation areas on the former floodplain of the lower River Murray in South Australia. This area is known collectively as the Lower Murray Reclaimed Irrigation Area (LMRIA) or the "Lower Murray Swamps".

Historically, this floodplain region contained patches of reed growth and standing water that changed according to river levels and local climatic conditions. The swamp areas began to be reclaimed in the late 1800s and between 1900-1930 development intensified with the construction of levee banks near the river edge, pumping out of standing water, and development of a drainage system to maintain the water-table at a sufficiently low level to grow pasture.

The LMRIA has faced severe challenges over the past seven years (2008-2015) from the effects of the severe "millennium" drought. River and groundwater levels fell to their lowest in over 100 years between 2007 and 2010. Coupled with restricted irrigation water allocations, there was very little irrigation water applied. This led to severe soil cracking to depths up to 4m, salinisation and acidification and severe socio-economic impacts. The result of this was that many irrigators ceased or down-scaled their operations in the LMRIA, with a pronounced loss of dairy farming activities.

Five years after the drought ended (in terms of river levels), the LMRIA soils, waters and irrigation infrastructure are still impacted. Infrastructure upgrades (laser levelling & channel repairs and renovation) are currently underway across approximately 500 ha as part of the Australian Government funded On-Farm Irrigation Efficiency Program (OFIEP) administered by the South Australian Murray-Darling Basin Natural Resources Management Board.

Climate change projections indicate there is an increased risk of negative drought effects in the Lower Murray becoming more prevalent in the future. The project aims to determine how best to sustain irrigation in future droughts. The field measurements and trials are being used to inform sophisticated 2-dimensional soil-water models of the irrigation area. These models can successfully represent the complex interactions between river level, groundwater level and irrigation under changing climatic conditions.

The models will then be used to optimise strategies (maintain soil moisture, prevent soil cracking and acidification, maintain groundwater levels, manage salinisation) to protect the LMRIA into the future.

This paper discusses the results of irrigation efficiency improvements and new strategies, including potential policy considerations to best manage priority land and water issues in the Lower Murray region of South Australia.

Improving subsoil constraints through innovative amelioration to sequester carbon on Eyre Peninsula

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[1] Rural Solutions SA, PIRSA

[2] Eyre Peninsula NRM

Presenter: David Davenport

Eyre Peninsula has a distinctive range of soil types and farming practices ranging from medium rainfall, intensively cropped areas to marginal cropping in the low rainfall zones.

Despite many advances in crop agronomy, plant water use efficiency on some soil types is still relatively low. This is due to the low inherent fertility of many of the soils in the region (particularly sandy soils and in highly weathered subsoils) and poor soil structure (due to low organic carbon levels, high sodicity and physical compaction).

These issues impact on plant available water, plant root growth and also impact on soil organic carbon (SOC) levels. There is wide variability in soil organic carbon stocks identified within similar soil texture/rainfall categories. This has been detected by analysing soil data conducted in the National Soil Carbon and Research Project (SCaRP) and from soil data contained in the South Australian Soil and Land Information Framework.

This suggests that modification of these soils and addressing constraints to carbon input and retention could deliver higher SOC levels. This is confirmed by research undertaken on sandy soils (Schapel et al) and on heavier soils in Victoria (Peries and Sale). In 2013 the Eyre Peninsula Natural Resource Management Board developed a successful project funded through the Australian Government Action on the Ground Program.

The aim of the project was to identify key soils on Eyre Peninsula with SOC levels below those of soils in similar rainfall zones and to research techniques to improve carbon and production levels on these soils. In 2014, four trial sites and 3 satellite demonstration sites were established. Treatments were designed to address the key soil constraints observed on the sites and included application of soil amendments (including lime or gypsum or clay) with and without the incorporation of organic matter.

Production increases have varied depending on the soil type. The largest increases have occurred on sandy soils with production increases up to double the control. Measurements of changes to soil organic carbon levels are currently being evaluated with the data to be presented at the conference. Eyre Peninsula farmers have shown a keen interest in the results and, with support from the project, are establishing new demonstration sites in the Buckleboo, Cowell, and Brimpton Lake districts.

Rapid recovery of endangered flora on the Fleurieu Peninsula

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Presenter: Rick Davies

The Mt Lofty Ranges is considered a biodiversity hotspot and much of the regions diversity is attributed to its flora. With the high level of historic land clearance in the region and the associated effects of fragmentation, it is no surprise that many plants in the region are threatened. To address the loss of regional floristic biodiversity, the AMLR region has been implementing a wide variety of threatened flora recovery projects. Many recovery projects are challenged by our lack of understanding of the key requirements of species which can often make recovery progress torturously slow. For example, the recovery of endangered orchids often requires an understanding of complicated mycorrhizal and pollinator interactions, or cryptic environmental factors which break dormancy and trigger flowering. In contrast *Allocasuarina robusta* (Mount Compass Oak-bush) is an example of a species where the recovery is much more straight-forward since the reproductive biology is relatively simple, the plants are relatively long-lived and readily observed at all times of the year. Mount Compass Oak-bush is listed as endangered under the Federal *EPBC Act* and the South Australian *National Parks and Wildlife Act*. The species has a naturally highly restricted distribution being endemic to the Mount Compass and Hindmarsh Valley areas of Lower Fleurieu Peninsula of South Australia. The species is confined to wet heath and open woodlands on low-lying poorly-drained areas and areas bordering swamps, habitats that have been extensively cleared for agriculture in this region. This has resulted in significant declines in the numbers of plants and populations of the species, with surviving plants now being confined to highly fragmented areas of native vegetation that are mostly on roadsides. Roadside populations are under threat from weed invasion, road management activities and herbicide spraying of roadside weeds. The species is further threatened by fertiliser and pesticide drift from adjacent farmland, along with changes in hydrology due to water extraction. Little if any seedling recruitment is occurring due to weed invasion, animal browsing and altered fire regimes.

It was on the criteria of small and declining population size and restricted geographic range that the species was listed as nationally endangered under the *EPBC Act*. Consequently these criteria formed the basis of performance criteria proposed in an Action Plan developed for the species as part of a recovery program. Initially coordinated by the Threatened Flora Ecologist Natural Resources AMLR, the program is now jointly delivered with Natural Resources SAMDB and now has many other partners including local government, land owners, the Threatened Plant Action Group and the Adelaide Herbarium.

Surveys were undertaken in 2016 to evaluate success of the recovery program towards addressing the performance criteria in the Action Plan and making progress towards achieving delisting of the species under the *EPBC Act*. All major remnant populations and plantings and the majority of smaller populations were visited to determine numbers of plants surviving and threats which still need addressing. The Recovery Programs' progress towards its target of downgrading the listing of the species is discussed along with emerging conservation challenges.

Risks to prime agricultural land in the South East NRM region from unconventional gas mining

Daw, A.

Agricultural Advocate and Member of the Round Table for Unconventional Gas Projects in South Australia Presenter: Anne Daw

About 30% of the farmers in the South East NRM region rely on irrigation to grow pastures for livestock, grapes, fruit or vegetables. In 2011, they produced more than $1 Billion in food, fibre, wine and other primary products. Tourism in the South East NRM area is increasing, with visitors spending about $300 million each year. Productivity of our agricultural land and tourism industries is threatened by the proposed unconventional gas mining, in the same way that it has impacted industries in NSW, QLD, Canada and USA.

In the South East NRM region, the thin layer of prime agricultural land sits over the limestone, which is porous and brittle. There has been natural subsidence in the region resulting in hundreds of sinkholes. Drilling and hydraulic fracture stimulation (fracking) in limestone areas increases the risk of subsidence and the impacts on water resources.

Drill holes penetrate aquifers and geological formations and the risks to water resources are poorly understood. Drill holes are known to break down over time, and there is clear evidence of it in the South East NRM region (Figure 8). After just 30 years, a hydrology observation drill hole, commissioned by Western Mining Corporation in 1982, had broken down, causing subsidence to at least 20 metres, alongside the casing and into the unconfined aquifer. When the water levels dropped in the aquifer, the limestone roof was exposed, increasing the risk of subsidence. This drill hole was remedied when the media highlighted the safety risks. The number of similarly-failed drill cases is not known to science, nor government managers because monitoring of historic drill holes is poorly resourced.

Government scientists have highlighted that declines in water levels have increased the risk of sea water intrusion in the Donovans Management Area to the south of Mount Gambier. Some movement of the salt water interface has occurred in deep observation wells. The science indicates that the risk of intrusion increased as the result of over allocation of bore water. On surrounding agricultural businesses, the risk of intrusion meant that several bores had to be decommissioned and capped. It is also apparent that water table and water quality monitoring have not taken place for long enough to ensure that sea water is not intruding in the Eight Mile Creek area.

Figure 8. Picture shows subsidence around a tired 32 year old drill hole in the South East of South Australia, indicating that casings and cement are no match for geological processes in the short term, let alone over the next 100 to 1000 years. Photo: AE Daw

Beach Energy LTD recently drilled through vertical fault lines which rise upwards, and in some cases, into the confined and unconfined aquifers. There is extensive science that indicates that such drilling and waste water re-injection increase the risk of earthquakes and opportunities for mining contaminants to leak into our aquifers.

No well comes with a guarantee of its integrity, neither during the drilling phase nor in 100 years. Wells that we drill today will be there forever. The science that underpins unconventional gas mining is poor, but it is clear that as time goes by, the risk of well failure increases, particularly in areas that are as seismically active as the South East NRM region. Casings and cement are no match for geological processes.

Rethinking Climate Adaptation Planning – Turning awareness into action

Day, P.R.[1], Meyer, W.[2] and Siebentritt, M.[3]

[1] Peter R. Day Resource Strategies (www.resourcestrats.com.au)

[2] Landscape Systems, School of Biological Sciences, University of Adelaide (www.adelaide.edu.au/directory/wayne.meyer)

[3] Seed Consulting Services (www.seedcs.com.au)

Presenter: Peter Day

This presentation will give reflections from experienced climate adaptation planners based on their experiences, reading and conversations. It will summarise some features of climate adaption planning particularly in an NRM regional context, it will present learnings from early attempts to put theory into practice, and it will suggest priorities for future efforts.

Planning for the future is always uncertain and often complex. Planning for adaptation to climate change is no different in that sense, but it has some additional characteristics to manage as well. The most important characteristics include the uncertainty about how mankind will influence emissions or mitigation,

the uncertain consequences of any given future climates for societies, economies and the environment and the fickleness of public attitudes, values and beliefs about climate change.

Effective planning for adaptation to a changing climate requires a suite of traditional, modified and new approaches. Foundation recommendations include the need to consider a range of different futures and plan a number of alternative pathways, the need to be clear on what to monitor to determine when key decision points are approaching, and take action now on matters requiring an immediate response. Ancillary recommendations include:

- build the capacity to make transformational changes, if and when required,
- understand the limited role of climate vulnerability assessments,
- focus engagement on key decision-makers and their advisers,
- focus the scope on strategic responses for high-priority themes, within a triple bottom-line, regional landscape, context,
- ensure plans are rooted in the values of regional communities and reflect the things that matter most to them,
- identify actions that are needed immediately, others that should occur to build the capacity and some that lie 'dormant' until situations arise when they may be enacted promptly,
- challenge people with transformational changes to long running programs,
- recognise that adaptation plans must be agile, full of 'action now' as well as plans for how to respond should specified futures unfold, and
- bind decision-makers and leaders to their role in instilling adaptation planning throughout organisations and communities.

Multi-objective optimization of distributed stormwater harvesting systems

Di Matteo, M., Dandy, G.C. and Maier, H.R.

School of Civil, Environmental and Mining Engineering, University of Adelaide

Presenter: Michael Di Matteo

In this presentation a modelling framework is introduced that handles the optimal placement of stormwater harvesting (SWH) infrastructure within an urban development. The framework produces preliminary SWH system designs representing optimal trade-offs between cost, water conservation, and water quality improvement measures. These trade-offs are dependent on a large number of design decisions for the type, size, and spatial distribution of stormwater harvesting components. To evaluate and identify optimal designs the framework includes an integrated urban stormwater model (eWater MUSIC) linked with a multi-objective genetic algorithm (NSGA-II).

The framework was applied to a case study for a greenfields housing development in the northern suburbs of Adelaide, South Australia. Results illustrated the potential benefits of distributing stormwater best managment practices (BMPs) in an integrated SWH system where space at the catchment outlet is limited. Trade-offs between lifecycle cost, supply reliability and total suspended solids (TSS) reduction were influenced by the proportion of investment in storage size to maximise yield and BMP surface area to capture and treat runoff. Bioretention basins in locations that received the highest inflows were preferred in cost-effective reliable systems and in systems with high TSS reduction performance.

Oceanographic Research Supporting South Australian Fisheries and Aquaculture

Doubell, M., Middleton, J., van Ruth, P., James, C., Luick, J., Redondo Rodriguez, A., Patten, N., Malthouse, P.and Ellis, H.

SARDI Aquatic Sciences

mark.doubell@sa.gov.au

Presenter: Mark Doubell

SARDI Oceanography provides fundamental cross-disciplinary research into the physical, chemical and biological processes which underpin South Australia's marine ecosystems. Research outputs are driven by the overarching objective of enhancing the sustainable development of the state's marine resources. This talk presents an overview of how observational platforms such as SAIMOS, as well as various modelling studies, are assisting South Australian fisheries and aquaculture. Examples from current and recent projects include; SAIMOS, Spencer Gulf prawn larval transport, finfish aquaculture carrying capacity and sardine habitat mapping. A brief introduction to future projects will be presented to demonstrate how oceanographic research will continue to enhance our understanding and use of the state's marine resources.

6 months, 60 experts and 37 threats: a rapid assessment of ecological risk to marine habitats in Spencer Gulf

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[1] School of Biological Sciences and The Environment Institute, The University of Adelaide

[2] South Australian Research and Development Institute, Aquatic Sciences

Presenter: Zoë Doubleday

Natural environments are under continual threat from numerous anthropogenic stressors. Managing and mitigating such threats, while balancing social, cultural and economic needs, is difficult and complex. Identifying the relative risk that different threats pose to an ecosystem and the relative uncertainty associated with that risk can guide management and research priorities under

inevitably limited resources. Expert elicitation is increasingly being used as a feasible, resource-efficient approach for rapid 'first-pass' risk assessments of data deficient systems that also encompass multiple threats and/or multiple risk units. Using a combination of expert elicitation (to assess the probable 'consequence' of a threat) and existing data (to assess 'likelihood' as a function of the level of threat exposure), we conducted a risk assessment for 37 human-mediated threats to eight marine habitats in Spencer Gulf (totalling 296 threat-habitat combinations). We developed a comprehensive score-based survey to collate expert opinion and assess the relative consequence of each threat to each habitat and an independent and qualitative score of respondent uncertainty associated with each consequence level. Sixty experts, representing multiple sectors and institutions, participated in the study, with 6 to 15 survey responses per habitat (n = 81 surveys). Based on survey data and pre-determined exposure levels, we identify which threats pose the greatest risk to Spencer Gulf habitats, and, critically, key knowledge gaps (i.e. risks associated with high uncertainty scores). This study will facilitate future resource prioritisation in a region of increasingly significant social, economic and environmental value, as well as provide a baseline dataset for future risk assessments.

Spatial analysis of different types of Australian hemiparasites

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Presenter: Bjorn Dueholm

With more than 150 different species of hemiparasites in Australia, this group of autotrophic and parasitic plants constitute an important part of Australian ecotopes. Members of the group include mistletoes (Loranthaceae and Viscaceae), sandalwoods (Santalaceae) and parasitic vines (Lauraceae).

Highly desired for its aromatic, high-value natural products, Australian sandalwood (*Santalum spicatum*) is nowadays a rare sight, due to severe harvesting of wild populations. For this reason, the species is now listed as 'vulnerable´ in South Australia, and a lack of natural vectors has added yet another constraint on its continued reproductive success. Humans, therefore, have an important role to play in securing the future of the species.

The parasitic vine, large dodder-laurel (*Cassytha melantha*), is, in contrast, a rather common sight throughout southern Australia. Being a shoot hemiparasite, this species is fully dependent on its host for water and nutrients, which can put a host under high levels of stress. Another species of *Cassytha* has been tested for its potential as a biocontrol agent on an invasive species with some promising results. A population of *Acacia ligulata* co-occurring with both Australian sandalwood and large dodder-laurel was used in the study presented here, and the objective of the study was two-fold. First, it was of interest to determine what set of conditions might positively contribute to the success of a population of Australian sandalwood. This knowledge could aid revegetation projects of this species. Second, the objective was to assess what impacts the parasitic vine had on the fabaceous host, and compare the findings to those previously reported for the other species of *Cassytha*. Another comparison was conducted between the host impacts potentially induced by the two different types of hemiparasites in the study. In these investigations a variety of spatial techniques were used. These techniques can also be used in other systems in which hemiparasites are preent.

The Nature *of* SA: Thinking differently about nature conservation

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[1] Department of Environment, Water and Natural Resources

[2] Conservation Council of South Australia

[3] PIRSA

Presenter: Anna Dutkiewicz

The nature of SA is changing

South Australia is blessed with an amazing environment: from diverse coastlines to arid ranges, mallee to stony deserts, from expansive ephemeral inland rivers and wetlands to the Murray River, remote wilderness, farmlands, and urban parks. Our wildlife is as unique and diverse as our environments. These natural environments and their wildlife are cherished and loved by many South Australians, and provide us with our sense of place, our identity, and underpin our lifestyles, and much of our livelihoods.

Our nature is changing. The places we love will change, and the wildlife will change as climate change increases. Some species will thrive, others will decline, or even become extinct in SA. Existing pressures from weeds, pest animals, changed flows, historical vegetation clearance and changes to land-use also continue to influence our natural environment and wildlife. This poses a quandary for all of us. What can we do to conserve as much of South Australia's biodiversity as possible? What should we keep doing? What should we stop doing? What do we need to tweak? And what new things can we do?

Is No Species Loss the right approach?

No Species Loss: A Nature Conservation Strategy for South Australia 2007-2017 was the first state-wide nature conservation plan from South Australia. Released in 2007, it has provided a ten-year strategy for halting and where possible reversing the decline in the State's terrestrial, aquatic and marine biodiversity. The strategy provides a whole of South Australian Government position on biodiversity conservation. In 2017, the State's conservation strategy will expire.

The Department of Water Environment and Natural Resources (DEWNR) completed an internal review of No Species Loss in 2014. The review identified that No Species Loss set out WHAT was to be achieved but it failed to adequately articulate the HOW.

Our traditional approaches to environmental planning, and indeed our biodiversity paradigms, are often founded on concepts of "pre-European state" and saving everything (e.g. No Species Loss); which may not be well suited to such transformational changes in our landscapes and climate. For strategies to be effective, there is a need to revise our approach toward biodiversity conservation.

We need to start asking meaningful and sometimes challenging questions. The answers to these questions can inform a new policy position post-2017, one that acknowledges our changing climate and incorporates the values and priorities of the community.

Collaboration and thinking differently

The Nature of SA project is tackling these challenging questions directly and that the community is key. Through working with the environment sector, and as many South Australians as possible, we want to think deeply to deal with this complexity and identify the things we need to do differently.

The ambition is for a truly collaborative approach. DEWNR, PIRSA and Conservation Council SA are exploring what the new approach might look like and how to involve the broader community in biodiversity conservation. We are committed to a collaborative approach to ensure greater cross agency and industry ownership of future policy settings and strategic directions, and also shared ownership in the delivery of future strategic priorities.

An engagement process has commenced. A series of workshops have been held throughout 2015-2016. The engagement process is encouraging acceptance of the need to think differently about nature in order to respond to increasing pressures on the natural environment.

Our goal is to understand the important role nature plays in our lives, question why and how we conserve nature in SA - beyond the expert ecological view, identify new ways to help conserve our nature, and involve a wider number of people – including 'unusual suspects'.

What we are hearing so far

The key messages that are emerging from the work so fare include:

- Nature is important for our quality of life.
- Climate change challenges the 'business as usual' approach to thinking about, and managing our landscapes.
- No Species Loss was fundamentally sound as a strategy, but a new approach towards conservation and implementation is needed.
- We must challenge the critical assumptions behind why we approach things the way we currently do and test these assumptions with ecologists, policy makers, industry and the community.
- A new collaborative approach is building trust in the sector and a creating a shared vision which will have greater influence for nature conservation in SA.
- We recognise that people have very different views and understanding of nature; from a profound sense of loss of the pre-European environment through to a love of mostly altered environments reminiscent of Europe.
- Understanding community values is essential to future conservation management.
- We want to establish a framework that sets out priorities and strategies for nature conservation that enables people to act and make a difference to SA's biodiversity.
- These future strategies need to be more inspiring.

Summary

In summary, our nature is changing and there is a need to challenge current thinking such as concepts of "pre-European state" (backwards looking), saving everything (lose no species).

The Nature of SA engagement approach is working toward five outcomes:

- Creating space for innovation
- Exploring the multiplicities of genuine biodiversity futures with the community
- Changing the story to increase nature's impact in our society
- Capacity building
- Exploring and learning from models of good biodiversity management beyond the environmental sector

Thinking differently, and in a collaborative way, is intended to create shared visions for nature conservation and craft strategies that are inspiring, effective and implemented. Ultimately, we want to tap into the great potential of our leaders and community to help us ensure that future generations of South Australians will have a healthy functioning natural environment.

Evaluating the landscape structure for hydrological restoration efforts – Using airborne Lidar and high resolution aerial imaging to assess the Fleurieu Swamps

Ewenz, C.M.[1], Hacker, J.M.[1], Lieff, W.[1], McGrath, A.J.[1] and Farrington, L.[2]

[1] Airborne Research Australia,

[2] Nature Glenelg Trust,

Presenter: Cacilia Ewenz

The Fleurieu Peninsula swamps offer habitat for a variety of wildlife. Swamps also slow down the flow of water and thus increase water quality and support groundwater recharge. The restoration of hydrological systems in the Adelaide and Mount Lofty Ranges Natural Resources Management (AMLR-NRM) region is therefore an important process to retain and/or improve biodiversity in the area and improve the water resources.

The Stipiturus Conservation Park (Glenshera Swamp) in the AMLR-NRM region is located in a remnant vegetated area. In 2015 the Nature Glenelg Trust performed an assessment of the site for the Department of Environment, Water and Natural Resources (DENWR), focusing on possible hydrological restoration methods, Bachmann and Farrington (2016). One important part of the assessment was to gather information on a broad spatial scale. Remote sensing is an efficient and non-destructive way to acquire the data. As part of the assessment Airborne Research Australia carried out airborne LiDAR measurements and aerial photography in August 2015.

The results of the LiDAR data analysis and aerial photography exhibit the three dimensional structure of the landscape, e.g. slope parameters necessary for the assessment of the surface water flow in the area. However, this is only one example of many important outputs that can be produced from the LiDAR data.

What is LiDAR and what is it used for?

LiDAR stands for Light Detection and Ranging. It is a remote sensing method which uses light pulses emitted by a laser system to measure the distance between the sensing instrument and a target area, Figure 9.

The Stipiturus Conservation Park (Glenshera Swamps) - one of the Fleurieu Swamps

The study of the Fleurieu Peninsula swamps was performed in collaboration with the Nature Glenelg Trust (NGT), Bachmann and Farrington (2016). A set of very dense transects were flown over the swamps employing airborne LiDAR and aerial photography. Data processing includes geo-referencing of the data using aircraft coordinates, speed and earth coordinates. Slopes, aspect ratios as well as vegetation parameters can be evaluated. Vegetation height and density are only some of the forest parameters which can be estimated from the derived return signals.

Figure 10 exhibits the result of the LiDAR survey of the Stipiturus Conservation Park (Glenshera Swamps). The three dimensional structure of the landscape captured by the LiDAR (Figure 10 top left) in form of a digital elevation model (DEM) clearly displays aspect ratios and slopes of the surface. Hydrological models can utilise this information in order to simulate surface water flow. Cross sections through the swamps display the bare surface but also the vegetation. Dense vegetation can hide flow characteristics which are revealed by the LiDAR scan using multiple return signals to evaluate the full structure of the landscape.

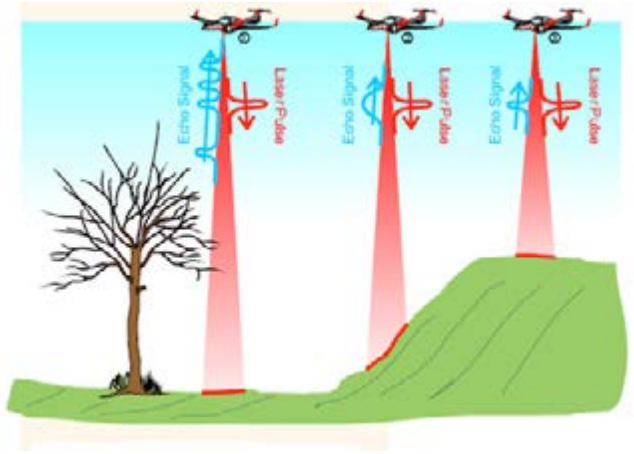

Figure 9. Echo signals resulting from different types of targets, Riegl (2012). The laser pulse will hit a variety of targets. Analysing the return signal leads to point measurements of the landscape. Accurate aircraft positioning information is utilised to retrieve a three-dimensional image of the environment.

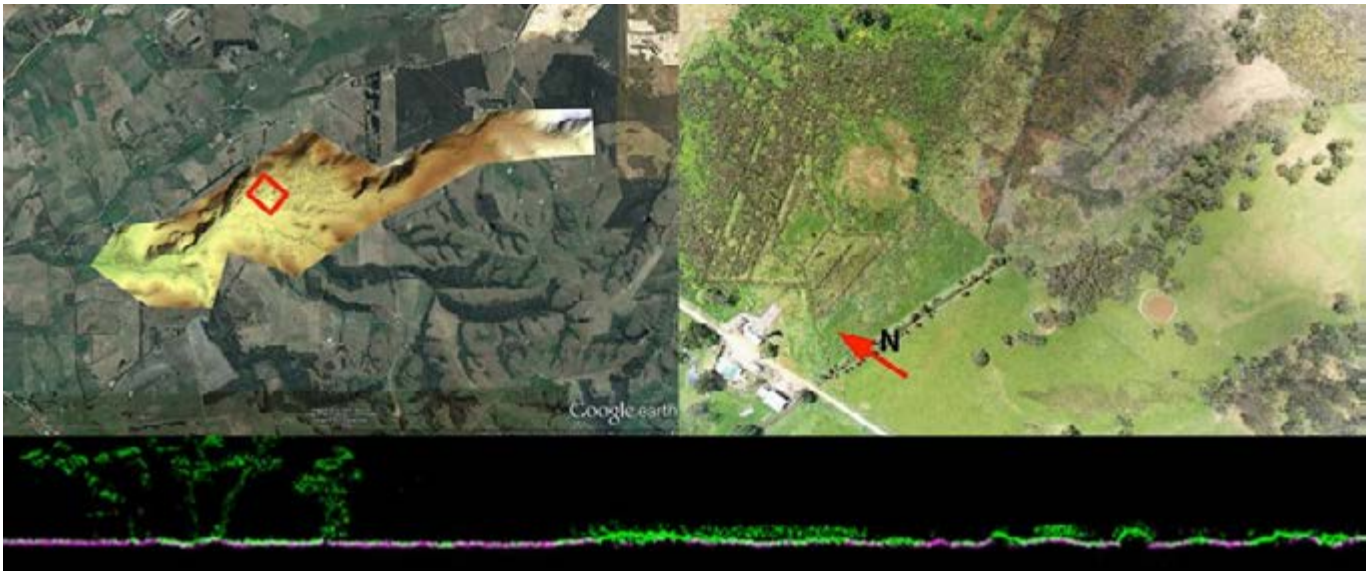

Figure 10. LiDAR Q 680i-S derived three dimensional image of Stipiturus Conservation Park, top left, LiDAR cross section bottom and Canon EOS 1D aerial photo, top right.The area photographed is shown on the top left google earth image by a red rectangle, the North direction in the photograph is displayed by a red arrow.

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Impact of fire on the reproductive success of terrestrial orchids in the Mount Lofty Ranges

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Presenter: Renate Faast

Prescribed burning has become an important factor shaping ecosystems across Australia; however impacts on key ecological interactions, such as pollination and herbivory, remain poorly understood. Terrestrial orchids are highly sensitive to disturbance and although fire can promote flowering in many species, the effect of managed fire regimes on their reproductive output is unknown. Most orchid species are strongly pollen limited, therefore increased flowering does not necessarily translate into increased seed production. In particular, orchids that depend on specific pollinators may be more susceptible to disturbance regimes than those utilising a generalist pollination strategy.

We have monitored pre- and post-fire emergence and reproductive success of spring-flowering terrestrial orchids within four prescribed burn areas and adjacent control sites in the Mount Lofty Ranges, South Australia. Pollination success, seed release and herbivory were monitored for two generalist (*Caladenia rigida*, *Glossodia major*) and two specialist species (*C. tentaculata*, *C. behrii*). We found no evidence for increased flowering following prescribed burning. However, emergence and fruit set were reduced following an autumn burn, while grazing rates increased.

In contrast, spring burning did not affect the emergence or reproductive success of *C. tentaculata*, *C. behrii* or *G. major*.

Some of our study sites were burnt in the Sampson Flat bushfires in January 2015 providing a unique opportunity to compare the impacts of prescribed burning with those of a wildfire. Initial results show that while fruit set increased at some bushfire affected sites, high levels of grazing resulted in very little or no seed release.

Technological advances to sustaining irrigation dependent communities – A partnership approach in the SA MDB region

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Presenter: Brenton Fenwick

Background

The Murray-Darling Basin is one of the most productive food and fibre regions in Australia. The region is currently undergoing significant water reform as part of the development of the

Basin Plan which aims to deliver a healthy working basin that supports communities, industry and the environment.

The South Australian Murray-Darling Basin Natural Resources Management Board is working in partnership with regional irrigation communities and the Australian Government to secure a long term sustainable future for irrigation regions and return water to the environment.

Purpose of Project/Programme

Since 2010 the SA MDB NRM Board has been acting as a regional Delivery Partner for the Australian Government funded Sustainable Rural Water Use and Infrastructure Program (SRWUIP). The SRWUIP invests in projects that support sustainable irrigation communities and that generate water savings that are shared between irrigators and the environment.

Through the On-Farm Irrigation Efficiency Program (OFIEP), Natural Resources SAMDB is contributing to increased sustainability for the region by assisting irrigators to become more efficient water users through infrastructure upgrades.

The program provides leadership and promotes new irrigation practices, technologies and management systems for the benefit of social, economic and environmental stability. It provides direction to growers about improving the precision of their irrigation distribution systems. This precision includes implementation of soil moisture monitoring, measuring evapotranspiration, improved field sensors, wireless networking, and automation and associated analysis tools. These technologies assist in understanding real time plant growth, deep drainage and uptake of salts and nitrates providing the information necessary to direct precise irrigation and fertigation.

Precision irrigation is a relatively new concept within Australia and it is suspected that no current irrigation system in this country could truly be classified as a precision irrigation system yet. A true precision irrigation system is a system that; knows what to do; how to do it; tracks what it has done and learns from it.

The high level objectives of the SRWUIP are closely aligned to the targets in the NRM Plan for the SA MDB Region and are consistent with the Board's triple bottom line approach to NRM delivery. The program has also allowed the NRM Board to build on existing partnerships with irrigation communities and actively contribute to the sustainability of the irrigation industry in the region.

Through this program, the benefits of moving towards precision irrigation are promoted and encouraged. These benefits include a system that can adapt to prevailing conditions, can be managed to achieve maximum water use efficiency, maximum yield and hence maximum profitability for the irrigator.

The outcomes of irrigation upgrades towards a more precise system extend well beyond the farm gate – creating business expansion opportunities and new jobs, helping our communities to become more resilient and our region to become more competitive.

Project/Programme Design and Methods

The SA MDB NRM Board has a long history in the delivery of irrigation efficiency extension and support services across the region through the Board's Sustainable Irrigation Program. The delivery of the SRWUIP funded projects through the Board's Sustainable Irrigation Program has provided a great opportunity to consolidate on previous sustainable irrigation outcomes.

The SRWUIP has clearly defined eligibility criteria and the Board has worked with regional irrigators to prepare technically and agronomically sound project proposals to maximise the opportunities that can be realised for irrigators and the region more broadly. The Board has also developed supporting documentation to assist potential project participants to make informed decisions about their specific project proposals in the context of program eligibility criteria.

The SA MDB NRM Board through this program, regular communication and information workshops are continually encouraging regional irrigators to consider further investment in improvements to their infrastructure towards a more Precision Irrigation system. This adoption of the latest technology by irrigators is ensuring that further research and development within the industry occurs and that return on investment is positive. Future funded projects delivered through the Board's Sustainable Irrigation Program will help drive Precision Irrigation to one day be the norm.

Findings of Project/Programme

Despite the early adoption of precision irrigation techniques in the SA MDB considerable investment has still been secured for the region through Australian Government funded initiatives such as the On-Farm Irrigation Efficiency Program (OFIEP) and the Private Irrigation Infrastructure Program for South Australia (PIIP-SA).

Since 2010 in excess of $68m has been awarded to the SA MDB NRM Board for investment in on-ground projects that improve the efficiency and productivity of irrigation water use. To date over 385 individual irrigators have worked in partnership with the Board to generate in excess of 27,500 ML of water savings and modernise an area of approximately 25,200 ha.

Conclusions and Programme Implications

Investment secured to date through the Australian Government's Sustainable Rural Water Use and Infrastructure Program in the SA MDB region will deliver significant and lasting water savings to the environment and ensure irrigators have sufficient capacity to adapt to a future with reduced water availability by moving towards a more precision orientated irrigation system.

OFIEP projects are increasing the sustainability of Riverland towns by strengthening the productivity and profitability of farm businesses and creating new jobs.

By developing a more profitable agriculture sector, we're making existing jobs in the region more secure, creating opportunities for businesses to expand and making the region more competitive.

Figure 11. Installation of sediment control structures.

The return of water to the environment ensures that we are enhancing and protecting our green assets for future generations to enjoy, whilst offering a spectacular landscape for the growing tourism sector.

The successful regional Delivery Partner model operating through the South Australian Murray-Darling Basin Natural Resources Management Board will continue to actively pursue additional funding into the future to build on the outcomes achieved to date and foster further collaboration between the irrigation industry, the community and the NRM Board.

Build it, they will come – Seabird use of an artificial sand island off metropolitan Adelaide

Flaherty, T.

Natural Resources Adelaide and Mt Lofty Ranges

Offshore of Port Adelaide, a small but significant sand island has been forming since the 1960's construction of a breakwater and subsequent deposition of dredge spoil. The now 1.6 kilometre island, stabilised by saltmarsh and other vegetation is now a significant bird colony. It provides an important breeding rookery for seabirds and waterfowl and hosts the state's largest permanent Australian Pelican colony as well as significant nest sites for endangered Fairy Tern and roosting and feeding for migratory shorebirds. Natural Resources AMLR have negotiated a memorandum of understanding between the port managers and agencies for collaborative conservation management. A biodiversity action plan has been developed and is being implemented along with on-going monitoring which has demonstrated the conservation significance of this area. This presentation will outline the values of this artificial habitat, management challenges and conservation objectives as well as the importance of monitoring to support conservation outcomes.

Shorebird use of the Samphire Coast in Gulf St Vincent.

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[3] BirdLife Australia

Presenter: Tony Flaherty

Gulf St Vincent is a significant shorebird area, recently recognised with the proposal to establish the Adelaide International Bird Sanctuary. At the peak of the summer migration season, over 25,000 birds utilise the gulf. Since 2012 Natural Resources

AMLR has been supporting the Victorian Wader Studies Group and Friends of Shorebirds South East to undertake flagging of individual shorebirds to better understand migration and use of the coast. More recently satellite transmitters have been deployed to better understand shorebird movements and use of the Gulf. A number of banded birds have since been recorded on migration in China, as they make their way from our shores through Asia to their Arctic breeding grounds. Satellite tracking has shown high site fidelity of one shorebird species, and highlighted the importance of different habitat types. A number of species also utilise large floating "islands" of seagrass wrack. This work forms part of a larger Samphire Coast Icon Project supported by the Australian Government and complements on-going NR AMLR supported work since 2008, with Birdlife Australia, to monitor shorebirds as part of the national Shorebird 2020 program. The ongoing commitment to monitor and conserve the area, along with educating people about its value has created a strong basis for the future conservation of shorebirds and their habitat. The presentation will highlight how research has been both a valuable tool for understanding shorebirds and progressing conservation management as well as providing an important communication tool for local community awareness and stewardship.

Managing Native Vegetation in Kangaroo Island's Agricultural Landscape – Successes and Challenges

Flanagan, G.

Natural Resources Kangaroo Island, Department of Environment, Water and Natural Resources Presenter: Grant Flanagan

Native vegetation is integral to life on Kangaroo Island. It provides the basis for the biodiversity that underpins our tourist industry, the KI Brand and the clean green image that gives much of the Island's produce a premium price. Over 50% of the Island's vegetation has been retained but this creates challenges as well as benefits. Some 45% of the Island's vegetation is managed by farmers within the agricultural landscape. They were early and enthusiastic adopters of Landcare, and with government assistance protected much of their native vegetation.

The presentation describes 25 years of native vegetation protection and enhancement on Kangaroo Island. It describes the improvements in native vegetation management and the pitfalls encountered along the way. It identifies the challenges ahead for agriculture in trying to meet the sometimes conflicting demands of increasing production, maintaining their resources and biodiversity assets in one of the most heavily vegetated regions of the state.

GIS data sets show the improvement in extent and connectivity and outline how the various methodologies have contributed to changing condition at the site and landscape scale. The discussion will look at how we can manage native vegetation to enhance landscape resilience and integrate with farming systems on the Island.

Fire and Water – Sampson Flat Fire effects on water quality at Millbrook Reservoir

Frizenschaf, J. and Nirmalaraja, A.

SA Water Corporation

Presenter: Jacqueline Frizenschaf

On January 2, 2015, the Sampson Flat bushfire burnt approximately 12,500 hectares in the mid and northern Mount Lofty Ranges, with 10,000 hectares of these encompassing drinking water supply catchments. The fire impacted the reservoir reserve land of Little Para (41% burnt), South Para catchment (12% burnt) and Millbrook catchment (76% of Kersbrook creek catchment and entire Millbrook reservoir reserve burnt). Bushfire events of this extent can fundamentally change catchment responses in terms of water quality. With heavy rainfall forecast immediately after the fire, SA Water installed 18 'emergency' sediment control structures to avoid slugs of sediment, rich in ash, carbon, nutrients, and metals, to be transported into the reservoir ().

This presentation highlights the approach to (1) a staged effort to prevent erosion events in the short and medium term to impact on water quality in the reservoir (up to 30+ structures and additional measures); (2) model initial risk of sediment transport to the reservoir; and to (3) assess water quality risks based on sediment, leachate and water quality analyses. A perspective will be provided linking these local assessments to other (inter-) national projects related to impacts of landscape fires on water quality (e.g., the Bushfire and Natural Hazard Cooperative Research Centre, BNHCRC, projects).

Barrage release strategy impacts on the Murray Mouth and Coorong

Fuller, J., Gibbs, M.and Eaton, J.

Department of Environment, Water and Natural Resources

Presenter: James Fuller

Changes to the natural flow regime the River Murray due to river regulation and extraction has had a strong impact the openness of the Murray Mouth and salinity and water level within the Coorong. Recent low barrage releases has led to accumulation of sediment within the Murray Mouth which led to the commencement of dredging in January 2015.

The Coorong, Lower Lakes and Murray Mouth is a RAMSAR site of national and international importance and with their health linked to objectives of the Basin Plan 2012. Increases in flow, for example from environmental water allocations, can assist with maintaining an open Mouth and reduce salinity concentrations within the Coorong. However, even within an available flow volume, the distribution and timing of flow releases through the barrages may be able to influence the sediment accumulation within the mouth and influencing salinity concentrations within the Coorong, improving the outcomes at the site within an available volume of water.

The purpose of this study is to investigate the effectiveness and interaction between the mechanisms available to control flow, and hence sediment accumulation at the Murray Mouth. These mechanisms include total flow, flow split between the barrages, and pulsing of flow releases to create larger higher peak flows with the aim of mobilising more sediment. A two dimensional hydrodynamic – sediment – wave model was developed to model flow, salinity and sediment transport processes at the site.

The devil within: the biosecurity risk of illegal pet reptiles in Australia

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Presenter: Pablo García-Díaz

Exotic reptiles have been the most common vertebrates intercepted at the border and detected on-shore in Australia during the last decade. Exotic reptiles are banned from importation into Australia for the private trade, but there is a illegal trade in reptiles that may pose a biosecurity risk if left unchecked. We evaluated the biosecurity risk posed by the illegal trade in reptiles in Australia, in terms of the likelihood of establishing a wild, self-sustaining, population. First, we constructed a predictive model to assess the factors that influence the establishment success (establishment of self-sustaining populations in the wild) of exotic reptiles in Australia. We applied our predictive model to the screening of 28 species of alien reptile species being illegally traded in Victoria, Australia. Our results indicate that reptile species released in higher propagule numbers (minimum number of release events that have happened regardless of the number of individuals released), with small body lengths and high fecundity rates are more likely to establish self-sustaining populations in Australia. Reptile species from within Australia introduced to other parts of the country outside their native range, are marginally more likely to establish than species from overseas. The risk of establishment of illegally traded species varied widely, with the highest likelihood of establishment posed by the Common snapping turtle, *Chelydra serpentina*. A whole-pathway screening found that four out of the 28 illegal reptiles are highly likely to become established if ever released in Australia (14.3%), increasing to 14 (50%) if released at moderate propagule numbers. We, therefore, confirm that the illegal trade in reptiles is a serious threat to biosecurity, and that the next reptile invader may be already within Australia. It is important to consider the risk posed by the illegal wildlife trade to prevent significant biosecurity breaches.

Botany 2016 — Past, present and future

Waite Arboretum – Past, present and future

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The Waite Arboretum was established following a bequest by pastoralist and businessman Peter Waite to The University of Adelaide. Waite's bequest, which remains one of the most generous in the history of the State, specified that the western half of his estate be held in perpetuity as a park or garden for the enjoyment of the public. The protection provided by the Waite Trust enables long-term testing of species for suitability to the climate of Adelaide and indeed much of settled south-eastern Australia.

Planting began in 1928 and from the outset good records were kept. In 1961 a pivotal decision was made by the then Curator, Dr David Symon, not to water the trees after establishment. New material was then sourced with a focus on homoclimes. The collection currently occupies 28 hectares comprising 2,400 specimens from around the world representing over 1,000 taxa. Evaluation of specimens performing well for up to 55 years on rainfall alone is becoming increasingly valuable and points the way to more sustainable species selection for our urban forests of the future.

This presentation will trace the development of the Waite Arboretum from Peter Waite's visionary bequest, through evolving collection policies and expanding educational roles, to the digital age making the information embodied in this significant collection available to the widest possible audience.

Three years of environmental flows in the South Para, Torrens and Onkaparinga Rivers

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Presenter: Steve Gatti

On 20 October 2005, the Minister for Sustainability, Environment and Conservation prescribed the surface water, watercourses and underground water resources of the Western Mount Lofty Ranges (WMLR). The process of prescription triggered the development of the WMLR Water Allocation Plan which included formal arrangements for environmental water provisions in the South Para, Torrens and Onkaparinga Rivers. The environmental water is supplied from SA Water infrastructure and is incorporated into SA Water's WMLR water extraction licence. An environmental flows trial commenced from 1 January 2012 to determine the efficacy of planned environmental water releases in achieving specified outcomes for the aquatic ecosystems in each of the river systems.

The field component of the trial ceased on 31 December 2014, however environmental flows have continued as part of SA Water's licence. The outcomes of the 3 year trial have been evaluated in terms of impacts on physical aquatic habitat, vegetation, macroinvertebrates and fish along 4 river reaches, these being:

- South Para River, Barossa Diversion Weir to Gawler;
- River Torrens, Gumeracha Weir to Kangaroo Creek Reservoir;
- River Torrens, Gorge Weir to Adelaide city; and
- Onkaparinga River, Clarendon Weir to the Onkaparinga River estuary.

The environmental flows regime for the four river reaches was designed following considerable investigations undertaken between 1999 and 2005, and in consideration of the critical function of the river catchments in urban water supply. The environmental flows regime and overall intended outcome of the trial was to:

1. deliver a flow regime that maximises the probability of achieving self-sustaining populations of biota that currently exist within the area, and
2. determine local environmental objectives and release patterns that best achieve self-sustaining populations of biota.

These broad outcomes were developed into hypotheses against which testing of achievement against expected responses could be measured.

Monitoring was based around the water releases and focussed on physical habitat, vegetation, macroinvertebrate and fish indicators as well as opportunistic field observations. Evaluation of this monitoring data was based on achievement of outcomes as well as testing whether observations matched those expected in the objectives and hypotheses.

The three year environmental flows trial partially achieved its intended outcomes and hypothesised responses. Environmental flow regimes that enhanced the probability of self-sustaining populations of some of the existing biota were achieved but not all the target populations were enhanced nor were all of the reach-specific objectives met in the first three years.

Significant changes in plant communities at the reach level were driven by changes in annual species. Provision of environmental flows alone were not sufficient to change long-lived plant communities along the trial reaches because the flows did not scour the channel and the current in-channel vegetation was well established. There was also evidence from the plant communities that the South Para, Onkaparinga and River Torrens Gumeracha Weir reaches were trending towards drier states, with more extensive reed beds and terrestrial vegetation rather than towards more complex and diverse plant communities with 'wetter' functional groups. South Para is the most at risk of some parts of the reach converting to 'drier' emergent and terrestrial habitats due to it being in a drier catchment.

The most significant environmental drivers of macroinvertebrate communities across all sites combined were temperature, specific conductivity (salinity), algae and bedrock. Accumulated flow and the number of riffle days were significant in the Onkaparinga, River Torrens Gumeracha Weir and South Para reaches. Water temperature and/or season appear to be key drivers of abundances in the presence of adequate flow.

Increases in the diversity of riffle-depenent macroinvertebrates were observed with the onset and maintenance of environmental flows in the Onkaparinga and South Para River reaches, however, this was not as evident in the River Torrens reaches. The macroinvertebrate communities appear to be resilient to the variable hydrological conditions observed throughout the trial, as a result of the adaptations evolved over time to increasingly ephemeral river conditions.

The delivery of environmental releases during the trial period, especially in summer and autumn, enabled partial achievement of the fish objectives. There was some evidence of a shift towards native fish and away from exotic species, especially in the Onkaparinga and River Torrens Gumeracha Weir reaches. However, increased flow corresponded to a higher rate of disease (parasites) across a broad range of species.

Eastern gambusia and gudgeons decreased in abundance with higher flows and galaxias increased with higher flows. This was as expected based on the hypotheses except that the gudgeons were expected to show no effect. Changes in the abundance of these species were the first and largest response in the fish community to increasing flows. There was also evidence that Common galaxias and Mountain galaxias dispersed with increased flows, which met the outcomes and reach-specific objectives.

Changes in flow in the trial period caused seasonal changes in fish communities but these effects did not persist throughout the year, which may mean that the trial has started a change that has not yet established or that the fish are not going to respond as expected over the longer term.

The outcomes of the environmental flows trial are currently being used to review environmental water provisions within the South Para, Torrens and Onkaparinga Rivers. This may result in changes to the timing, frequency, duration or volume of environmental flows for improved ecological outcomes.

Aquatic macroinvertebrate community development in riffle habitats with onset of flow

Giglio, S.

Australian Water Quality Centre Presenter: Sonia Giglio

Assessment of macroinvertebrate community responses to environmental water provisions (EWPs) was one component of the Environmental Flow Trials in the Western Mount Lofty Ranges monitoring program, managed by the Department of Environment, Water and Natural Resources (DEWNR). During the three-year trial period, between January 2012 and December 2014, monitoring was focused on addressing a number of predicted ecological responses of macroinvertebrates to EWPs, particularly in communities occurring in riffle habitat (to the exclusion of those occurring in edge or still-water habitat). The rationale behind focussing on riffle habitat and associated taxa was based on the knowledge that these environments are most constrained by flow reduction, and hence are most responsive to change associated with the addition and/or subtraction of flows within the reaches studied. Additionally, riffle dependent taxa (RDT) are generally more sensitive, with more specific habitat and survival requirements than taxa residing in predominately still-water. One expected ecological response in particular will be the focus of this presentation, that being:

The diversity of RDT will increase with onset and maintenance of flows and highest diversity will be achieved in the "spring" (October-December) season.

This expected response was supported initially by a 'succession sequence' hypothesis whereby a succession of species would occur over time (i.e. advancement in stages from prey to predator-prey communities). This potential response was regarded positively given more diverse communities are generally considered to be reflective of healthier environmental conditions and are more resilient to short-term disturbance. This hypothesis was however unsupported by the first year's data with the appearance of unexpected functional groups relatively early in the development of riffle habitat being detected, including predators and pupae. This led to a revised 'riffle development pathways' hypothesis, which does not indicate a community progression in stages, but rather that the end-of-season proportions of riffle dependant taxa (RDT) and still-water taxa are influenced by the riffle start-point being in a "wet" or "dry" state.

An overall increasing trend in RDT richness was evident in the Onkaparinga and South Para reaches, but not as evident in the Torrens River reaches. General support from this trial for the 'riffle development pathways' concept has increased understanding of the development of riffle habitat with the onset of flow, and was useful in explaining predicted changes to RDT from the point of riffle creation. It also highlights the importance of dry-weather flow through riffles driven by groundwater, in sustaining macroinvertebrate communities.

Seascape genetics for shark management: an innovation in sustainable fisheries modeling

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Presenter: Bronwyn Gillanders

Harvesting marine resources can reduce the abundance of target species, alter the complexity of food webs and reduce the number of trophic levels present in marine ecosystems. Species particularly at risk of overexploitation are those that are highly valued, slow to mature and have sporadic or low recruitment – traits typical of sharks. Estimates of regional life history characteristics and knowledge of population structure at different spatial scales are necessary to optimise and ensure accuracy of fisheries models, but are lacking for many shark species. We used two approaches, single nucleotide polymorphisms (SNPs) and multi-element vertebral profiles to quantify population structure of two highly mobile and commercially fished shark species: bronze whaler (*Carcharhinus brachyurus*) and dusky shark (*C. obscurus*). Several population structure hypotheses and the signal consistency across neutral versus candidate loci were tested using thousands of SNPs obtained through complexity-reduction genome sequencing. We found that *C. obscurus* was panmictic within Australasia and across the Indian Ocean to South Africa for all marker types. For *C. brachyurus*, the westernmost Australian samples were separated based on neutral loci, whereas the Australian east coast samples were different from the rest of Australia and New Zealand based on candidate loci. Both species showed different patterns of population sub-structure, or lack thereof, confirming the importance of studying each target species independently instead of assuming commonality among closely related species with similar dispersal abilities. For bronze whaler sharks we quantified multi-element vertebral profiles of individuals collected from three regions throughout South Australia using laser ablation-inductively coupled plasma mass spectrometry. We used multiple approaches to account for and address seasonal and lifetime rates of element incorporation. Boosted regression trees showed that variability in multi-element concentrations at the vertebral edge (representative of the time at capture) was explained primarily by spatial and ontogenetic differences. An integrated lifetime elemental signal indicated ontogenetic, but few spatial, differences in patterns of movement. Cluster analyses of the elemental profiles across vertebrae indicated that patterns of movement were highly individualistic, with few length- or sex-based trends evident, reflecting the migratory behaviour of this cosmopolitan species. These results along with demographic information will be used in a population model to estimate harvest limits. Overall, our results showed evidence of

connectivity across the regions sampled using both molecular and vertebrae chemistry approaches, suggesting that fisheries targeting these species should consider the cumulative effects of fishing and the potential need for cross-jurisdictional management.

Native vegetation & invertebrates: landscape-scale provision of ecosystem services

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Presenter: Richard Glatz

Over the previous decade there has been increasing scientific focus on understanding and ascribing value to the full range of benefits provided to humans by the environment. These benefits have become known as Ecosystem Services (ES). While ES have long been known to exist, a broadly accepted conceptual framework of ES was not well developed until relatively recently and the ability to account for ES in environment or economic management has remained elusive. A range of collaborative groups has been established to grapple with these issues. At the same time there is a trend towards development of NRM plans that aim to manage resources at landscape scale, and this implies consideration of how to deliver ES across a landscape.

Native vegetation is one of the most obvious land management targets and is associated with a range of ES such as:

1. agricultural pest/weed management
2. agricultural biosecurity
3. pollination of crops and native vegetation
4. increasing/maintaining landscape adaptive capacity and resilience
5. biodiversity maintenance/habitat provision
6. salinity prevention/mitigation
7. tourism/marketing/'clean & green' image
8. social/community benefits

By contrast, invertebrates are rarely considered in management plans despite comprising over 90% of the terrestrial animal diversity. Furthermore, invertebrates are equally dominant with regard to their functional significance and the many interactions between native vegetation and invertebrates play a large role in the top five ES listed above. Understanding the close associations between invertebrates and plants could provide a capacity to increase these ES at a landscape level, if clear vegetation management options are available. Here, I discuss the role that invertebrate-vegetation interactions play in these ES and some of the associated mechanisms. This is discussed in the context of developing vegetation management options to deliver improved ES across a landscape.

Challenges targeting potable groundwater in the APY Lands, South Australia

Gogoll, M.

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Michael.Gogoll@sa.gov.au Presenter: Michael Gogoll

Water supply in the arid APY Lands of South Australia has been a concern since the establishment of cattle stations, such as Ernabella Station in 1935. Despite best efforts, finding a large sustainable sedimentary alluvial aquifer within the APY Lands has not occurred in over 60 years of water exploration. The scarcity of alluvial groundwater sources and shortfalls of previous drilling campaigns led the project team to target fractured basement groundwater with the aim of accessing more sustainable supply than has been located previously.

Challenges encountered during targeting were: compartmentalized aquifers, low sporadic rainfall/recharge, average annual evaporation exceeding 3500mm (Watt, 2011), highly variable groundwater salinity, varying alluvial aquifers depths, high level of structurally deformity, sparse existing drill hole data, limited subsurface geological knowledge and broad interpretation of faults (zone of 100–200 m rather than ~1–5 m required).

Airborne geophysical data sets were considered the best available method for targeting undercover fractured basement groundwater. Reviews of the geophysical datasets obtained by the Geological Survey of South Australia and the CSIRO Goyder Institute gave valuable insight into the underlying geological and structural setting of the Musgrave Ranges and alluvial plains to the south. Several large (regional scale) structures/faults were identified as potential sources of sustainable fractured basement aquifers, such as the Woodroffe Thrust, Ferdinand Fault and Mann Fault. Areas of significant structural features coincidental with drainage and an increased thickness of alluvial sediments were prioritised for drilling.

Drilling results highlighted the ability to target fractured basement through geophysical methods, and the capacity of fractured basement to deliver large supplies of groundwater over short term pumping. Well 5345-162 north of Pukatja yielded 9L/sec and pumping test data indicated a response consistent with radial flow rather than fractured flow over the short term. It is also worth noting that interpretation of geophysical data (aimed at targeting of fractured basement) led to the discovery of water bearing alluvial sediments at much greater depths than expected.

Reference

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Mixed fortunes: contrasting status, trends in abundance and management issues for South Australian pinnipeds

Goldsworthy, S.D.[1], Shaughnessy, P.[1,2], Mackay, A.I.[1] and Bailleul, F.

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Presenter: Simon Goldsworthy

Pinnipeds in southern Australia were subject to unrestricted sealing in the early 1800s from which they have yet to recover. Censuses of pup abundance have recently been undertaken throughout South Australia (SA) for long-nosed and Australian fur seals, and for Australian sea lions. Results from these, in conjunction with data from long-term monitoring sites, indicate that pup production in the long-nosed fur seal has increased 3.5 fold over the last 24 years and now number ~20,400. Australian fur seals have recently colonised SA, with breeding first recognised in 2007. Pup production has increased steadily and was estimated to be 85 in 2014, with the species now recorded to breed at four sites in SA. Australian sea lions are unusual for having a non-annual (~18 month) breeding interval and an asynchronous breeding habit. Pup production per breeding cycle is estimated to number ~2,500 in SA. Comparison with earlier surveys indicate that pup abundance at most breeding sites (82%) has declined. The overall rate of decline was 2.9% per year, or 4.4% per breeding cycle, but varied considerably between sites and regions. Following IUCN Redlist assessment methods, the estimated change in pup abundance over three generations (38 years) assuming a constant exponential rate of change was -78.2%, indicating that the ASL population in SA meets the 'Endangered' threatened species category (decline ≥50% and ≤80%). Continued interactions with human activities and differences in life-history traits appear to account for the contrasting status and management issues for fur seal and sea lion populations in SA. For fur seals, there is now growing concern from the seafood (wild fisheries, finfish aquaculture) and some ecotourism (little penguins) industries that populations are overabundant and that their impacts need to be managed. To address these perceptions, projects are currently underway to investigate the importance of commercial fish and finfish aquaculture species in fur seal diet, and develop trophic models to assess the impact of consumption on current and future seafood production. For sea lions, the major threatening process most likely limiting their recovery is incidental bycatch mortality, especially in demersal gillnet fisheries. Management measures to mitigate bycatch have been introduced into the fishery since 2010 and include electronic monitoring programs, spatial closures, and bycatch trigger limits. Logbook data reports on ASL interactions suggest these measures have resulted in a reduction in bycatch in that fishery, with two mortalities reported since 2012. Considering the life history of the species, it may take decades to detect the effectiveness of these measures in the recovery of the species.

Mound spring conceptualisation and holistic models

Gotch, T. and Keppel, M.

Department of Environment, Water and Natural Resources

Presenter: Travis Gotch

The South Australian mound springs are iconic elements of the outback. Continuously discharging water for in excess of 1 million years they have created a refuge of stability in an ever-changing environment. As a consequence they are perhaps the most biodiverse environments per square metre in South Australia and have a complex and detailed cultural history for both Aboriginal and non-Aboriginal Australia. While there are mound springs in other states, with few exceptions they have not been around for as long, or approach the levels of endemism that are present in the SA springs. Intrinsically linked to the Great Artesian Basin (GAB) the health of the springs and the ecosystems they support are totally dependent on the good management of the GAB water resource.

To allow for sustainable use of the GAB requires an understanding of the springs that extends beyond just hydrogeological parameters. The different types of springs do not respond similarly to changes in water pressure and consequently flow. Equally the cumulative impacts of other stressors on springs such as grazing and sulphation need to be included so that the impacts of changes in groundwater pressure can be better understood to minimise the chance of spring extinction.

Recent investigations have been undertaken to address these issues as part of the National Partnership Agreement on Coal and Coal Seam Gas Lake Eyre Basin Springs Assessment (LEBSA). We will present some of the outcomes of this work including the spring models, types and evidence base tables and discuss the management implications of this work on future developments in the GAB.

New methodology for assessing risk posed to water dependent ecosystems due to altered flow regimes

Green, D.and Maxwell, S.

Science, Monitoring & Knowledge, Department of Environment, Water and Natural Resources

Presenter: Douglas Green

The effective management of water resources requires the balancing of the differing needs of industry, society and the environment, ensuring that ecological communities are protected while providing industry and society with appropriate resources. The over-arching ecological objective for water allocation planning is to maintain the current ecological community, improve it if possible. In the past the ecological risk posed by different water resource management options has been reliant on expert opinion to underpin decisions leading to increased uncertainty. We propose

using response models developed for key aquatic biotic groups, along with modelled flow data from different management options to underpin an empirical method for assessing the risk posed to aquatic ecosystems. We will be able to quantify measures for the maintenance of current condition as well as a measure of improvement for individual management scenarios. This work will provided managers with a transparent, empirical process that they can use to assess risk to ecological systems which directly links back to the overarching ecological objective.

Evaluating the implementation of a water allocation plan in the Mount Lofty Ranges, South Australia

Greenwood, A. and Savadamuthu, K.

Science, Monitoring & Knowledge, Department of Environment, Water and Natural Resources

Presenter: Ashley Greenwood

The water resources of the South Australian Mount Lofty Ranges became subject to water allocation plans (WAPs) in 2013. WAPs aim to protect water resources for all users including the environment, and provide greater certainty for water users now and into the future. Management actions include securing ecologically significant low-flows and ensuring water allocations are sustainable in the face of changing water availability. Implementation commenced in 2014, a process which includes evaluating WAP effectiveness and that its objectives are met. A number of condition indicators have been developed to provide a basis for WAP evaluation. Certainty of water availability will be evaluated by monitoring significant variation in rainfall-runoff relationships underpinning WAPs, requiring the development of an assessment approach which takes into account hydroclimatic drivers. While such assessments are well-represented in research they are yet to find routine application in statutory water management planning. This paper demonstrates how this may be done in the Mount Lofty Ranges, a region important for high-value irrigated horticulture, including premium wine production. The region's water resources are limited, highly variable and at risk of change under the impacts of climate change. Assessments of hydrological change draw on concepts that integrate regional climatic drivers and significant catchment-scale processes, particularly surface-groundwater interactions, germane to both the stability of rainfall-runoff relationships and other management prescriptions such as securing low flows. Fundamental to the success of this work is the recognition of the need to confront the immediate realities of changing water availability, widely regarded as a future threat but not addressed in quantitive terms in a policy context.

Investigating the molecular basis of echidna biology for application in conservation, wildlife management and habitat monitoring

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Presenter: Frank Grützner

The iconic short-beaked echidna belongs to the extraordinary order of egg-laying mammals which are an integral part of the most diverse habitats all over Australia including urban, agricultural and revegetated areas. Their wide distribution and ability to adapt to diverse environments makes echidnas a key indicator species of environmental change, habitat degradation and fragmentation.

Many aspects of echidna biology are still being explored and documented. Tools generated from the studies of the planets oldest surviving mammal provide sound assessment and monitoring techniques to address important issues regarding echidna conservation management. Understanding this species biology and ecology will further our insight into climate change adaptation and new technological advances are providing the additional necessary knowledge base.

Over the past ten years there has been a surge in molecular information in particular for the platypus, the other egg-laying mammal, providing unprecedented insights into the molecular basis of their biology. Importantly such data are now being generated for echidna on a large scale. It is timely to harness the information of both monotremes and to develop molecular approaches to investigate fundamental aspects of echidna biology to unravel their remarkable ability to adapt to a changing environment.

In this project we aim to bring together interdisciplinary research groups (molecular biology, field ecology, veterinary science) and stakeholders (Zoos, NRMs, conservation groups and landowners) to tackle important questions in echidna biology and to apply this research to conservation management, breeding strategies and climate change adaptations. The comparison of genetic diversity, diet, immune system and reproduction in different wild and captive populations will establish a novel knowledge base to reveal the molecular basis of echidna biology and inform conservation and management strategies. Importantly this will produce new innovative tools for use of echidnas as powerful indicators of environmental change (e.g. through monitoring movements of individual echidnas and analysing the invertebrates consumed) of natural, urban or agricultural environments.

Response of Adelaide City electricity consumption to outdoor weather in summer

Guan, H.

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Presenter: Huade Guan

Cooling energy consumption is a large component of electricity consumption in summer. With a warming climate, summer electricity consumption and peak demand increase. This situation is exacerbated by the urban heat island intensity. Knowledge of the response of electricity consumption to outdoor weather is important to guide electricity planning and management in summer. This study, based on the Adelaide Central Business District (CBD), investigates the weather dependence of electricity consumption. The results indicate that the electricity consumption of the Adelaide CBD increases with mean daytime temperature when it is warmer than 17 degrees. The electricity consumption is also sensitive to the residual temperature (defined as the difference between air temperature of the previous day and the current day). At the CBD scale, electricity consumption is insensitive to specific humidity. These results provide useful information to predict electricity consumption and peak demand in Adelaide CBD for better planning and management in hot summer and during heat waves. This information is also useful to achieve a carbon-neutral Adelaide.

Centres of plant biodiversity in South Australia

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Presenter: Greg Guerin

We examined regional patterns of plant biodiversity across South Australia using a large compiled dataset of species records. We identified six centres of high plant biodiversity: Western Kangaroo Island; Southern Mount Lofty Ranges; Anangu Pitjantjatjara Yankunytjatjara lands; Southern Flinders Ranges; Southern Eyre Peninsula; Lower South East. The data were also used to investigate how sensitive species composition is to changes in climate, based on spatial models, and we found that the arid-mediterranean ecotone is the most sensitive. While locations with important plant biodiversity in the state are already recognised, the hallmark of this study was the use of numerical, objective and repeatable methods and metrics highlighting different aspects of biodiversity and conservation importance, such as phylogenetic endemism, without reliance upon expert opinion. The project resulted from partnership between The University of Adelaide, Department of Environment, Water and Natural Resources and the Terrestrial Ecosystem Research Network.

Projected climate change implications for the South Australian flora

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Presenter: Greg Guerin

South Australia has experienced a significant warming trend of approximately one degree since 1950, and steady increases in sea surface temperatures since around 1900. Climate forecasts suggest that over the course of this century, the state will experience in the order of two degrees of warming and a ten percent decrease in rainfall over a 1986–2005 baseline, with relatively more heating but less drying over northern regions. Predicted rainfall decreases will also lead to increased solar radiation due to lower cloud cover.

We explore the implications of observed and projected climatic warming and drying on the flora of South Australia, from physiological and morphological consequences for individual species to regional-scale predictions of changes to biodiversity. The South Australian flora is about 10% endemic, with plant biodiversity (measured according to various metrics) concentrated within six localised centres (Western Kangaroo Island; Southern Mount Lofty Ranges; Anangu Pitjantjatjara Yankunytjatjara lands; Southern Flinders Ranges; Southern Eyre Peninsula; Lower South East).

Community assembly provides a general context for understanding climate change influences on the flora. It can be visualised as a set of environmental filters operating on a regional pool of available species. At the scale of a habitat patch, species that have passed through these filters are capable of survival and may disperse to the patch and interact with other species, resulting in particular patterns of composition and relative abundance. Climate change filters the species that are able to survive in a given location, directly via mechanisms such as altered mortality or recruitment rates, and indirectly, for example through changes to fire regimes. Modest changes to community level ecophysiological constraints (such as photosynthetic rates and water balance) can be absorbed within an ecosystem through mechanisms such as morphological shifts and changes to relative abundance. Eventually, though, there will be species turnover to meet newly imposed constraints.

A range of empirical studies have been undertaken to measure climate effects on South Australian plant species and biodiversity. For example, in the Hopbush, *Dodonaea viscosa*, plants in more northern locations have leaves that are narrower but with higher stomatal densities. This indicates adaptation for higher temperatures, because narrower leaves are better for convective heat loss while dense stomata can be used for rapid evaporative cooling or short periods of rapid growth when moisture is available. Indeed, leaves of this species have been shown to have become narrower in conjunction with climatic warming in South Australia, matching predictions from the spatial cline in leaf width with

maximum temperatures. Genomic sequencing across 970 genes has revealed significant genetic correlations with temperature and aridity, suggesting selection on functional genes including those linked to variation in stomata and leaf shape. Similar stories are emerging across multiple individual species throughout the Mount Lofty and Flinders Ranges. The ratio of stable carbon isotopes in leaves, which can be used to infer water stress, show similar trends across more than 100 tested species, with a general pattern of increasing stress (i.e. more positive δ13C) at locations with lower rainfall, demonstrating ecophysiologically important climatic differences between populations.

At regional level, there is good evidence that plant community composition is sensitive to changes in climate of the magnitude experienced in South Australia and projected in the future. In fact, temperature increases in the order of those projected would, according to model predictions, drive complete turnover in species composition at particular sites. Quantitative field data has further demonstrated that there are climate-related patterns in key community metrics such as species richness. One such pattern is a trend towards more uneven allocation of biomass among species with decreasing rainfall, leading to lower diversity and altered ecosystem processes generally. Spatial climate sensitivity analysis at regional and state level has highlighted a major climatic transition zone between the Desert and Mediterranean Biomes of South Australia where community composition changes more rapidly with climate, along with shifts in family-level composition and vegetation structure. This ecotone is expected to be the most vulnerable to climate change, although resilience is a function of other landscape stressors and not just climate sensitivity *per se*. Of the six biodiversity centres in the state, the southern Flinders Ranges has been identified as the most climate sensitive.

In summary, we can expect climate change to influence the ecophysiology of individual plants and species, leading to changes in patterns of primary productivity and water stress. Beyond the limits of evolutionary adaptation, which are still being explored, significant climate change in South Australia is predicted to ultimately lead to lower species richness, altered species composition and higher biomass appropriation by dominant species via differential performance in processes such as mortality, recruitment and growth. The Desert–Mediterranean ecotone and landscapes with lowered resilience may be the most at risk. A network of field plots known as TREND has been established along the Adelaide Geosyncline by the Terrestrial Ecosystem Research Network to monitor changes in plant biodiversity due to climate change and validate spatial models of climate sensitivity. Early data include baselines for vegetation composition and structure plus subsequent measures of variability due to seasonal differences and time since fire.

We have a good empirical understanding South Australian plant communities and their sensitivity to climate change. However, we need to be more sophisticated in our approach to forecasting the ecological impacts of climate change because there are complex interactions between biodiversity, biomass, fire, habitat fragmentation and evolutionary adaptation. With a range of information from empirical studies, modelling, monitoring data and spatial information, we are now in a position to develop process-based landscape models that can project ecological constraints and diversity under a range of future climate and management scenarios.

Botany 2016 — Past, present and future

Seed conservation for South Australia

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Presenter: Jenny Guerin

The South Australian Seed Conservation Centre was established in 2003 with the purpose of safeguarding South Australia's threatened flora through seed collection, seed banking and research. To date we have collected seed from 71% of state listed plants and the aim is to conserve up to 90% of threatened plant species by 2021. The field work undertaken for this program has provided new information on the distribution and habitat of plant populations. Curation of the seed collections includes the assessment of seed viability, dormancy and germination requirements. The study of seed biology is integral to seed banking and contributes to knowledge required for successful species recovery and restoration of plant communities. Information, gathered throughout this program is being compiled into a website (www.saseedbank.com.au) focussed on seeds and plants of native species and their use in seed based in situ conservation.

Long-term revegetation success using a Kimseed Camel Pitter and Rangeland Contour Seeder in the central Flinders Ranges

Haby, N.

Presenter: Nerissa Haby

Natural Resources South Australian Arid Lands, Department of Environment, Water and Natural Resources

A history of overgrazing has caused the decline and loss of palatable species from areas within the Flinders Ranges National Park. To increase recruitment nine species were direct-seeded at five degraded sites, defined by bare (scalded) soil, high weed cover and proximity to erosion gullies, in 2004. To investigate revegetation success using a Kimseed Camel Pitter and Rangeland Contour Seeder after 10 years, at each of the five sites, ten 10 x 4m quadrats were randomly positioned over contour rip and camel pit lines. The species, maximum diameter, and demographic phase for each plant were recorded within the 'hump', 'dip', and 'flat' microtopographic zones. One-way ANOVAs and Tukey multiple comparison tests were used to compare i) the response of species groups,

species, and demographic phases of abundant species across microtopographic zones, and ii) species groups between methods. A total of 57 species were detected, including seven of the nine direct-seeded, and naturally occurring, species. Direct-seeded plants had survived on the 'hump', but recruitment was greater in the 'dip', and also present on the 'flat'. Wild species had also recruited on the 'hump', and to a greater degree in the 'dip' (i.e. perennial and annual species). The response of individual species varied, but supported increased abundance and relative cover (*Acacia victoriae* ssp. *victoriae*, *Atriplex vesicaria*), or relative abundance (*Maireana pyramidata*, *Atriplex stipitata*), in the 'dip'. Across demographic phases, a greater abundance of seedlings occurred in the 'hump' (*A. vesicaria*, *Maireana georgei/turbinata*, *M. pyramidata*, *Enchylaena tomentosa*, *Sida fibulata*), but relative cover was higher in the 'dip' (*A. vesicaria*, *M. pyramidata*, *S. fibulata*). Alternatively, reproductive *A. stipitata* had greater relative cover on the 'flat'. Across methods (Site 3 only), contour rips supported a higher abundance and relative cover of perennial species (and relative cover for *A. vesicaria*). After 10 years the contour rips continue to influence recruitment by providing opportunity for germination on the 'hump', and a more favourable micro-climate and seed trap for growth and survival in the 'dip' (e.g. perennial species).

Small mammal and reptile response to a 15-year old integrated management program in a semi-arid environment

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Natural Resources South Australian Arid Lands, Department of Environment, Water and Natural Resources

Presenter: Nerissa Haby

Prolonged unsustainable grazing regimes in the past, combined with the invasion of introduced herbivores and predators, has degraded communities in the semi-arid central and northern Flinders Ranges, South Australia. To improve the capacity of the landscape to support native species, multiple, integrated pest control and monitoring programs were activated under 'Bounceback'. To track the response of small mammals and reptiles to the removal of a regulated grazing regime (cattle and sheep) and rabbit control, eight monitoring webs were surveyed between 1997 and 2011. Fine-scale environmental composition varied between webs, leading to the data being stratified before testing for differences in species richness between areas using univariate statistics (ANOVA). Additional generalised linear mixed effect models were used to explore drivers of species-specific responses. Preliminary results identified greater species richness in ungrazed (cattle, sheep) low and tall shrub vegetation on sloping loamy soils, and tall shrubs on sloping and flat sandy soils, or in areas of rabbit control in low shrubs in ephemeral creeks. In contrast, more species were detected in areas under a grazing regime in low and tall shrubs on flat topography, and tall shrubs in ephemeral creeks. Mixed support for increased small mammal and reptile richness in response to reduced herbivory by introduced species highlights the need to consider the contribution of native herbivores to total grazing pressure in a semi-arid environment, and an appropriate scale to sample environmental change as well as species' responses, when designing a monitoring program.

Putting a price on stocking rates conducive to *Eucalyptus coolabah* recruitment

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Presenter: Nerissa Haby

Coolibah survival is dependent on available soil water moisture in every stage of its life cycle, which may limit any opportunity to increase recruitment via stock management in a dynamic, arid system. This investigation aimed to determine: i) how stocking rates relate to coolibah browse, and ii) useful indicator species for monitoring grazing levels conducive for coolibah growth. Sites were surveyed three- and four-years into a dry phase across a range of stocking densities. Recommended stocking densities were estimated using generalised linear models (GLM), correlations between impact indices and understorey composition explored using nonmetric multidimensional scaling (NMS), and monitoring species identified using indicator species analysis (ISA).

The maximum recommended stocking density was 0.91 cows km^{-2} or 0.88 cows km^{-2}, three- or four-years into a dry phase (based on a hypothetical policy threshold of 15% coolibah browse). This infers reducing current stocking densities by 0.81 or 0.14 cows km^{-2}. To negate a possible loss in profit, an incentive should exceed $27.56 or 4.76 km^{-2} (based on 15% profit of the current market price of a heavy steer). Indices of coolibah browse by cattle and rabbits were correlated with changes in understorey composition (NMS axes $r^2<0.42$), leading to 22 species being identified for a monitoring program (ISA IV 60.0–100.0, $P<0.05$), including: *Eragrostis* spp. *Salsola australis*, *Sclerolaena intricata*, and *S. diacantha*. The local stocking rate index was positively correlated with variability in understorey composition (i.e. increased scatter in NMS ordination space), and negatively correlated with rabbit browse on coolibah.

Overall, this incentive may increase confidence in pastoralists to reduce floodplain stocking densities earlier than is currently practiced, and subsequently alleviate herbivory on coolibah and slow the loss of understorey into a dry phase. However, this incentive should be implemented with rabbit control and restricted access to congregation areas suitable for coolibah recruitment.

How do bush fires change our landscape – using airborne Lidar to assess the fire signature of the Sampson Flat Fire

Hacker, J.M., Ewenz, C.M., McGrath, A.J. and Lieff, W.

Airborne Research Australia

Presenter: Jorg Hacker

Areas affected by wildfires have occasionally been surveyed by airborne LiDAR, but there are only very few cases, where such areas – by coincidence – had also been surveyed using identical technology before the wildfire changed them. Between 2nd and 5th of January 2015, the Sampson Flat Fire affected approximately 20,000 ha of land in the Adelaide Hills, including large areas of natural and plantation forest. A small area of natural forest near Gumeracha had repeatedly been surveyed using high-resolution airborne LiDAR before the fire and twice more afterwards. This enabled an analysis of the forest structure before and after the fire. Here we are presenting first results from an analysis of airborne lidar and hyperspectral data from this area before and after the fire.

So far airborne lidar data has been analysed from 6th Nov 2013 and 25th Jan 2015, ie. 13 months before the fire and less than 1 month afterwards, respectively. 0.5 m pixel size airborne hyperspectral was available from 28th Jan 2015, also less than 1 month after the fire. More data is available and is awaiting to be added to the analysis.

The lidar data was collected using a Riegl Q560/240 (6/11/2013) and a Q680i-S (25/1/2015) high resolution full waveform resolving small footprint scanner; the hyperspectral data was collected using a SPECIM EAGLE II scanner. All of these sensors plus ancillary sensors were flown on one of ARA's small ECO-Dimona research aircraft. The area covered is a small bush block (~20 ha) near Gumeracha shown in the left panel of Figure 12. The image is taken from Google Earth (date 5 Jan 2015); the white rectangle shows the area analysed (360 m x 580 m), the purple polygon encircles the area affected by fire as determined from the hyperspectral image shown in the right panel of Figure 12 (~2.2 ha).

Figure 13 shows lidar data before (6/11/13) and after (25/1/15) the fire. Data shown are 0.5 m DSMs for elevation of vegetation (mainly trees) above the ground. It can clearly be seen that the tree cover is considerably reduced inside the fire-affected area (purple polygon) with little change visible outside of it (apart from some trees having grown larger and some others fallen over). Overall point density on both occasions is similar. An aerial photo of the burned area is shown in Figure 14.

Imagery from this study and some other data are available at their maximum resolution and as Google Earth kmz-files on ARA's website at www.airborneresearch.org.au.

Botany 2016 — Past, present and future

Botany and Science at Adelaide's Botanic Gardens since the founding of the State Herbarium

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In a program of revitalising and diversifying the activities of Adelaide's Botanic Garden following the appointment of Noel Lothian as Director in 1948, the re-establishment of a botanical and horticultural library and more particularly of a herbarium were seen as key elements in securing a scientific role for the institution. This was reinforced with the plan developing into a proposal for the establishment of the first government-funded State Herbarium for South Australia. When this became a reality in 1955 with the consolidation of key herbarium collections and the appointment of a suitably qualified Keeper, the State Herbarium became the focal point for botanical scientific activity at the Botanic Garden. Its activities were integrated with others in the organisation, with overlapping interests including wide-ranging expeditions to collect seed for exchange, propagating materials for introduction of Australian plants to horticulture as well as developing knowledge of the State's flora.

As the gradual progress was made towards ensuring the viability of the State Herbarium, interests in other areas of investigation were also being pursued, such as techniques for propagating plants (especially Australian species new to horticulture), germination studies, experimentation with mist propagation and propagation media and investigation of diseases in ornamental plants. With increasing emphasis on reliable and current identification of the plants growing in the Gardens a Herbarium of Cultivated Plants was established, and in time qualified staff. In the mean-time a capability in plant pathology was established with the appointment of a Senior Research Officer, Ornamental Horticulture. These early developments led to several decades of gradually expanding and diversifying botanical and scientific activity in the Botanic Gardens, complementing that of the State Herbarium, though generally on a significantly smaller scale. What were the principal lines of investigation that waxed and waned over that period to the present as the organisation evolved in response to local, national and global influences? Can an understanding of this historical perspective assist in identifying likely future trends?

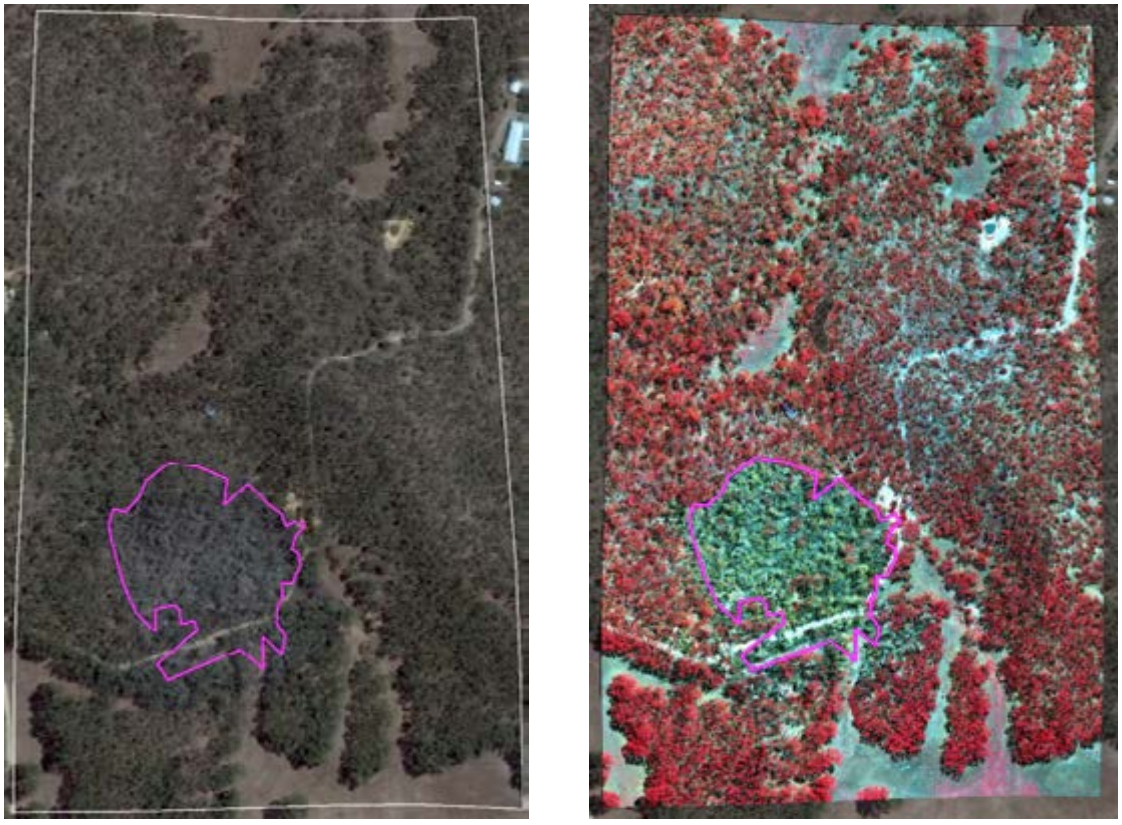

Figure 12. Area near Gumeracha, SA analysed in this study. Left: Google Earth of 5/1/2015. Right: False colour image from hyperspectral scanner of 28/1/2015. For further explanations, see text.

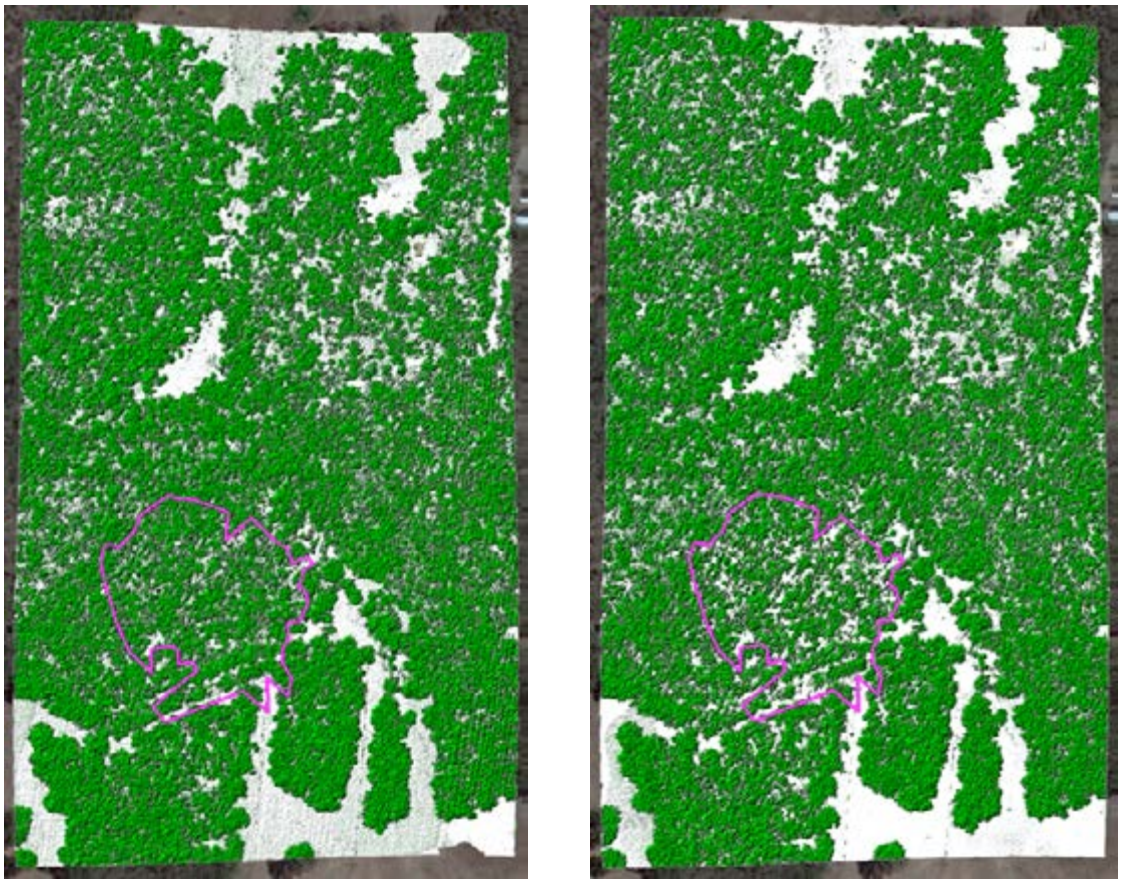

Figure 13. 0.5 m pixel size DSMs for elevation of vegetation (mainly trees) above the ground. Left: Before the fire (6/11/13). Right: After the fire (25/1/15). For further explanations, see text.

Figure 14. Aerial and ground photographs of parts of the area taken on 28 Jan 2015.

The impact of water and soil salinity on water market trading in the southern Murray-Darling Basin

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Presenter: Juliane Haensch

Irrigators in the Murray-Darling Basin (MDB) of Australia face a salinity triple threat, namely: dryland salinity on their land and surface-water and groundwater salinity in their irrigation water. The MDB is an area of great agricultural, ecological, cultural and recreational significance and is often referred to as the 'foodbowl' of Australia. The geological and climatic characteristics of the Basin make it naturally prone to salinity. In addition, periods of drought and the introduction of irrigated agriculture have triggered secondary salinization. Following the removal of native vegetation in favour for the introduction of irrigation, shallow aquifers began to rise and salt from saline groundwater was lifted to the surface, creating increased surface-water salinity after discharges and dryland salinity after evaporation. The natural process of leaching salt through the soil was impaired by reduced water availability due to, for example, drought and increased consumptive water use raising the salinity levels in water and land. On the one hand, drought causes groundwater levels to fall, hence reducing salt mobilization to soils and rivers. But at the same time reduced river flows cause local increases in river salinity, e.g. in the Lower Lakes and the Coorong in the southern MDB.

Irrigators can be highly affected by high salinity levels in land and water due to declining crop yields and reduced agricultural profitability caused by e.g. a required change in land use and soil erosion in response to land salinization. As a result irrigators have had to adapt to changing environmental conditions, including climatic changes and declining water availability and they have adopted water trading to help deal with these issues. What is unknown is how various salinity issues on water and land have influenced the adoption of water trading. The literature on irrigators' water trading decision making suggests that physical or environmental/spatial factors might have a significant impact on water trading behavior, in addition to socio-economic and farm characteristics. In particular water entitlement trading is expected to be more influenced by environmental features given the permanent nature of these licenses, as compared to the temporary nature of trading water allocations. However, to date there has been limited research conducted on what role salinity features have played in water market trade, mainly because of the difficulty in obtaining water market, spatial and environmental data.

This study uses a number of unique water market and spatial databases to investigate the association between the severity and extent of areas which suffer from salinity and permanent water trade in the southern MDB (namely South Australia, southern New South Wales and northern Victoria) from 2000/01 – 2010/11, holding other regional characteristics constant. The southern part of the MDB along the River Murray is of most interest for studying water market behavior, as it is hydrologically linked, and thus allows for interregional and interstate water trading.

It was found that larger volumes of permanent water entitlements were likely to be sold from areas suffering from higher dryland salinity. In addition, increases in the concentration of groundwater salinity was found to decrease volumes of surface-water entitlements sold, providing evidence that groundwater entitlements (where they are viable substitutes) have been increasingly used as substitutes for surface-water entitlements in recent years. Such evidence of the substitutability of groundwater for surface-water needs further investigation, as it may have significant ramifications in terms of the total amount of water used in the Basin, reflows into the system from connected groundwater and the actual amount that is available for environmental flows in rivers. There was no significance shown between water entitlement selling and surface-water salinity. Other key influences on water sales included water entitlement prices and net rainfall.

Botany 2016 — Past, present and future

Ecologically-guided discovery of bioactive plant compounds

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Presenter: Casey Hall

Plants growing in arid zones are faced with multiple environmental stressors. Arid zone plants have evolved unique adaptations to cope with desiccation, large temperature variation, high UV and nutrient poor soils. Australia's aridifcation began around 15 million years ago, allowing our arid adapted flora a long time to evolve a storehouse of chemical constituents that may posses ecologically and/or medically relevant biological activity, including allelopathy, anti-feedant, anti-microbial and anti-cancer. The Australian Bioactive Compounds Centre (ABCC) has recently been established between the University of Adelaide and the University of South Australia to apply both ecological and indigenous knowledge in the identification of bioactive plant compounds from Australia's arid ecosystems.

By observing relationships between plants and their environment it is possible to determine factors that contribute to the secondary metabolite profile of a species. For example, the combined effects of environmental factors such as temperature and herbivory can significantly alter plant secondary chemistry. Such ecological knowledge can be used to optimise the search for bioactive compounds. To illustrate this, I discuss some of our current projects: the isolation of allelopathic growth inhibitor compounds from *Casuarina cristata*; inter and intra-population variation in DHA concentration in nectar from *Leptospermum scoparium*; and the isolation of pigment compounds from Chenopod species. These examples support the idea that ecological knowledge can be used to aid in the identification of bioactive plant compounds.

MALLEE SEEPS – An Opportunity or Land Degradation

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Presenter: James Hall

Mallee seeps have emerged as an issue affecting many cropping farmers across the agricultural regions of South Australia. Within the SA Murray Mallee, seeps are widespread often occurring in low-lying areas at the foot of sand hills and where perched water has surface expression. Where and when seeps will appear in the landscape is unpredictable, however they generally appear on the lowest point in the landscape but have appeared mid slope.

Once seeps form, they can quickly degrade, becoming saturated, bare and scalded. The lack of ground cover can result in the loss of top soil through wind or water erosion, making the establishment of ground cover more difficult.

The number of reports from farmers affected by dune seeps is rapidly increasing, as they watch productive land become waterlogged, bare and scalded and finally unproductive.

The options available to farmers to control or contain the spread of Mallee seeps needs to be practical and suited to the farming enterprise, especially with current modern farming machinery and systems.

In partnership with the National Landcare Programme, Mallee farmers, the South Australian Murray Darling Basin Natural Resources Management Board and the Department of Environment, Water and Natural Resources, an investigative and assessment study was commissioned to determine the extent and nature of the problem.

The study included an assessment of the landscape and soil analysis at three sub-catchments and the establishment of trial sites to determine suitable agronomic and environmental options to manage the problem.

Options currently under investigation and assessments being conducted include;

- strategic planting of perennials
- soil characterisation and land unit mapping at three representative sites
- improving water use efficiency through spading high rates of chicken manure
- EM38 Mapping and soil analysis
- installation of 4 capacitance soil moisture probes at 2 sites

Investigations have shown that Mallee seeps are caused when unused water from a sand dune moves down through the soil profile, beyond the reach of plant roots, to an impermeable clay layer. A perched water table forms when water accumulates below ground level upon a clay layer with a very low permeability. Perched water can manifest at the land surface and cause severe waterlogging where the low permeability clay is at shallow depth (e.g. 1–2 m).

Drilling at several locations in the Mallee found saturated layers at depth (up to 10 m deep) below sand dunes.

In the Murray Mallee, a geological deposit known as 'Blanchetown Clay' forms the low permeability 'aquatard' that causes the perched water table. Similar materials of similar age occur throughout agricultural South Australia and the Victorian Mallee.

The practice of continuous cropping combined with improved summer weed control may also contribute to the development of seeps because these farming systems utilises less rainfall, allowing more water to seep through sandy soils.

The options available to farmers to control or contain the spread of seeps need to be practical and suited to the farming enterprise, especially with current modern farming machinery and systems.

Who needs drugs when you've got geology? The epic tale of the Finke River and the Pedirka Basin

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Presenter: Megan Hancock

The geological history of the Pedirka Basin and its connection to the Finke River is truly epic. The basin is located in the arid interior on the border of the Northern Territory and South Australia. The basin sediments have been deposited over the last 300 million years by glaciers, forests (that are now coal), a vast river network (now the Great Artesian Basin), and advancing and retreating oceans. The Finke River overlies all of this history and is known to recharge groundwater of the Great Artesian Basin.

Fast forward to the present day, and the Pedirka Basin is now being targeted for the energy resources that are present at depth in the basin. The Australian Government established an Independent Expert Scientific Committee (IESC) on Coal Seam Gas and Large Coal Mining Development to provide independent expert scientific advice concerning the impacts such developments may have on water resources. The Australian Government Department of the Environment is also undertaking a programme of Bioregional Assessments to improve scientific understanding of cumulative impacts on water resources from coal seam gas and large coal mining development, As part of this initiative, the Department of the Environment funded DEWNR to address critical knowledge gaps concerning the regional scale hydrogeology (groundwater flow systems) of the Pedirka Basin.The results of a two-year investigation indicate that modern day recharge from the Finke River to the Pedirka Basin is negligible, and the coal bearing formation is indeed hydraulically connected to the only reliable water resource in the region (the Great Artesian Basin). This will present significant challenges for development of the coal resources in the Pedirka Basin.

A number of products will soon be available for download from www.waterconnect.sa.gov.au: technical reports, an interactive 3D pdf model of the basin's hydrogeological units, and a class 1 numerical groundwater model (available from DEWNRs Model Warehouse) (Figure 15).

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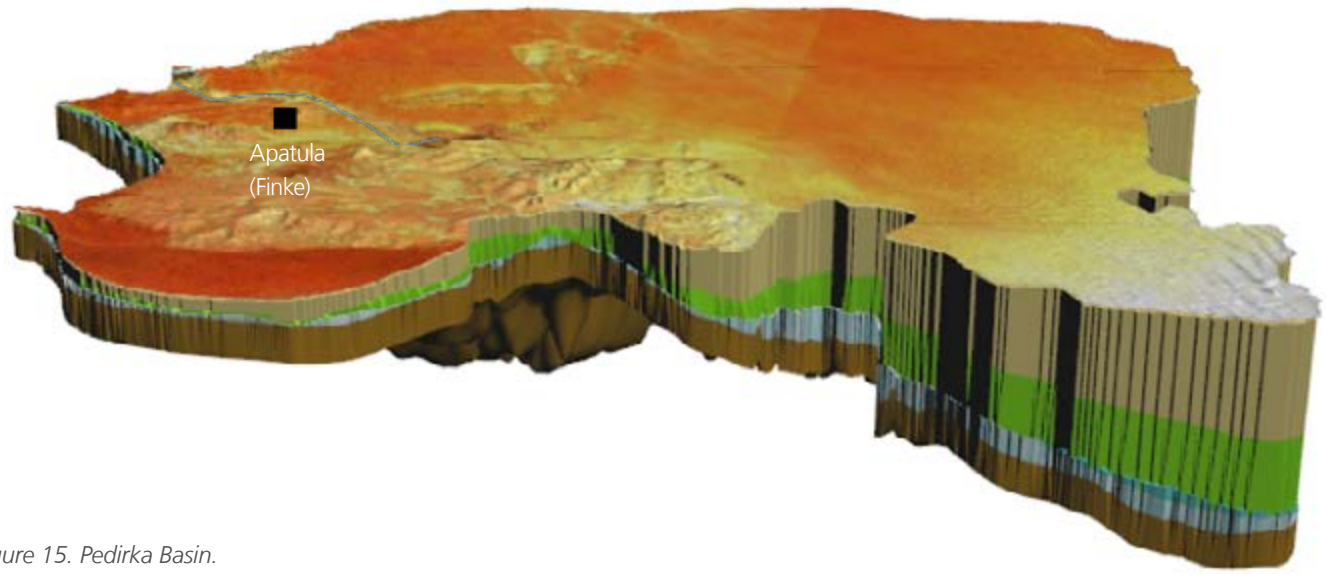

Figure 15. Pedirka Basin.

Eyre Peninsula Marine Parks Bioblitzes – creating a lasting connection with the ocean through science

Harrison, S.

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Presenter: Shelley Harrison

Those who work in marine conservation do so because they are passionate about the ocean. It's a hard slog, so you wouldn't do it otherwise. But that passion comes from somewhere deep within. It comes from childhood experiences, which create wonder. Wonder then turns into a search for knowledge, then advocacy and possibly a career.

However, by the time many children become adults they have lost that sense of wonder about nature as they haven't been given the opportunities to develop their own lasting connection. This means that for many, the ocean is taken for granted. It's often seen as just a resource, not as a provider of life, a place of deep cultural connection, a place where up to 80% of what lives in our southern ocean is found nowhere else in the world.

That's where this project comes in. It's about reconnecting kids with that sense of wonder and empowering them with knowledge. They witness firsthand the deep connection that ancestral people have with the ocean or Sea Country, they're immersed in that environment, so that they can develop their own unique connection. Only then, will they understand how truly amazing and special the ocean is and why it needs protecting.

Why is this important? Children are our future scientists, teachers, lawyers, natural resource managers, fishermen and seafood consumers. They will become advocates for the ocean, which means more sustainable seas for the future.

The project includes both classroom and field based knowledge sharing. In the classroom, students learn about the diversity and endemism that lies beneath the waves. They learn about the weird, the wonderful and the cool. How everything is interconnected through a food web and how removing pieces of a food web has a flow on trophic cascade effect. They learn about the impacts of threats such as marine debris, how we protect the ocean and how they can themselves make a difference.

Out in the field, students spent time with Barngarla descendants, the ancestral people of the areas we've explored on the Eyre Peninsula during this project. The students benefit from witnessing their deep connection with sea country and learning about why this environment is so important to their culture. The kids are led in cultural activities which connect them to the coastal sites visited.

Students are also involved in marine science bioblitzes within a sanctuary zone where scientific data on animals and plants is collected to assist with the monitoring and management of marine parks. Activities such as Rapid Beach Assessment and surveys on coastal vegetation, bird and beachcombing all give the opportunity for the students to become for scientists for a day. But even more importantly, they are collecting data which links into the Marine Parks Monitoring Evaluation and Reporting Program.

The children come away with not only wonder, but knowledge and a connection with the ocean. These experiences have allowed them to develop their own personal connection, pride and empowerment. Science and knowledge really can change the world!

Talking with dryland farmers about adapting to climate change; the understandable focus on the near future and the status quo bias

Hayman, P. and Thomas, D.

SARDI Climate Applications

Presenter: Peter Hayman

This presentation reports on the South Australian component of a national CSIRO led project titled "Evaluating transformative adaptation options for Australian extensive farming." The project is funded as part of the Filling the Research Gap component of the Carbon Farming Initiative of the Australian Government.

Transformational adaptation is understood in a spectrum from incremental to systemic and then transformational. *Incremental* - extensions of existing farm management actions that already reduce the losses or enhance the benefits of natural variations in climate and extreme events. *Systemic* – grouping of incremental adaptation practises together that result in a new or revised land use. *Transformative* - those land use practises that are adopted at a much larger scale or intensity, those that are truly new to a particular region or resource system, and those that transform places and shift locations.

There is overlap between the upper end of incremental and the lower end of transformation. Rickards and Howden (2012) p242 note the "heuristic, subjective and relative character" of transformational adaptation. In the dryland farming context, this is in part due to scale whereby a farm enterprise exiting cropping may be transformational for that business but until most other farms in the district exit cropping it makes little difference to the landscape or region. In the same way a farm business exiting through relocation, retirement or bankruptcy is transformative for the enterprise but in most cases a neighbour buys the property and continues with a similar land use.

Two of the challenges in farmers considering systemic and transformational change are an understandable focus on the near future and a general sense that while the current crop livestock system has its problems, they are not easily convinced that there are profitable alternatives. Focussing on the near future is human nature, but this focus is increased under financial stress. Growers and agronomists are likely to apply a discount rate to their attention. This does not exclude adaptation options

that have payback periods that start beyond the coming five years; it just means that they need to be large paybacks with a high level of confidence. In farmer workshops, farmers made it clear that they were concerned about the general profitability of farming and issues of debt and the cost price squeeze. According to ABARES (2014) farm business debt in Australia more than doubled in real terms in the decade to 2009. Since then it has levelled or declined slightly (in real terms from $63.4 billion at 30 June 2009 to $60.7 billion at 30 June 2013). SA crop livestock farms have had a profitable run of years with reasonable to good rainfall and commodity prices (ABARES 2014).

The relationship between farm debt and transformational change is complex. Most farmers in discussion groups were keen to run successful businesses that built wealth. The purpose of building wealth was to set up the next generation. Although high levels of farm debt makes it difficult to consider the long term horizon required for transformational change, it can also be considered a 'push' factor as identifying structural problems in the existing system. For example in their discussion of transformational change Rickards and Howden (2012) list low equity as one of the vulnerabilities exposed by climate change. One farmer stated that "cropping in low rainfall farming put us into debt and we need to keep cropping to try and get out of debt".

There is an alternative view, that although there are some farms with unsustainable levels of debt, many farms have taken on a sustainable level of debt and this should be seen as a vote of confidence in the future of agriculture in the region. Discussion with agricultural consultants highlights the point that many farms have positive relationships with the providers of debt and use it widely in building their business. ABARES (2014) lends some support to this view. Despite the doubling of debt in the decade up to 2009, the proportion of broadacre farms in severe financial stress (equity ratio of less than 70 per cent) and relatively high debt servicing commitments (interest to receipts ratio exceeding 15 per cent) peaked at 8 per cent in 2006–07 and reached 7 per cent in 2009–10 before declining slightly to an estimated 6 per cent in 2012–13. This is well below the highs of around 12 per cent recorded in the early 1990s. A simple way of stating this is that unhealthy debt levels may contribute to a sense that the system is broken and this increases the push for change whereas healthy debt contributes to the notion that the existing system is working.

In addition to the understandable focus farmers will have on the near term the second challenge seems to be a level of status quo bias. Again it is a human condition to be resistant to change. Park et al (2011) and Rickards and Howden (2012) note that climate change adaptation is essentially about 'persistence through change'. The ratio of change to persistence increases from the incremental through systemic to transformational adaptation. Farmers and agronomists that we engaged with are interested in transformative adaptation but emphasise persistence rather than change.

It is not surprising that farmers and agronomist are keen to preserve the current system. Part of this is the status quo bias but two other aspects emerged from discussion. First, the existing system is quite dynamic in terms of adopting zero tillage and changes to the business of farming over the last decade. Second in their working life time farmers had been exposed to alternatives, especially during the 1990s when the profitability of the crop livestock system was lower. The alternatives ranged from native plants for flower and foliage production, timber, olives, ostriches and cumquats. Their judgement is that few if any of these ventures were successful while there remain many successful crop livestock enterprises.

Another reason that is difficult to consider future options is that the relative advantage of continuing cropping to changes depends largely on rainfall in the coming years. In poor years alternative systems will be advantageous whereas in good years, cropping is more profitable. Farmers expressed this reluctance to change due to the uncertainty in rainfall projections. This raises the question of the volatility of the relative advantage which is related to risk but not analogous to risk (Sanderson et al 2015). The volatility is a key factor in Real Options analysis which is a form of economic analysis catching up with human decision making (Nelson et al 2013).

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Palaeolimnology demonstrates how European impacts have fundamentally changed the ecology of the Lower Lakes and Coorong

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Presenter: Deborah Haynes

The potential of diatoms to reveal past water conditions has been demonstrated using dated fossil assemblages in 16 sediment cores from the terminal wetlands of the River Murray. Diatoms preserved in sediments deposited between ~8,000 and 4,000 years ago reveal that Lake Alexandrina was a fresh, river-dominated environment, while fresh to occasionally brackish water conditions prevailed in Lake Albert. Fresh conditions

persisted to ~6000 years ago in Lake Alexandrina, despite regional sea levels being 1–1.5 m higher than at present. For this to be the case, the climate across the Murray-Darling Basin must have been much wetter than today. Diatoms preserved in Coorong sediments indicate estuarine to marine conditions, with only episodic hyper-salinity in the south lagoon.

A distinct change in the microflora of all three water bodies occurred in the mid-20th Century. Small diatoms from the Fragilariaceae family (*Pseudostaurosira*, *Staurosira* and *Staurosirella* genera) became dominant throughout the wetlands, indicating radical alteration of their respective hydro-chemistries. In the case of the Lower Lakes, the development of closed, turbid lacustrine conditions can be attributed to reductions in River Murray discharge following construction of many regulatory structures throughout the Murray-Darling catchment, and of the barrages at the Murray Mouth. The cessation of seasonal river water throughput and maintenance of Lake Alexandrina water to proscribed AHD levels has increased bank erosion and concentrated fine sediments and nutrients that were previously flushed from the system.

In the case of The Coorong, the cessation of regular freshwater inflows from Lake Alexandrina and the southeast catchment means that estuarine conditions are now rare, rather than the norm and silting at the Murray Mouth regularly compromises the lagoon's connection with the ocean. Hyper-marine salinity levels occur more frequently in both lagoons, and particularly in the south lagoon. The water circulation processes previously driven by marine water ingress through an open mouth and regular freshwater discharges from Lake Alexandrina and the southeast catchments, are now largely driven by tides and/or seasonally variable water levels determined by evaporation. These chemical and physical changes have resulted in reduced water clarity and quality and advantaged a 'weedy' diatom species, *Staurosirella pinnata*, in the lakes and north lagoon, while halo-tolerant diatom species now comprise the flora of the south lagoon.

Ngarrindjeri Futures – The future of Aboriginal Partnerships in South Australia

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Presenter: S. Hemming, L. Trevorrow, G. Rigney, and L. Sutherland

The Ngarrindjeri Yarluwar-Ruwe (NYR) Program was established in 2007 and provides a culturally appropriate and strategic mechanism for the facilitation of Ngarrindjeri engagement in the integrated management of Murrundi (River Murray) and the surrounding Ngarrindjeri Nation.

The NYR is guided by the ground-breaking Yarluwar-Ruwe (Sea-Country) Plan, 2006, and puts into place and applies the principles of the Yannarumi Assessment process (Speaking as Country).

The NYR has taken on a major role in Caring for Country across the Ngarrindjeri Nation – traversing multiple NRM jurisdictions in the SA Murray-Darling region. The program is also partnering with the Department of Environment, Water and Natural Resources (DEWNR) through the Coorong Lower Lakes and Murray Mouth Recovery Project to support Ngarrindjeri engagement in major regional NRM projects, and recently won the prestigious Australian River*prize* for its innovative Ngarrindjeri engagement initiatives. NYR focusses on healthy programs for the Ngarrindjeri Nation through building the core capacity of Ngarrindjeri to engage in natural resources and cultural heritage management.

The sustainability of Indigenous Caring for Country programs like the NYR requires a reimagining of the NRM model – creating a true partnership model that supports Traditional Owners to take the leading role in Indigenous engagement and Caring for Country. There is opportunity for significant reform that places Aboriginal representative organisations in the lead partner role of determining Aboriginal specific Caring for Country targets and priority projects, takes a Country-based approach to planning and funding, and that prioritises Aboriginal engagement capacity in Aboriginal organisations above government agencies. Recent NYR program initiatives provide a case study into the benefits of these types of approaches.

These opportunities hold the potential to sustain Indigenous-led Caring for Country programs and improve the health and wellbeing of Aboriginal Nations in South Australia.

Engaging with Ngarrindjeri Cultural Knowledge

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Indigenous knowledge is often considered by NRM practitioners as a set of facts to be selected from to support western scientific frameworks and management decisions. The tendency to ignore Indigenous Knowledge as a system that needs to be reproduced and applied by the holders of that "situated" knowledge is extremely problematic to Indigenous Nations. A range of factors, including the power and privileging of western science contribute to this situation and directly affect the allocation of NRM resources to Indigenous Nations to meet their cultural obligations to Care for Country.

Processes that recognise the holistic value of Indigenous knowledge and appropriately support its application and protection are therefore critically important.

The Ngarrindjeri Regional Authority (NRA) in partnership with the Department of Environment, Water and Natural Resources (DEWNR) through the Coorong Lower Lakes and Murray Mouth Recovery Project has developed an innovative approach to engaging Ngarrindjeri in environmental management initiatives while promoting and protecting the ethical use of Ngarrindjeri knowledge. This includes the development of Statements of Commitment that articulate Ngarrindjeri contemporary interests and acknowledge the depth of knowledge held by Ngarrindjeri. The commitments seek to progress initiatives of mutual interest and benefit and are supported by accompanying Cultural Knowledge agreements that protect and guide the way Ngarrindjeri knowledge is treated, stored and applied.

Ngarrindjeri Partnerships Project

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The Ngarrindjeri Regional Authority (NRA) is a key partner in the delivery of the South Australian Government's Murray Futures program which includes the Riverine Recovery Project (RRP) and Coorong, Lower Lakes and Murray Mouth (CLLMM) Recovery Project. The NRA led the development of the Ngarrindjeri engagement strategy for Murray Futures and leads the implementation of the Ngarrindjeri Partnerships Project (NPP) in partnership with the Department of Environment, Water and Natural Resources (DEWNR) through the Coorong Lower Lakes and Murray Mouth Recovery Project. The NPP has been developed out of the Yannarumi principles of Ngarrindjeri Speaking as Country. The project has enabled the development of a greater understanding of the implications of this Ngarrindjeri philosophy and this has been applied to policy development and project implementation and practice.

The success of the NPP is underpinned by innovative 'tools' such as the Kungun Ngarrindjeri Yunnan Agreement strategy (Listen to what Ngarrindjeri have to say - KNYA) and the Ngarrindjeri cultural knowledge protection regime. These tools have provided protection for Indigenous knowledges and interests whilst enabling the integration of Ngarrindjeri values and worldview into research, planning and management activities. The NRA-led Indigenous engagement strategy is directed at building Indigenous capacity to sustain long-term engagement in NRM including water-related research, policy development, planning and management.

Fundamental to the NPP has been the process of sharing Ngarrindjeri worldviews of their lands and waters and increasing the awareness of partners regarding issues of power and privilege. A range of strategies have been developed to assist this initiative and to drive Institutional change in government to improve outcomes for Ngarrindjeri. We argue that better outcomes for Indigenous Nations like the Ngarrindjeri are realised as NRM Science moves from promotion to partnership. What is clear is that through the NPP South Australia has developed a form of what can be described as partial Indigenous 'co-management' that has been Indigenous-led and characterised by the KNYA strategy since 2009.

Ngarrindjeri worldview on the description of Ramsar ecological character

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Presenter: S. Hemming, D. Rigney and L. Trevorrow

The current review of the Ecological Character Description (ECD) of the Coorong Ramsar site in South Australia has involved an innovative partnership with the Ngarrindjeri Nation; a practical example of sharing science. The previous ECD (2006) included a limited amount of information relating to the relationship between Ngarrindjeri and their traditional lands. This relationship, Ruwe-Ruwar, expresses the powerful reciprocal bond Ngarrindjeri have with Yarluwar-Ruwe ('Sea Country' – their traditional lands), and a responsibility to care for and speak as Country. Ngarrindjeri partnership in the ECD review process identified a profound difference in approach between Ngarrindjeri and established

ECD authors. This led to Ngarrindjeri representatives reviewing the principles underlying the ECD, and identifying a number of concerns regarding the models underpinning the ECD process:

- A pronounced division between the Country and human influence. Ngarrindjeri consider this to be an artificial distinction.
- A presumption that the land was 'untouched' prior to colonisation. Ngarrindjeri take pride in their active "management" of, and co-existence with, their lands since the time of Creation.
- An emphasis on the 'Limits of Acceptable Change'. Ngarrindjeri consider that for many criteria it is not possible to set limits of acceptable change. While Ngarrindjeri agree that change must be assessed and managed, a different methodology is required.
- A bias towards western ways of 'knowing' the land. Ngarrindjeri have detailed cultural ecological knowledge of their lands. This information has historically enabled Ngarrindjeri to live prosperous lives within Yarluwar-Ruwe and merits recording and inclusion in any examination of the site.
- For Ngarrindjeri components, processes and services cannot be separated. The concept of wellbeing is central to Ngarrindjeri understandings of their relationship to Country.

Ngarrindjeri believe that the work of the ECD is important and they support the process and its goals. Ngarrindjeri hope that raising their concerns and introducing their knowledge will lead to opportunities for greater recognition of Indigenous interests across Ramsar policy and site management nationally and internationally.

How South Australian farmers saved our soils from the brink of extinction – a success story

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Presenter: Tim Herrmann

The sustainable management of our soil is essential to maintain the productive capacity of our land and our social, environmental and economic well-being.

Early agricultural practices in South Australia led to severe erosion and devastation of the soil. By the 1930's, farming and pastoral land was in a sorry state. It was obvious that if erosion continued at the rate it was occurring, farmers would no longer be able to grow crops and pastures.

Depression, drought, low commodity prices, rabbits and exploitive farming practices such as over-grazing, numerous cultivations and burning of crop stubbles, resulted in land being ravaged by wind and water erosion. Fences, roads and railway lines were covered by drift in sandier areas, and water gouged the landscape in hilly areas, carving gullies and washing soil from paddocks.

A report on soil erosion in the late 1930's led to a number of initiatives, including legislation and provision of technical advice to farmers through the Department of Agriculture. From 1940, farmers, farmer groups and government worked together to deal with erosion and successfully bring the land back from the brink of 'extinction'.

Farmers changed their farming systems and practices, and set out to repair the damage caused by erosion and protect the land for the future. Today, farmers continue to adopt more sustainable farming practices that protect the soil, and improve soil health and productivity.

The improvement in the condition of the State's agricultural lands has clearly improved. DEWNR has monitored the level of soil disturbance and surface cover on cropping land for over 15 years. The estimated number of days in a year the soil is regarded as being adequately protected from erosion has risen from 276 in 2002 to 340 in 2015.

The collaborative efforts of farmers, advisers and researchers and their sharing of ideas, innovation, knowledge, experiences and observations have led to these changes.

Botany 2016 — Past, present and future

The vegetation history of South Australia

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Presenter: Bob Hill

South Australia today is one of the most arid regions on Earth, with a vegetation that is well adapted to either a strongly developed winter rainfall pattern, with associated hot, dry summers (mostly near the south coast), or, over the rest of the State, to highly intermittent rainfall and otherwise extremely hot and dry conditions. Despite being an very stable piece of land with a deep geological history, South Australia, as an integral part of Australia, has had a highly variable history in terms of its global positioning and its climate, so that even within the relatively recent past 65 million years (since the catastrophic event that signaled the end of the Cretaceous), the position of South Australia has changed dramatically, from very close to the South Pole, through to its current position in mid-southern latitudes, and during that time the climate has changed to such an extent that the land has seen a change from highly diverse, very complex, effectively "tropical" rainforest, through to today's scleromorphic forests and shrublands and various forms of desert vegetation. The transition between these extremes has not been a smooth one, and especially in more recent times there has been significant controversy over the impact on the vegetation of the arrival of Homo sapiens and the demise of the remarkable megafauna.

There is some evidence for the vegetation that preceded the end-Cretaceous event, especially in sites like the Triassic Leigh Creek coal field, and other scattered locations of varying ages, and there is also a wonderful record of very early life, both in the early part of the Precambrian and also in the latest Precambrian in the iconic Ediacaran biota. However, the Precambrian sites represent marine environments and so far tell us little about the evolution of vegetation, and the Leigh Creek Triassic vegetation, while beautifully preserved and diverse, stands as a beacon from one specific time period in an otherwise vast stretch of largely unknown history.

Hence our focus will be on the post-Cretaceous history of the vegetation, which is the time during which almost all aspects of the modern vegetation came into being. We will summarise both the macrofossil (leaves, wood, reproductive structures) and microfossil (pollen and spores) records to indicate what we do know about the way our vegetation evolved, and we will also indicate where gaps still exist, and the major questions that remain to be answered.

Linking the landscape for woodland birds in the Upper South East

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Department of Environment, Water and Natural Resources

Presenter: Cassandra Hlava

One in five woodland birds in South-eastern Australia is threatened or declining and many of these declines can be attributed to habitat loss and fragmentation. To address these declines, large-scale habitat restoration is required. With limited financial resources it is crucial to implement habitat restoration activities in locations where they are most likely to benefit declining woodland bird species.

The Australian government-funded Landscape Links project, being implemented in the Bangham district of the Upper South East, allows for targeted habitat restoration by offering an incentive payment to landholders for agricultural land that is taken out of production. This provides a rare opportunity to target restoration efforts on sites where they will be of optimal benefit.

The goals of the Landscape Links project are to establish wide corridors made up of diverse species, link and buffer patches of remnant bushland, involve landholders in landscape scale conservation; and restore South Australian Blue Gum (*Eucalyptus leucoxylon*) woodland habitat for declining woodland birds. A GIS spatial model was developed using metrics derived from physical, biological and economic properties of the landscape to identify sites with the highest likelihood of meeting restoration goals.

The on-ground delivery of the project involves private landholders, contractors, NGOs and volunteers to implement the restoration works. A volunteer-based bird monitoring program has been established to capture baseline information about avifauna in the district and with continuation of the monitoring program we will be able to track changes in woodland bird communities as the revegetation establishes.

This project applies science to inform on-ground works, engage the community and to monitor ecological outcomes at the landscape scale.

Monitoring soil erosion risk in the agricultural landscapes of South Australia using MODIS satellite data

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Presenter: Giles Forward

The loss of soils by erosion is one of the greatest threats to the productivity of our agricultural landscapes. Land management practices have evolved over recent decades to reduce cultivation and improve protective plant cover. These practices have aimed to reduce or eliminate the amount of time where soils are exposed and are at risk of erosion.

To safeguard our soils, and deliver appropriate resources and information to ensure the sustainability of these landscapes, DEWNR has monitored the agricultural lands of the state using ground-based surveys to represent the landscape since 1999. These surveys have shown an improving trend of soil protection over the last 15 years.

Soil mapping information, satellite data and computing power has also evolved over recent years. It is now possible with this new information and techniques to provide a cost effective and standardised method to monitor soil erosion risk across the entire landscape.

Field survey data between 2006 and 2014 (i.e. four surveys per year by 5600 survey sites) and MODIS Fractional Cover satellite information has been used to build new soil exposure and erosion risk models for agricultural landscapes. These models evaluate the degree of soil exposure to wind and water erosion, at four critical times per year, for every hectare within the landscape.

Maps of modelled soil erosion risk for all agricultural areas can be produced within a few weeks of the satellite passing over the state. This information can be used to inform responsive and adaptive land management decisions by natural resource managers and for long-term monitoring of soil erosion risk in South Australia.

Carbon sequestration potential of priority revegetation activities in Eyre and Yorke Peninsula landscapes under a changing climate

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Presenter: Trevor Hobbs

To restore and conserve the unique and diverse ecosystems of Eyre and Yorke Peninsulas both regions have adopted a collaborative, landscape-scale planning approach to biodiversity conservation. This process has identified important biodiversity assets and developed strategies for their future care and maintenance. Several open woodland and mallee vegetation communities have been identified as important assets for regional conservation goals.

Targeted revegetation is part of WildEyre's and Southern Yorke Peninsula's integrated strategies to restore the extent and functionality of these plant communities. While these revegetation activities may be designed for ecological benefits, they also have the potential to provide co-benefits to the community and

individual landholders through the sequestration of atmospheric carbon dioxide and access to carbon markets. Estimates of carbon sequestration rates from targeted revegetation activities in the region can assist planners and landholders to evaluate the potential economic value of these new assets through carbon markets.

To guide future landuse planning and investment decisions spatial-temporal models of carbon sequestration from revegetation have been recalibrated for priority vegetation communities in both regions. Maps of estimated carbon sequestration rates from potential targeted revegetation activities at 25 and 45 years of age have been generated under historic climatic conditions. Models have also been used to explore the likely impact of several climate change scenarios on carbon sequestration, plant mortality and vegetation structure across both regions.

Just add water? Frog breeding response to environmental watering of temporary wetlands in the lower Murray region, South Australia

Hoffmann, E.

Natural Resources South Australian Murray-Darling Basin, Department of Environment, Water and Natural Resources, Presenter: Emily Hoffmann

Environmental water (e-water) is being increasingly used to inundate wetland and floodplain areas in an attempt to restore ecological processes that have been altered by river regulation and reduced flooding frequency. Frog species are often targets of e-water activities as they are water-dependent and highly sensitive to changes in hydrology and habitat alteration, and information on frog ecological responses to e-watering is essential to support adaptive wetland management, including the roles of inundation frequency and duration.

In November and December 2014, Natural Resources SA Murray-Darling Basin delivered water from the Commonwealth Environmental Water Holder and State Environmental Water Reserve to over a dozen priority wetlands between Morgan and the South Australian border. This study monitored the breeding response of frogs following the environmental watering of temporary wetlands.

Frog and tadpole surveys were conducted monthly between December to April at between six and 12 e-watered wetlands to determine species presence and abundance. Data were used to examine temporal patterns of breeding and spatial relationships with habitat and site characteristics.

Delivering e-water to temporary wetlands via pumping triggered and supported frog breeding across all wetlands, with a total of seven frog species detected including the threatened Southern Bell Frog, *Litoria raniformis*. Successful recruitment was observed of all species through the presence of tadpoles and metamorphs. In this presentation I will present further major findings of this study and discuss some of the conservation and management implications of e-watering for frog populations.

Of bees and burns: conservation of the green carpenter bee *Xylocopa aeratus* in relation to fire-history on Kangaroo Island

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Presenter: Katja Hogendoorn

The green carpenter bee, *Xylocopa aeratus*, is an Australian endemic bee species. It is the largest bee in southern Australia (up to 2 cm) and is a striking species, having a brilliant blue-green metallic integument. As a result of extinction in Victoria and mainland South Australia, *X. aeratus* now has a disjunct distribution, occurring in native bushland around Sydney, and on the western part of Kangaroo Island (KI). The cause of extinction on the mainland and the eastern part of KI is likely to be a combination of habitat clearing and large-scale bushfires. The latter can have a profound influence on the occurrence of carpenter bees, because of a range of attributes related to their nesting habits and lifecycle, which we briefly explain below.

Adult carpenter bees live for a year and, unlike honeybees, they do not store food. They will be active on any warm day and therefore require sufficient floral resources year-round within an area of 2 km around their nest. A bushfire during any time of the year can greatly reduce such floral resources. In addition, compared to other solitary bee species, carpenter bees have a prolonged period of food provisioning for their offspring. This also means that bushfires are likely to have a larger impact on carpenter bees than on many other bee species.

The main nesting substrates used by *X. aeratus* are large, dead *Banksia* trunks that can be re-used for several generations and dead flowering stalks of grass trees that are more ephemeral. As with other bee species that nest in wood, fire can threaten existing nests and directly influence their survival. However, to make matters more complicated, the availability of the main nesting substrates used by *X. aeratus* is intricately linked to the fire regime. Flowering stalks of grasstrees are available between 2 and 5 years after fire, while the presence of suitably sized Banksia trunks requires at least 20 years in the absence of burns and often much longer.

With this in mind, we investigated the current distribution of *X. aeratus* on KI in relation to fire history. We surveyed the western part of the KI for the presence of active nests and nesting substrate and combined our findings with earlier surveys and historical collection data. We conclude that fire can cause the local extinction of carpenter bees through: (a) Complete burns of isolated patches; (b) Frequent burns, which do not allow time (at least 20 years) for regrowth, death and colonisation of *Banksia*; (c) Burns of large areas of continuous vegetation,

which synchronise the availability of the two substrates on time scales that do not support ongoing survival of the bee.

For the conservation of *X. aeratus* on KI, fire management should: (a) refrain from prescribed burns in areas that currently support the green carpenter bee; (b) refrain or perform localised and very infrequent burning (>25 years) in habitat with suitable *Banksia* but no carpenter bees; (c) relocate active nests during winter from areas that are targeted for prescribed burning.

Management of biodiversity for apple and pear pollinators

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Presenter: Katja Hogendoorn

Apple production relies for 80% of on animal pollination – pear for 50%. Pollination not only increases yield, it also enhances the shape and hence the quality of the fruit. In terms of dollar value, the pollinators of apple and pear contribute a total value of $54 million per year to South Australia's economy. Therefore, the health and density of pollinators is of vital importance to the apple and pear industry.

Despite the importance of pollination, most South Australian growers place less than the recommended density of 2-4 honeybee hives in their orchards and many do not use any commercial pollination services - they rely partly or wholly on free pollination. This free pollination supplied by feral honeybees and by a range of native pollinators. The native pollinators include several species of native bees (there are > 1,500 species in Australia) and other insects such as flower wasps, flies and beetles.

Both the density of insects that supply free pollination services for apple and pear and the health of managed honey bee hives rely on the presence of flowering plants in and around the orchard. These plants are the main food sources before and after flowering of the orchard trees and can help to meet the dietary requirements of bees during crop flowering Thus, planting pollen and nectar resources for pollinators has the potential to enhance free pollination of apple and pear and provide a healthy environment for managed hives.

Funded by PIRSA and working closely with the apple and pear industry in the Adelaide Hills, we are investigating the revegetation strategies that can help meet the needs of pollinators of apple and pear. We do this by finding answers to the following questions: (a) Which bee species, other than honeybees, pollinate apple and pear? (b) What are the periods of activity of these useful pollinators? (c) Which plant species surrounding the orchard support these bees? (d) When do these plant species flower, relative to the crop flowering time? (e) Which flowering plants need to be avoided in to prevent attraction of lorikeets that will harm the fruit? (f) Which of the plants that support crop pollinators can be used in revegetation programs and/or as wind breaks?

The outcomes of this project will inform revegetation strategies in the Adelaide Hills. Here, we will present some of the insights gained regarding the species of native bees that visit apple and pear and the plants that support these bees when orchards are not in flower.

Assessing the hydrogeology of Hookina Spring (Pungka Pudanha), Ikara-Flinders Ranges

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Presenter: Lauren Houthuysen

Hookina Spring (Pungka Pudanha) is the only registered Songline in South Australia [under the *Aboriginal Heritage Act 1988*] and holds a unique cultural, archaeological, biological and hydrogeological significance to the Traditional Owners – the Adnyamathanha community. The Adnyamathanha community are concerned about the sustainability of Hookina Spring in the face of erosion, livestock grazing, water extraction, tourism, weeds and feral animals, all of which could potentially damage the cultural and environmental value of the site. A hydrogeological assessment was undertaken as part of a collaborative project between the Ecology and Groundwater Teams within DEWNR's Science Unit, Natural Resources South Australian Arid Lands and the local Aboriginal community.

The aim of the study was to provide a scientific understanding of the spring and surface water systems, identify groundwater ages to infer the source of the spring water, and to identify potential risks to the resource resulting from changing approaches to natural resources management.

A desktop and field-based evaluation of the site provided geomorphological insights which were further investigated using hydrochemistry. These analyses indicated that groundwater at the spring is around 1500–3000 years old, which indicates that rainfall recharge in the immediate region is not the primary source of water for Hookina Spring but rather, water is likely sourced through groundwater via the process of mountain-block recharge that ostensibly occurs a few kilometres away.

The conceptual model resulting from this study has given the Adnyamathanha community a better understanding of the hydrogeological processes that appear to govern Hookina Spring. This model has proved to be a valuable communication tool for all stakeholders which aids in protecting a culturally-important site and demonstrates the importance of partnerships between DEWNR and Aboriginal communities.

Developing a New Monitoring and Evaluation Framework for Victoria's Marine Protected Areas

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Presenter: Steffan Howe

Parks Victoria is establishing a new monitoring and evaluation framework as an integral part of its Adaptive Management Framework (AMF) for the network of Marine National Parks (MNPs) and Marine Sanctuaries (MSs). The new framework will ensure systematic, robust and integrated ecological monitoring across the system of MPAs and provide a stronger evidence base to better inform management decisions. Over the past few years Parks Victoria has developed a set of clear, specific and measurable objectives for key natural assets and threats for each MPA, as well as a set of management strategies to help achieve those objectives. A set of criteria have also been developed to further refine monitoring priorities across that state. A suite of monitoring indicators were then selected that relate as directly as possible to the priority assets and threats, whilst being cost-effective, anticipatory and interpretable. Indicator thresholds are being developed for triggering management responses and for reporting against objectives. A variety of methods are being used to inform the selection of thresholds including historical data, thresholds used by other agencies and expert opinion. Some rigorous thresholds for water quality have already been developed by relevant state government agencies, while interim thresholds are currently being developed for a range of other indicators. We will present a worked example of the monitoring and evaluation component of the AMF for Port Phillip Heads MNP.

What are we doing to combat soil acidification in South Australia?

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Presenter: Brian Hughes

Soil acidification affects about two million hectares of land in South Australia and is a major threat to soil health and the productive capacity of our soil.

Soil acidification is a natural process, but the extent and severity of acidic soils is increasing due to the high use of nitrogen fertiliser, greater cropping intensity and removal of high crop and hay yields.

Acidification of the sub-surface (10-20cm) soil layers is increasing and is more difficult to treat. In some cases, soils that had neutral surface soils over alkaline subsoils have now become acidic.

Regular application of lime is the most effective treatment for acid soils. About 200,000 tonnes of lime is required to counteract soil acidification that occurs each year. However, current sales of lime are only about 50% of that required.

An additional two million tonnes of lime is needed to remediate surface soils that are already acidic. More lime is needed to treat soils with sub-surface acidity.

Precision pH testing at the paddock scale using specially designed machines provides spatial data which enables the rate of lime application to be varied according to pH zone. Comparisons on a range of soils and land management systems has shown that the machines predict similar patterns of pH variation in the paddock to maps produced using conventional testing.

Several decision support models have been developed to assist landholders to make better decisions in treating soil acidification. An auditing tool enables landholders to determine the approximate annual acidification rate on their farm based on the area of acid prone soils, land use categories and intensity of production. Other tools include the impact of acidification on production (cost of not liming), and a cost comparison of liming products.

Barriers that inhibit landholders treating acid soils have been identified and are discussed.

Good Ol' Olive debate – Is your control as effective as it can be?

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Presenter: David Hughes

Background

The wild *Olea europaea* ssp. *europaea* is distributed across southern Australia in clusters mainly from the cities Perth, Adelaide, Melbourne and Sydney where it was planted as a fruit tree that has now naturalised as an invasive bushland weed (Richardson 2011). The control of wild olives is difficult and can require large inputs of resources (APCC 1999).

Introduction

If you are paying contractors to control wild olives by a method such as drill and fill, or doing it yourself, it may be time to consider a different method. Basal bark treatment of wild olive has been used with great success in the North Para region since 2007. A 2015 trial to compare overall cost for the treatment of mature wild olives using basal bark and drill and fill treatments was conducted. 14 mature trees were treated firstly with basal bark treatment and a week later a different crew drilled and filled the same trees.

Discussion

The basal bark treatment showed clear benefits:

- No need to clear the ground of debris, lower branches or hazardous objects, saving time and cost
- The reach of the spray wand eliminates the need to trim olive branches
- Work is mainly from an upright standing position, rather than crouched or kneeling
- Labour efficiencies of basal bark treatment resulted in a $356 cost, compared to $2913 for drill and fill.

Multiple treatments can be required with the basal bark treatment in order to deliver enough chemical mixture to larger trees. Consequently operators do need to be skilled to ensure effective application. However other treatment methods often will require repeat treatment for regrowth.

YouTube Video:

https://www.youtube.com/watch?v=5-N_4qUVJ9w&list=PL4IsUu0-il4r9zQUTaGefpZOso1GPTIct&index=2

References:

Animal and Plant Control Commission South Australia (1999) "Weed risk assessment and management of olives" (APCC, Adelaide).

Richardson F.J. (2011) "Weeds of south-east an identification guide for Australia" (F.J. Richardson, R.G. Richardson, R.C.H Shepherd).

Birds in Black Box: Avian community drivers in floodplain woodlands

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Presenter: Thomas Hunt

The Black Box woodlands of the Murray River floodplains are thought to play a unique role for woodland birds in the region, providing key resources seasonally and during drought. These woodlands are threatened through modified flood regimes, and the current MDBA plan is unlikely to deliver enough environmental water to maintain them.

To determine the consequences of this for birds, we surveyed and compared avifaunal assemblages at 36 sites in the Riverland region of South Australia. Sites were divided between healthy and degraded Black Box and adjacent Red Gum and mallee woodlands, surveyed seasonally from 2013-2015 using 2ha 30-minute area searches.

Analysis showed that each woodland type supported a unique bird assemblage over each season, though there was greatest similarity between healthy Black Box and mallee communities. Degraded Black Box supported the least consistent bird assemblage, and the lowest species diversity and abundance. Certain bird species, particularly honeyeaters, pardalotes and whistlers, showed shifts in abundance between woodland types, following changes in seasonal resources (eucalypt flowering, invertebrate abundance); in effect a temporal habitat complementarity.

Healthy Black Box woodlands do play an important ecological role in the landscape, sustaining unique bird assemblages and providing resources that drive seasonal bird movements and abundance between woodland types. Critically, there is a considerable deterioration of the bird community as Black Box degrades, with implications for woodland birds regionally if hydrological deficiencies are not addressed.

Assessing white shark activity at the Neptune Islands to minimise the effects of cage-diving tourism

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Presenter: Charlie Huveneers

Wildlife tourism is one of the fastest growing sectors of the tourism industry. White sharks, *Carcharodon carcharias*, have become a key attraction to wildlife tourism, which often occurs at important shark aggregation areas. In South Australia, the intensity of cage-diving activities more than doubled around 2007 from about 120 days of operations per annum to 265 days. Recent studies assessing the effects of such expansion showed that cage-diving operations can affect the behaviour and residency of white sharks. It is, however, unknown whether such changes are detrimental to sharks. We deployed activity packages encompassing high frequency acceleration and swim speed loggers, depth and temperature recorder, and animal-borne camera to describe the fine-scale behaviour of white sharks at the Neptune Islands and assess whether cage-diving tourism changes the energy expenditure of white sharks due to increased activity. Ten sharks were fitted with activity packages for deployment periods ranging from 30 minutes to ~40 hrs (mean 22 hrs). A range of behavioural modes were recorded and varied between and within individuals. Strong accelerations were observed throughout the day and night. Bait chasing and a natural predation were recorded by the loggers and camera allowing to allocate accelerations and swimming speed to behaviours and compare the energetic cost of activities between these behaviours.

Family Matters: genes of life in the world of rabbits

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Presenter: Amy Iannella

Supported by the Foundation for Rabbit Free Australia and the Invasive Animals CRC

Rabbits live in a soap-opera world. Every week there are 15 new births, and 10 more funerals, while the most attractive guys can sneak around with all the ladies.

The question is: what determines which rabbits get to breed, and which meet an early end? And can we harness this to set feral rabbit populations on a downward trajectory?

Using Next-Generation DNA sequencing techniques we have reconstructed the family tree of a large population of South Australian rabbits. We are using this to determine:

- Which rabbits are reproducing successfully
- How much influence a rabbit's family background has on its survival
- How important are genes (eg RHDV resistance genes) compared to environmental or random factors in determining rabbit success?

Dealing safely with leaky, hot, high pressure wells in the Great Artesian Basin

Inverarity, K.and Dennis, K.

Science, Monitoring & Knowledge, Department of Environment, Water and Natural Resources

Presenter: Kent Inverarity

When hot, high pressure artesian wells in the GAB spring a leak, things can get bad quickly. This became evident in late 2014 when Georgia Bore, on Etadunna Station near Marree, started to leak hot water near in the wellhead. Three months later the wellhead was completely surrounded by a pool 4 m to 8 m across of 70 deg C water.

In order to figure out where the water was leaking from and how to deal with it, we surveyed the full depth of the well with geophysical logging instruments, along with some nearby wells constructed at the same time. Once this was done the well was later abandoned using downhole explosives after building a stone platform for a drill rig to get over the wellhead.

The geophysical surveys revealed the well was not leaking through corrosion or damage to the casing, but that the leak was probably coming to the surface via the formation around the well. This was caused by improper construction when the well was drilled in 1995: cement was placed to an inadequate depth, allowing water from the J-K aquifer (Algebuckina Formation) to infiltrate into weaker overlying shales and silts; and cement was squeezed through perforated holes in casing, probably fracturing the shale in this area and facilitating further infiltration of water upwards around the annulus. Once the drill rig was in place, holes were blown in the casing at four places and more than 20,000 L of cement was used to fill the well and surrounding cavities, stopping the leak for good.

The presence or progress of any leak underground is essentially impossible to detect with downhole geophysics or other means before it reaches the surface, emphasising how important it is to get the construction of artesian wells right in the first place, to avoid the dangerous situation of a well leaking in the future – and the financial cost of replacing it at short notice!

A coordinated approach to planning landscape-scale ecological restoration

Jellinek, S.and Meffin, R.

Department of Environment, Water and Natural Resources.

Presenter: Jellinek, S.

The Millennium Drought had severe ecological impacts on the Coorong, Lower Lakes and Murray Mouth (CLLMM) region. In response, the five-year CLLMM Vegetation Program was established as a key component of the CLLMM Recovery Project. Jointly funded by the Australian and South Australian governments, the CLLMM Recovery Project is one of Australia's largest landscape-scale restoration programs and aims to restore the character of this iconic Ramsar wetland and build ecological resilience. Three key tools were utilised to coordinate the program and achieve these goals. First, an integrated Landscape Assessment was used to identify priority vegetation types for restoration in the region. Second, a Site Planners' guide was developed to identify the most appropriate vegetation types to reconstruct depending on site characteristics. Finally, a Marxan analysis was conducted across the region to prioritise sites for restoration works based on the aims of the program.

While it is too soon to fully assess program outcomes, there are early indications of success. Buffering and connectivity of existing vegetation remnants have been increased and bird species are starting to use revegetated sites. Work is underway to assess the ecological function and resilience of restored communities with a view to providing a baseline against which to measure future outcomes.

Together these tools provided a framework underpinned by sound science for planning landscape-scale restoration programs to maximise ecological benefits. This framework has the potential to be widely applied to other restoration programs with similar aims.

Sharing Learnings on Environmental Watering – the 'frog effect'

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Returning water to the environment is easy to say and very challenging to deliver! In the South Australian Murray Valley, unless there is a natural flood, water has to be lifted 1-3 m to reach floodplain sites. This is a multi-skilled operation, involving those with irrigation and pumping know-how, those with ecological know-how and those with muscles and equipment. The key questions revolve around 'what does the environment need this year?' and 'what can be delivered practically?' The constraints include budget, water availability, site suitability, equipment and manpower.

The Water For Nature initiative of Nature Foundation SA has a contract with the Commonwealth Environmental Water Holder to deliver up to 10 GL per year over the period 2012-2017, and was the first NGO to obtain environmental water from this source. The Water For Nature program is targeting the River Murray floodplain on small to medium sites, mostly on private land, to complement the larger government programs watering significant areas of mostly public land.

Site selection is determined by a range of factors, including willing landholders, available equipment, available water, feasibility of water delivery, current environmental priorities and available volunteers. Under the Water For Nature initiative, the range of sites currently being watered includes mid-elevation floodplain sites with black box seedlings, floodplain lagoons and swamps, semi-permanent waterholes and river terraces. Many currently watered sites are protected by regional salinity interception schemes, which are lowering elevated groundwater and reducing soil salinity in the unsaturated zone, thus reducing a major stress factor.

A key environmental priority for current watering projects is sustaining extensive black box regeneration triggered by the flow peak in February 2011 (Figure 16). The value of this germination event is heightened by the lack of successful broad-scale regeneration in black box since the 1955-56 floods. Environmental water is being applied at multiple Riverland sites to sustain seedlings until they are self-supporting. The inputs needed for environmental watering projects include access to energy sources to lift water out of the river, suitable irrigation equipment to distribute water on the higher levels of the floodplain, people to re-locate sprinklers, modified trailers to shift equipment, willing landholders and appropriate approvals in place for each watering project.

The return of water to riverine ecosystems is creating green assets, with multiple ecological, economic and social benefits. Those who are involved in the projects are seeing first-hand the multiple benefits, with social benefits including the involvement of volunteer groups such as Mens' Sheds, LAP groups, schools and local irrigators contributing in many ways to make the projects work. The *Water For Nature* workshop in October 2015 included presentations from multiple projects outlining the significant commitment of volunteers to keep the projects going, and the inaugural list of 13 individuals and groups nominated as Water For Nature Wetland Champions were announced.

Many projects have been enhanced by the 'frog effect', which occurs within 1-2 days of filling a desiccated wetland. As the water pours across the deep cracks, landholders become more and more excited, especially as they start to hear the frog calls. Landholders who were initially hesitant about a watering event become converts and start suggesting extensions to their project.

The next challenge is to turn the 'frog effect' into concrete evidence of the social and economic benefits of environmental watering. In order to sustain provision of environmental water into the future, it is urgent to demonstrate that this is not only diversion of water to maintain ecological health, but more importantly a necessary investment of water to sustain long term benefits for the whole community.

Figure 16. Watered black box seedlings at Thiele Flat near Loxton in the South Australian Riverland (May 2014)

Translating the Landscape Assessment Framework for the Mount Lofty Ranges into Targeted Restoration Action

Johnson, R., West, A. and Rogers, D.

Department of Environment, Water and Natural Resources

Presenter: Randall Johnson

Identification of priority ecosystems in the region was undertaken using terrestrial bird species (Rogers 2011). Two broad ecosystems were found to be strongly associated with species at risk of extinction:

- Grassy ecosystems (and particularly grassy woodlands) in lower rainfall areas of the landscape, on gentle slopes.
- Closed shrublands associated with a variety of environmental settings, with or without an overstorey.

Preliminary analysis that identified priority patches for restoration was considered alongside recent targeted survey work for species such as the Beautiful Firetail (closed shrublands) and Diamond Firetail (grassy woodlands). The 'habitat restoration/ reconstruction prescription' for given areas were derived following analysis of the target species' diet, foraging guild, preferred microhabitat variables and breeding requirements. This may result in a deviation from a strict replication of the probable 'pre-European' vegetation thought to have occurred at a site.

Observations from degraded habitats and historic plantings at Monarto and elsewhere indicate that many lower rainfall ground foraging grassy woodland decliners respond first and foremost to structure, scale and landscape context, calling into question the focus of the many declining woodland bird habitat restoration projects trying to reinstate native grasses and forbs at considerable expense. Restoring at the scale required to reverse declines in terrestrial bird species requires large areas to be restored as cheaply as possible and with a focus on structure and specific habitat components. Likewise in closed shrubland sites, the focus will be on scale, structure and specific food and habitat plants for target species, rather than an attempt to reinstate the richness and strata at perceived benchmark sites.

Further work is being undertaken to increase the confidence of future modelling exercises in the lower rainfall grassy ecosystems, including fine scale mapping of woody vegetation where current floristic mapping is inadequate and further bird surveys in the relatively under-surveyed modified habitats of the northern and eastern Mount Lofty Ranges.

Botany 2016 — Past, present and future

The value of the "other stuff" in collections-based scientific and cultural institutions

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Many collections-based institutions such as galleries, libraries, archives and museums, but also botanic gardens and herbariums, keep collections of objects and materials which, at first, might appear to be at the periphery of core business. Recent experiences at the Botanic Gardens and State Herbarium would suggest otherwise.

The Adelaide Botanic Garden was established in 1855 and the State Herbarium in 1955. The Botanical collections are best represented by the living collections or "the garden" and the scientific collections by the herbarium and seed bank. However, a survey of the collection will reveal a trove of objects in the form of: a library (including rare books), art collection, archive and museum of economic botany. The Botanic Gardens of South Australia is one of the few institutions around the world that include the full suite of foundation pillars of; a living collection, herbarium, seed bank, library, art, archives, economic botany, museum, exhibition programme and education programme.

Through the auspices of the recently restored Santos Museum of Economic Botany and the sponsored exhibition program, these collections are brought together to provide an exploration of the botanical world through exhibitions and publications. Nature is examined through the lens of the artist, scientist or historian for the benefit and education of the public.

Botany 2016 — Past, present and future

South Australian lichens – A Kangaroo Island case study

Kantvilas, G.

Tasmanian Herbarium, Tasmanian Museum and Art Gallery, Hobart, Presenter: Gintaras Kantvilas

An eight-year study of the lichens of Kangaroo Island has been based on extensive field trips to the island and a review of all existing herbarium records from public institutions. The study has hitherto revealed a diverse flora of more than 325 species, 14 of which were discovered for the first time and have been described as new to science. Many other species are new records for South Australia, Australia or even the Southern Hemisphere.

The distribution and composition of the lichen flora is determined chiefly by vegetation type and a complex geology that includes limestone and siliceous rock-types in close juxtaposition. Some of the main vegetation/habitat types investigated for lichens are the littoral zone, mallee woodland, dry sclerophyll forest, coastal heathland, *Melaleuca*-dominated swampy woodland, *Callitris*-dominated woodland on sand dunes, *Allocasuarina* woodland, bare consolidated soil and agricultural land.

As a result of its isolation, small population and having 25% of its area in nature reserves, Kangaroo Island has retained a significant element of its natural environment. However, land clearing, extensive fires, housing developments and windthrow in woodlands have fragmented many habitats and reduced the lichen flora drastically. Hence rocks, isolated trees and small wooded copses provide important but highly fragile lichen refugia in an otherwise severely modified landscape. Mallee and *Callitris*- and *Melaleuca*-dominated woodlands are particularly severely impacted.

Most of the species recorded are shared with mainland southern Australia, and with Tasmania and its off-shore islands, but there is also a significant number of species recorded only from Kangaroo Island. The question "Is Kangaroo Island special?" is considered.

This pioneering study has investigated the composition of the flora and the taxonomy of several poorly known groups, and contributes significantly to the knowledge of South Australian lichens.

Botany 2016 — Past, present and future

The vascular flora of South Australia

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Presenter: Jürgen Kellermann

South Australia is currently home to 5007 taxa (species, subspecies and varieties) of vascular plants: 3378 of these are native and 1288 weeds (26%). The State Herbarium of South Australia maintains the Census of plants in the State and tracks developments and changes in the flora. The Census is based purely on herbarium specimens held in the State Herbarium. SA is divided into 13 "Herbarium regions" with mainly artificial boundaries.

The current SA Census database was established in 1990 and since then over 1000 taxa of vascular plants were added; of these, 447 taxa were established through splits from existing taxa and 566 taxa were new discoveries in the State (native or naturalised). Over 800 taxa changed their names and c. 70 taxa were a result of the combining of existing taxa. Spikes in taxonomic change were recorded in 2005, 2006, 2008 and 2013. These mostly follow the publication of major taxonomic works; in 2005 the high number of name changes occurred during the preparation for the 5th edition of the printed Census.

In 2015, 44 taxa changed their name (29 natives, 15 weeds) and 68 were added new to the SA Census. Thirty-five of the latter were newly discovered taxa (13 natives and 22 weeds), with the remainder a result of splits or combinations involving existing taxa. New native plants are both, new scientific discoveries, or plants that are present in neighbouring states and have now been found in SA.

The origin of weedy taxa can be traced to escapes from gardens and agriculture. Most weeds are found in the Southern Lofty (SL), Northern Lofty (NL) and South-Eastern (SE) regions, areas with the highest population density and agricultural activity. Regions in the arid north of the State, in particular the North-western (NW) region, have the lowest density in weeds, as the pool of invasive plants adapted to aridity is smaller.

Of the 428 endemic plants in SA, most occur in just three of the State's regions. Regions with the most endemic taxa that only occur in a particular region are: Kangaroo Island (KI; 5.5% of species endemic to the island), Eyre Peninsula (EP; 3.4%) and SL (1.3%). If all SA endemics are taken into account, most occur on EP (45%), followed by SL and KI (30% each).

Notable examples of additions and changes to the Census from the last years are: (1) the re-discovery of *Hibbertia hirsuta*, a species with a disjunct distribution in Tasmania and a small area in the SL region of South Australia. In SA, it was only known from a specimen collected in 1881; its rediscovery in the State was published in 2014. (2) A recent revision of *Euphorbia* split the widespread species *E. drummondii* into 12 taxa; *E. drummondii* is now restricted to WA, NT, Qld and NSW, with only one record in the far north-west of SA. (3) The WA endemic native cypress *Callitris drummondii* is starting to become naturalised in the SL region and spreading into bushland in Belair National Park. This is an example of an Australian species becoming a weed outside its native range.

A hydrochemical characterisation of springs in the vicinity of Lake Blanche, Lake Eyre Basin, South Australia

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Science, Monitoring & Knowledge, Department of Environment, Water and Natural Resources

Presenter: Mark Keppel

This presentation provides a summary of a hydrogeological characterisation study of a number of spring complexes located within the Lake Blanche region, Far North South Australia. This study was completed as part of a vulnerability assessment associated with potential coal seam gas (CSG) development within the Cooper Basin and was funded by the Australian Federal Government.

The specific objectives of this study were to provide an initial description of structural setting and primary controls on spring formation using previously published basinal architecture interpretations, an interpretation of near surface conditions using acquired geophysical data and a description of the primary groundwater source for springs based on hydrochemistry data. These descriptions provided input to a conceptual model for a number of spring groups also including ecological, geomorphological and risk profile considerations. This presentation will focus attention on the hydrochemical investigations undertaken and the associated outcomes.

Groundwater from 14 springs and 17 wells was collected and analysed for major ions, trace elements, the stable isotopes $\delta^{2}H$, $\delta^{18}O$ and $^{87}Sr/^{86}Sr$ as well as radiocarbon and ^{36}Cl; and provided the basis for source aquifer characterisations. Based on trends observed within and interpretation of hydrochemical data from water wells, five hydrochemical classifications were established. Each classification correlating to the aquifer from which groundwater's were sourced; 1) Crystalline basement aquifer, 2) Cooper Basin (Patchawarra Formation) aquifer, 3) J-K aquifer (Algebuckina Sandstone and Cadna-owie Formation) of the GAB, 4) Coorikiana Sandstone aquifer (Shallow GAB) and 5) Tertiary aquifers.

Although the majority of spring water analysis inferred a J-K aquifer source, a number of spring waters inferred other aquifers may contribute to spring flow at those locations. Most notably, a number of spring complexes located closest to the Cooper Basin are most likely supplied water from shallow aquifer systems such as the Tertiary and Coorikiana Sandstone. This suggests that despite the likelihood for fault-related connectivity between these spring systems and supplying aquifers, such connectivity appears insufficient in providing significant hydraulic connectivity between springs and deeper aquifers such as the J-K aquifer under current hydrogeological conditions.

A major finding of this study was the identification of the Coorikiana Sandstone as a potentially important aquifer with respect to the supply of groundwater to springs within the area of investigation. The Coorikiana Sandstone is a thin sandstone unit that occurs between the Bulldog Shale and Oodnadatta Formation, which are the two most important confining units above the major aquifer unit (the J-K aquifer) within the South Australian portion of the GAB. Although the Coorikiana Sandstone has been previously recognized in parts of the basin to the north of the area of investigation, a review of historical logs has found sandstone and other sandy sediments at a similar depth much further to the south. Additionally, a review of historical logging data indicates that a number of wells within the area of investigation have either been completed within the Coorikiana Sandstone or that water from the Coorikiana Sandstone is currently leaking into the well annulus. Although further work is required to confirm this finding, this interpretation has important implications with respect to our understanding of the geology, basin architecture and the hydrogeology of this region.

A number of management and regulatory implication stem from the finding of this work, most notably with respect to recognising that groundwater dependent ecosystems are potentially supplied by a multiple aquifer system and that groundwater from the Coorikiana Sandstone is a relatively small but important resource within the area of investigation. By extension, these results highlight the importance of the SAAL NRM water allocation plan with respect to the management of springs supplied by non-J-K aquifer groundwater, given such springs are not specifically covered by the Australian Government EPBC (1999) Act. Finally, the concept of scale in data collection and assessment was highlighted during this investigation and consequently it is recommended that any potential resource development require local scale confirmation of spring-related structures or source aquifers.

A citizen science community bird monitoring project on Eyre Peninsula

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Presenter: Greg Kerr

In order to assess medium to long-term landscape scale biodiversity change on Eyre Peninsula arising from factors such as changes to land management practices and climate, there was a need to develop a scientifically valid, cost-effective, long-term and broad-scale monitoring program. Previous monitoring programs were ad hoc, expensive, reliant upon specialist skills, project specific and not at a regional scale. Furthermore, existing data entry and storage was compromised by high data entry costs and complexities in storage, and subsequently rarely analysed.

Natural Resources Eyre Peninsula has facilitated the establishment of a citizen science bird monitoring project to develop a new generation of skilled bird observers. The project aims to foster a skilled body of citizen scientists across Eyre Peninsula capable of carrying out bird surveys to facilitate a long-term monitoring program. Successful implementation of both programs has required a range of challenges to be overcome. These include a low population density (0.65 people / km^2), extensive area (65 000 km^2) of poorly studied fauna with limited understanding of distribution, habitat use and species demographics, and limited existing bird identification or survey expertise.

To date 190 volunteer community members have attended a free 40 hour course and have contributed over 5000 observations to the program. Data is stored securely in an Atlas of Living Australia online portal, providing community ownership of the full data set. The projects has also supported the formation of several new community-based groups.

BIGG Recovery of native pastures after bushfire

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Presenter: Georgie Keynes

In 2014, areas of the Eastern Mt Lofty Ranges near the Barossa Valley were burnt in two separate fires. The Eden Valley Fire occurred on 17 January and burnt over 24,000 ha between Eden Valley and Truro. The following December the Hutton Vale fire burnt 1,400 ha east of Angaston.

The vast majority of the area burnt in both fires was native pastures, made up of a range of grasses including native perennials, legumes and other plants. These play a crucial role in the local livestock grazing system. In addition, they are critical within the local environment by providing habitat and food for native animals and birds, such as the endangered Diamond Fire-tail Finch.

A community recovering from a major bushfire requires immediate and on-going support. Joint funding from Natural Resources Adelaide and Mount Lofty Ranges (AMLR), and Natural Resources SA Murray-Darling Basin (SAMDB) enabled the Barossa Improved Grazing Group (BIGG; http://biggroup.org.au) to investigate the recovery of native grasses following the fires and support producers in managing their pastures and grazing business's.

BIGG conducted scoping workshops, soil testing, and fertiliser trials at sites monitoring the recovery of pastures after the fire. We also facilitated extension and information sharing opportunities for fire affected landholders. Through these activities, BIGG has empowered over 20 fire-affected producers who are managing 10,000 ha to sustainably manage the recovery of their native pastures.

The Project has helped producers make informed grazing management decisions and improve their skills for the future recovery and management of their pastures. Two years after the Eden Valley fire, monitoring sites show us that pasture dry matter levels remain one third below pre-fire levels. The perennial native grasses have, in many cases, regenerated from the original burnt plant and there has been some germination of perennial grass seed. Many of the annual grasses which provide feed through the spring and summer months have reduced, resulting in less production being obtained from these pastures. This has also decreased ground cover resulting in a higher risk of soil and water erosion. After two dry springs, producers are utilising this information to make informed decisions, with many choosing to either destock their pastures two to three months earlier than normal or running reduced stocking rates. Monitoring will

continue for 2016 to continue to provide important information to producers. Networking and information sharing activities to BIGG's network of over 250 producers and stakeholders have helped the community recover from the fires and remain resilient. Most importantly it has also facilitated the development of a case study booklet, video and information sheet. These outcomes have been widely communicated and used by other landholders and agencies in the 2015 Pinery bushfire recovery.

Development of Hyperspectral Reference Database to enhance imagery mapping of seagrass distribution in Adelaide, South Australia

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Presenter: Tim Kildea

The loss of over 50 km² of seagrasses from the metropolitan coast of Adelaide (South Australia) has been documented with aerial photography taken irregularly since the 1950s. There are limitations to the use of these photographic records to analyze this historical trend due to issues with low temporal resolution for some of the earlier images and problems with differentiating between different vegetation types and dead/live seagrass.

A project was developed in conjunction with Taiwanese National Cheng Kung University and Instrument Technology Research Center, South Australian Water Corporation and Flinders University, with the support of the Premier's Research and Industry Fund, to improve our ability of mapping seagrass distribution by using an underwater hyperspectral scanner (UHI). The aim of the collaboration is to develop instrumentation that can be potentially deployed on multiple platforms (boat, unmanned aerial/underwater vehicles and aircraft).

Effective remote sensing of seagrass populations depends on the ability of a sensor to identify the distinct spectral features of a representative substratum in the optically shallow water environment. In particular, this involves efficiently generating reliable hyperspectral libraries to assist in the analysis of aerial and satellite remote sensing data. Seagrasses growing at different water depths, geographic location, with variable epiphyte cover and stem age, all have the potential to have substantially different spectral signatures. The initial phase of this study focused on the development of a spectral library assessing the differences between various benthic bottom types and seagrass species. Early results show that certain seagrass groups can be spectrally distinguished from their hyperspectral signature.

The presentation discusses some of the results from early trials of the UHI, in particular the development of a spectral database for identifying individual seagrass species growing along Adelaide's metropolitan coast. Preliminary results show that weather conditions and in particular water turbidity play key roles in the performance of the UHI's ability to accurately identify seagrasses. The outcome is to provide a more robust and cost-efficient tool to identify and monitor seagrass distribution and health that can be used at seasonal and/or yearly time-scales. This will also assist managers to target environmental initiatives such as where to improve water quality along the metropolitan coast.

Integrating disciplines for NRM outcomes: an example from the River Murray floodplain

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Taking advantage of the wide variety of data sometimes available – often specialised modelling data from different disciplines – for ecological response models for NRM outcomes, is made challenging by the differing format and scales of the available data. Bayesian belief networks (BBNs) have become increasingly used to model ecological responses to environmental change, and have the benefit of being able to take a variety of qualitative and quantitative inputs. In addition, the visual presentation of the BBN facilitates wide communication of the underlying ecological conceptual model.

Here, an example is given from the Pike floodplain, part of South Australian River Murray, where and an integrated ecological response model to assist site management was sought. BBN models, based on ecological conceptual models, were developed for River Red Gum (*Eucalyptus camaldulensis*) and Black Box (*Eucalyptus largiflorens*), and integrated data from hydraulic, hydrological and groundwater modelling. They BBN models were linked to spatial data, to produce spatial outputs of ecological response, which can assist in communication of management actions to site managers as well as the public.

Bringing participatory planning workshops together with spatial conservation planning: a case study from the Eyre Peninsula

Koch, P.

Greening Australia, Presenter: Paul Koch

The WildEyre project is a collaborative, regional-scale conservation project focussed on the western Eyre Peninsula and forms part of an identified Naturelinks corridor in South Australia. It involves an alliance of government and non-government NRM organisations

and is underpinned by a Conservation Action Plan (CAP; initially developed through a series of facilitated workshops) and an adaptive management framework. The project team has been meeting quarterly since 2007 to discuss and refine planning, on-ground activities, monitoring and fundraising as required.

An important innovation developed through the WildEyre planning process has been the use of spatial conservation planning tools in conjunction with workshops to identify spatially explicit priorities for investment. GIS planning tools including MAXENT (species distribution modelling) and ZONATION (identification of high value areas) were used in conjunction with participatory mapping processes to create maps showing high value areas and important areas for enhancing landscape connectivity. Potential sites for implementing on-ground activities were then assessed by the project team and prioritised for investment based on conservation value, threat severity and feasibility.

The involvement of the project team in spatial decision-making workshops was essential in ensuring that the GIS analysis genuinely informed priorities for on-ground works. It also highlighted the importance of incorporating local knowledge into spatial conservation planning.

Carbon exchange of perennial semi-arid woodland in south eastern Australia responding to drought and fire – implications for NRM planning to manage global carbon

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Presenter: Georgia Koerber

The Calperum Mallee flux tower is part of the Australian Supersite Network (ASN), a facility of TERN collecting ecosystem data. The site is 300 km from Adelaide in South Australia, 20 km from Renmark in the Mallee woodlands. The tower has been operational since August 2010. A bushfire in January 2014 burnt the Mallee and tower instruments. These were restored within three months to monitor bush fire recovery. In addition to the tower measurements of carbon, water and energy fluxes, leaf area derived from ground level images of intercepted light has been monitored. A mass balance approach and periodic soil respiration measures have been used to calculate heterotrophic soil respiration.

Basal soil respiration has been determined and compared to the other ecosystem fluxes. Paul Jarvis's research on soil respiration pulses after rain (the "Birch" effect) and Xin Wang's recent metadata analysis in Global Change Biology both suggest that increased rainfall in summer and our changing climate is going to increase basal soil respiration. This will reduce the net uptake of carbon by the plants.

In this study we used a new approach to partition net ecosystem exchange. Constructed ecosystem assimilation as a function of radiant enabled partitioning of net CO_2 exchange into photosynthesis and respiration by the plants and soil heterotrophs. To verify our partitioning we used leaf area index recorded prior to the bushfire and every month since as an indicator of the ecosystem respiration.

The relationship between ecosystem respiration and leaf area index provides basal soil respiration from the y-intercept (213 g C m^{-2} $year^{-1}$). This value is only 2 g C different from basal respiration calculated from measurements of net primary productivity and mass balance of carbon added to the soil from canopy litter and loss from soil respiration. The annual net ecosystem exchange (-46 g C m^{-2} $year^{-1}$) indicates that this ecosystem is a sink for carbon with net primary productivity of 261 g C m^{-2} $year^{-1}$. Our measurements provide rarely available evidence of the large contribution of basal soil respiration (44%) to the total C balance. NRM plans aimed at promoting endemic ecosystems for C sequestration will need to reassess the likely uptake and loss of C from these ecosystems particularly if climate becomes warmer and drier or seasonality of rainfall changes.

Wastewater tracers: Using artificial sweeteners and other compounds to track contamination sources

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Presenter: Rai Kookana

Introduction

Marker compounds or tracers are commonly used to track potential sources of contamination into a system. These compounds can also be useful in assessing the potential impacts (in terms of toxicity and geographical breadth) of wastewaters derived from municipal and industrial sources. A range of organic compounds and inorganic contaminants can be associated with the wastewaters generated

by a particular source or industry. Some of these compounds could potentially be considered as tracers. However, it is considered important for these compounds to pass the following four criteria to qualify as tracers, i.e. the tracers (i) need to be conservative (i.e. stable in the environment), (ii) need to be mobile (i.e. to disperse in the environment with the wastewater), (iii) specificity to a source and (iv) detectability (i.e. present in high enough concentrations to be detectable with routine analytical techniques).

Artificial sweeteners as tracers

Artificial sweeteners, such as saccharin, aspartame and acesulfame (Table 1), are widely used in a range of beverages and food products and are therefore ubiquitous in wastewaters. These are high volume chemicals and their total sale exceeded US$7 billion in 2013. Several of these compounds satisfy the criteria listed above and can serve as good tracers to identify sources of wastewater pollution. A majority of these compounds tend to be very mobile and stable as well and they can be easily detected in the environment using liquid chromatography and mass spectrometry. Where anthropogenic activity is the source of pollution, especially in population centres, these compounds can serve as useful indicators of pollution.

In a study in Switzerland, Müller et al. (2011) found that the levels of acesulfame sweetener in surface waters of Swiss rivers had a very good (r^2=0.94) linear correlation with population. This study also found that the levels of perfluorinated compounds (PFOA/PFOS) in surface water were fairly well correlated with acesulfame concentrations. Artificial sweeteners can indicate anthropogenic influence on groundwaters. For example, a Canadian study (Van Stempvoort et al. 2013) found that levels of pharmaceutical compounds (carbamazepine, primidone, a degradation product of nicotine (cotinine)) and an artificial sweetener (cyclamate) were strongly correlated as co-tracers and thus demonstrated the link of groundwater contamination with wastewater. In Germany, Wolf et al. (2012) identified the impact of leaking sewers on ground waters using acesulfame and carbamazepine.

Applications in Australia

CSIRO has been involved in a number of studies to assess the presence of a range of artificial sweeteners and pharmaceutical compounds in the environment. For example, in a study in Queensland (Wolf 2013) we detected the presence of artificial sweetener acesulfame and pharmaceutical carbamazepine in surface and ground waters, which demonstrated the impact of wastewaters on these receiving environments (Figure 17). Similarly in other studies, the detection of artificial sweeteners in surface water streams have indicated the extent of wastewater impact from the overflow of sewers during a storm.

The presence of artificial sweeteners has been found to be correlated with other chemical contaminants originating from anthropogenic activity. Artificial sweeteners and other co-tracers, such as carbamazepine, could serve as good indicators of wastewater as a source of general anthropogenic pollution in surface and ground waters.

Table 1. Some commonly used artificial sweeteners, their brands and code as food additive.

Name	Food Additive code	Popular brand name
Acesulfame	E950	Sunett, Sweet One
Aspartame	E951	Equal, NutraSweet
Cyclamate	E952	Sucaryl, Sweetex
Saccharin	E954	Sugarine, Sweet 'N Low
Sucralose	E955	Splenda
Alitame	E956	Aclame

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Practical implementation of environmental water deliveries downstream of water supply reservoirs in the Western Mount Lofty Ranges

Kotz, S. and Iacopetta, J.

SA Water

Presenter: Steve Kotz

The Western Mount Lofty Ranges (WMLR) water resources were prescribed on 20 October 2005 by the Minister for Sustainability, Environment and Conservation. Following the process of prescription, the WMLR Water Allocation Plan was developed which included formal arrangements for environmental water releases downstream of SA Water metropolitan water supply infrastructure in the South Para, Torrens and Onkaparinga Rivers. Up to 16,500 ML per annum was made available for an environmental flow trial over a 3 year period. The volume released is offset by pumping from the River Murray, not including water delivered on the River Torrens downstream of Gumeracha Weir which is recaptured in Kangaroo Creek reservoir.

Trial release patterns were developed for 4 individual river reaches across the 3 catchments; South Para River downstream of Barossa Diversion Weir, River Torrens downstream of Gumeracha Weir, River Torrens downstream of Gorge Weir and Onkaparinga River downstream of Clarendon Weir. The timing and magnitude of releases were developed based on investigations into environmental water requirements in the individual systems and the ability to operationalise delivery. A

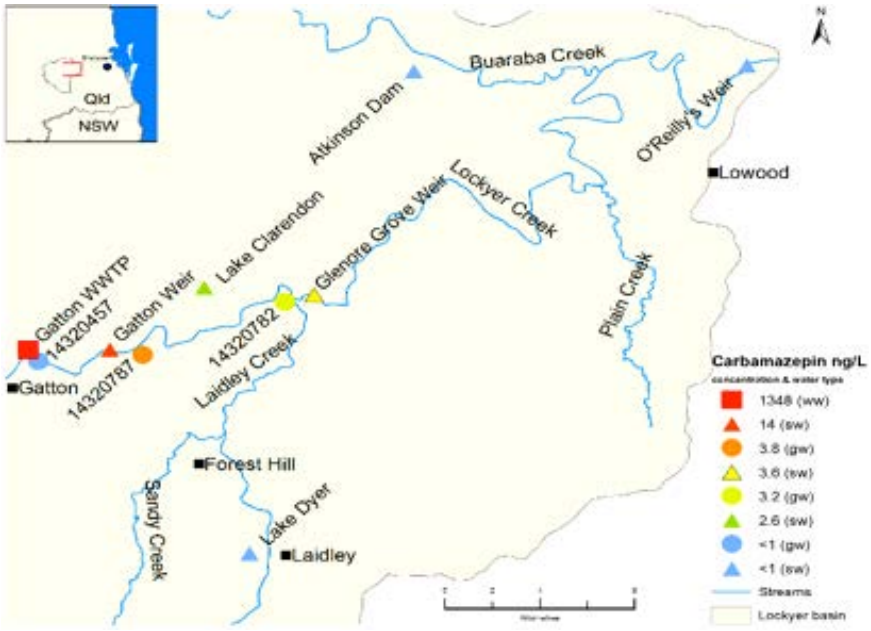

Figure 17. Sampling sites in Lockyer Valley (Qld) where surface and ground waters were found to contain artificial sweeteners and carbamazepine pharmaceutical indicating impact of wastewater (after Wolf 2013)

combination of baseflow provisions, higher flow bands (fresh and flush events) and cease to flow periods were developed for each reach, complementing the observed natural flow variability from the previous 5 years. The environmental flows trial has provided important insight into the challenges facing the practical implementation of environmental water delivery from historical infrastructure and during times of low resource availability.

Adapting bulk water infrastructure for environmental water delivery

The practicality of delivering environmental water in the WMLR to a defined schedule was restricted by the original design of the bulk water infrastructure which focussed on shifting large volumes of water for metropolitan public water supply and resisting natural flood events. The infrastructure in these reaches are more than 100 years old and required modifications that were sensitive to the heritage value while enabling the existing diversion weirs to supply smaller volumes associated with baseflow provisions. In most cases 'environmental pipes' or low flow valves were retrofitted to the existing infrastructure to enable supply.

Delivery of higher flow bands required the need to balance consumptive deliveries to off-stream reservoirs with controlled spills over the weir. To achieve a controlled spill over the Barossa Diversion Weir, the weir pool needs to be filled to full supply and the gates to the Barossa Reservoir closed. These higher flows can only be delivered for a few days at a time to avoid impacting supply to the customers who depend on Barossa Reservoir. Similarly, high flow events downstream of Clarendon Weir require releases to be manipulated at Mt Bold Reservoir to ensure supply is maintained to Happy Valley Reservoir and Clarendon Weir spills the correct volume.

Coordinating environmental water delivery to a specific hydrograph was often constrained by the inability to supply precise volumes as 'spill' over the weirs or was reliant on the timing and volume of natural catchment inflows to facilitate a spill. When targeting a release of 40 ML/day downstream of Gorge Weir, for example, a 1cm variance in gauge height can equate to a 20 ML or more difference in flow rate. Furthermore, in the reach downstream of Gumeracha Weir the delivery of fresh and flush events was solely dependent on natural inflows and the water level behind the weir. Unlike the other trial reaches, there is no reservoir upstream from which environmental water can be released. Given the delivery of higher flow bands in this reach relied on sufficient rainfall meeting the desired flow trigger, spills often occurred outside of the planned delivery regime.

Modifying environmental water delivery in response to climatic stressors

Climate is a key driver for the effective delivery of environmental water in the WMLR. Prolonged rainfall deficiencies can impact on the volume of effective runoff into the hills' catchments leading to reduced storage levels in the major water supply reservoirs. Under particularly dry conditions, securing metropolitan water supplies takes precedence and can impact on the ability to deliver environmental water to the full extent. In contrast, natural catchment inflows may result in greater magnitudes of flow which occur at times outside of the planned program, diminishing the role of the scheduled releases.

Given the naturally variable climate of the WMLR, such challenges to environmental water delivery can be expected. In particular, the drier than average conditions experienced during the latter stages of the trial highlighted the need to adequately consider the balance between releasing environmental water and managing the security of supply for SA Water customers.

It became apparent during the trial that the adaptive management of releases in response to dry conditions could be enhanced. For instance, in Year 2 (2013), inflows to the South Para catchment were significantly reduced leading to low water levels and water security concerns for South Para Reservoir. In light of the dry conditions, the environmental flow program was suspended in the reach that year. The decision to suspend the program in Year 2 was delayed as much as practicably possible, and subsequently did not occur until water security had already become an evident concern.

Reactive approaches to amending or postponing environmental water releases as conditions deteriorate can result in the 'over commitment' of resources, delaying system recovery as conditions improve. This can not only place additional pressure on resources to equally supply customer demands and the needs of the environment, but can also increase the cost of supply.

Establishing a conservative delivery profile based on analysis of system condition and the likely inflow scenario (using annual exceedance probability for example) has the potential to be a more effective approach to adapting environmental water releases. This can allow for releases to be increased as conditions improve. Proactively managing releases has benefits for maintaining the balance between water security and delivery of environmental water, and may potentially reduce the need to reduce or cancel environmental commitments on an ad hoc basis.

Striking the right balance between environmental water releases and water security will be an ongoing learning exercise, one which is not isolated to the WMLR. Actions undertaken within other water supply catchments to promote a more equitable balance between deliveries for consumptive and environmental purposes will provide important learnings which can be adapted to the WMLR situation.

The trial also identified concerns with relating the release of the higher flow bands with specific months rather than in response to natural hydrological cues. By artificially creating a flow event there is potential for sub-optimal environmental outcomes to arise which may undermine ecosystem resilience. Additionally, delivery of high flow events without appropriate rainfall triggers can exacerbate the risks to water security in those dry and drought years when the system is less able to recover from large releases of water. Ensuring better linkages to climatic indicators, such as releasing higher flow bands in response to rainfall events, or prolonging baseflow deliveries may better support the natural variability of the catchments.

Maintaining good quality monitoring networks is therefore integral to strengthening our understanding of how each system responds to hydrological cues and changes in climate. Robust data that supports decision making is important for ensuring future release patterns are managed in a way that compliments natural inflows.The lessons learnt during this period are continuing to guide the development of future licence conditions for extractions from the WMLR for public water supply while achieving the best benefit to the environment with the water we have available.

Adelaide's Managed Aquifer Recharge story – success, complexity and continuing innovation

Edwards, D.-L. and Kretschmer, P.

Department of Environment, Water and Natural Resources

Presenter: P. Kretschmer and D.-L. Edwards (co-presenters)

Managed Aquifer Recharge (MAR) is the purposeful harvesting and storage of stormwater or treated wastewater underground to meet later demand. Following initial proof-of-concept projects led by DWLBC and PIRSA in the early 1990's, over 50 schemes have now been developed in metropolitan Adelaide, many of which are interlinked with pipe networks that connect suburbs across the metropolitan area. MAR's growth was stimulated by the Millennium Drought, academic-led innovation and strong community support for water-conscious environmental initiatives. A new recent driver is reduced nitrogen discharge targets to Gulf St. Vincent from treated wastewater.

As a result of the growth of MAR, large regional pressure fluctuations and local water quality changes have occurred in the aquifers underlying the Adelaide Plains. This growth has required regulators to remain highly-adaptive and informed when assessing third-party risks. An added complexity to MAR regulation is that injection is regulated under the Environmental Protection Act, whereas extraction (whether it be from prescribed surface water or groundwater) is regulated by the Natural Resources Management Act. In addition, the NRAMLR is in the process of developing a Water Allocation Plan for the Adelaide Plains which will influence how some of the various aspects of MAR schemes are regulated.

Despite the success of MAR, a detailed understanding of the overall performance of Adelaide's schemes has yet to be qualified or quantified. The success of MAR has regularly been expressed as the sum of the design harvest capacity for all constructed schemes when compared to the target of 35 GL/year of stormwater harvested by 2025-2030 listed in multiple strategic plans. The design harvest capacity of Adelaide's MAR schemes in 2014-15 was in the order of 16 GL/year which is a positive result. However, this does not assess how well the schemes are performing compared to their designed harvest capacity.

A recent assessment found that in 2014-15, total volume of water harvested was approximately 4.5 GL/year which represents only 28 percent of the designed harvest capacity. There was also a wide variability in the performance of individual schemes. These findings raise questions: what are the factors that allow some schemes to achieve their design capacity?; do the lower actual harvest volumes provide the desired water security?; do current yields effect the viability of some schemes in the long-term?; what infrastructure 'bottlenecks' may restrict capacity and performance and does DEWNR have its policy settings optimised to support the continued growth of MAR? As a result of improving our knowledge of MAR operations we can refine the science and policy used for aquifer resource management and MAR schemes.

Investigations of low salinity confined aquifer groundwater for use as a potential replacement town water supply for Naracoorte

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Presenter: Jeff Lawson

The township of Naracoorte in the lower south east of South Australia is supplied with groundwater sourced from the Tertiary Confined Sand Aquifer (TCSA), known locally as the Dilwyn Formation. Groundwater salinity as supplied to the town is about 1200 to 1300 mg/L, higher than the recommended Australian drinking water standard of less than 1000 mg/L.

Most groundwater extraction within the Lower Limestone Coast management area occurs from the unconfined Tertiary Limestone Aquifer (TLA) better understood as the Gambier Limestone. To supply groundwater from this aquifer to the town is not an option as the salinity is similar to the TCSA.

This project is a partnership between the South Australian Water Corporation (SA Water) and Department of Environment, Water and Natural Resources (DEWNR) to investigate groundwater options to potentially supply lower salinity groundwater to Naracoorte. Innovative Groundwater Solutions assisted with the groundwater chemistry sampling and interpretation

Previous regional work demonstrated the confined aquifer is recharged through an uplift zone located in the general Nangwarry area. Groundwater flow in the confined aquifer radiates away from this area with the northwest flow path of particular interest as it travels beneath Bool Lagoon.

The government database indicated that low salinity TCSA groundwater (650 to750 mg/L) exists in this area, located about 20 to 25 kilometres South East from Naracoorte. Investigations resulted in construction of a TCSA production and TLA observation well, with the latter completed at the base of the limestone and located 20 m east and a TCSA observation well was located1.5 kilometres west. In addition another two TCSA observation wells were drilled and located 8 and 12 kilometres away.

The TCSA production well was aquifer tested at 50 L/sec over 3 days with the unconfined aquifer well monitored to determine any inter aquifer leakage, resulting in only a barometric related water level response. Aquifer test interpretation from all four confined aquifer wells confirmed the TCSA sediments to produce the highest transmissivities recorded in the Limestone Coast region.

Groundwater ages from Carbon -14 were found to be modern (less than 100 years) around Nangwarry, Tarpeena and the Victorian Border which is consistent with this being the main recharge area for the Dilwyn formation. Ages became progressively older in a North West direction reaching between 3,000 and 6,000 near Bool Lagoon. A stark difference in the major ion chemistry between the bottom of the Gambier Limestone aquifer and the Dilwyn Formation aquifer around Bool Lagoon indicates little inter-aquifer leakage occurring, supported by more than 5,000 years difference in estimated groundwater ages.

The salinity results from the TCSA wells in the program indicated the wells constructed 8 and 12 kilometres away recorded the lowest values. If a well field was to proceed SA Water will need to carefully consider the best location.

Additionally DEWNR completed a regional hydrostratigraphic study to confirm the potential of the TCSA to provide a long-term water supply for Naracoorte. It has shown that long-term, low salinity groundwater can be provided from a transmissive confined aquifer that has remained stable across the last 30 years.

Nullarbor to Naracoorte: DEWNR's extensive Limestone and Coastal Karst assets – DEWNR Science informing Natural Heritage

Lewis, I.D.

Science, Monitoring & Knowledge, , Department of Environment, Water and Natural Resources

'Karst' is the scientific term for special features formed by the actions of water on and in the world's soluble rocks – for example, surface pitting, limestone blades and pavements, caves, sinkholes, coastal cliffs, tubes and sea platforms. DEWNR administers many important land and coastal karst features across South Australia. Steady geological uplift of the southern Australian continental edge over the last million years has given this State three large exposed ancient limestone sea floors – the Nullarbor Plain, the Murray Basin and the Upper and Lower South East. This type of limestone is very limited in the other States and rare across the planet but is extensive in South Australia.

Thus all our resulting caves and coastal landforms – cliffs, lagoons, extensive sand dune corridors and ranges – are very special and suggest that DEWNR could consider a broad coordinating approach to karst science, interpretation and management across our South Australian Parks system.

Six selected examples epitomise these karst assets from west to east – the Nullarbor Cliffs, Koonalda Cave, the Southern Eyre Peninsula cliffs, Kelly Hill Caves, the Naracoorte Caves and Piccaninnie Ponds. The links between DEWNR's karst assets will be explained and examined, together with the story they tell of South Australian environmental and climatic change to the present day. It's a big one-million year story. You can read it in the landscape. And it's interpretable to the public.

One level of special identification, recognition, protection and promotion is the listing of sites on the SA State Heritage Register.

The State Heritage legislation for 'Natural' environments is landscape-based and oriented towards 'G.A.P.S' Heritage - Geological, Archaeological, Palaeontological and Speleological sites of significance. As part of a process to provide a greater balance between the approximately 150 'Natural' and 2,000 'Built' heritage listings, SMK Branch is providing to DEWNR's State Heritage Unit specific information on the 'G.A.P.S.' features of a series of 'Natural' environment features for State Heritage nomination.

The current project is preparing the nomination of the Naracoorte Caves and Karst Landscape for State Heritage listing. This limestone landscape and caves contain many significant geological elements demonstrating three very important geological phases in the formation of coastal South Australia –

- The developing of the new Southern Ocean limestone sea floor 37-12 million years ago following separation of Australia from Antarctica.
- The commencement of the 13 ancient coastlines across the region resulting from the Quaternary global Ice-age cycles in the last million years.
- A preserved hydrogeological record of the million-year changes in groundwater levels resulting in development of caves, sinkholes, springs, lagoons and interdunal freshwater corridors that originally drained into the southern Coorong.

The Naracoorte Caves complex itself consists of 37 large and small caves which demonstrate -

- Each aspect of South Australian geological history listed above
- A World Heritage palaeontological record including the megafaunal extinction event
- Early European regional settlement history
- The development of cave tourism from 'wild caves' to modern professional interpretation
- Attractive cave decoration which records climate change history
- Close association with three prominent South Australian scientists and explorers
- The output of specialised speleological exploration, discovery and documentation

Evidence of past climates and environmental changes are obtained from dating and chemical analysis of the many speleothems (stalactites, stalagmites and flowstone) and deep sediment sequences contained within multiple caves.

Directly associated with the sediments, the world's largest and most comprehensive assemblage of Australian mammal fossils dating from 0.5 million years ago is excellently preserved within Victoria Fossil Cave and many other cave sites. The fossils are recognised by UNESCO World Heritage and Australian Natural Heritage designations. They are on-site displays to the public with high-quality scientific interpretations of the unique fauna of Australia from the world's most isolated continent. While the fossils are listed, the many caves themselves are not – hence SMK's preparation for a South Australian State Heritage nomination.

Elements of all these and many other important scientific aspects are threaded throughout DEWNR's State karst assets from the western border to the east. Even older karst remnants are tucked away in some of our Ikara-Flinders Ranges parks.

SMK science is informing the preparation of more State Heritage Natural site nominations – eg the Tantanoola Caves (not in limestone but in dolomite affected by nearby volcanism) and the non-karst geological sites of Shingle Beach near Whyalla and Glacier Rock near Victor Harbor.

In 2015, the South Australian Government commenced an initiative to promote 'Nature-based Tourism' through better public engagement with DEWNR Parks. This concept could also include more utilisation and visitation for some of our 'Built' and 'Natural' Heritage features. Finding a balance between public visitation and preservation of the feature or area can be a delicate issue in promoting awareness of Heritage features. It is here where the opinions of SMK scientists can count.

Dalhousie Springs wetland composition, function and dynamics revealed by remote sensing

Lewis, M. and Clarke, K.

School of Biological Sciences, The University of Adelaide

Presenter: Megan Lewis

As artesian spring wetlands are globally threatened by anthropogenic demands on groundwater the need for effective monitoring increases. However, the natural range of variation in these aquatic habitats is not well documented or understood, and there are few tools available for monitoring. In arid South Australia, Great Artesian Basin spring flows support extensive wetland complexes of vegetation and surface water that vary considerably over time. Detecting anthropogenic impacts on these dynamic systems requires a thorough understanding of their natural drivers and range of variation.

We have applied a range of complementary remote sensing tools and analyses to reveal new insights into arid spring-fed wetlands, focussing on the iconic Dalhousie Springs Complex in Witjira National Park, northern South Australia. Time-series of MODIS Normalised Difference Vegetation Index satellite images since 2000 show clear seasonal pulses of seasonal greening and drying and marked longer term trends of vegetated wetland area that are strongly related to preceding annual rainfall. Even with this coarse resolution imagery, the distinct seasonal phenologies of different wetland species can be detected. This and our other studies with high-resolution satellite mapping of the Dalhousie wetlands have established relationships between spring flow and wetland area. In addition, we used Water Observations from Space (WOfS), a time series of apparent surface water derived from Landsat imagery, to further examine the pattern and drivers of intra- and inter-annual inundation extent from 1988 to 2013. We showed that there is significant variation in open water

extent within and between years, even though gauge records show the spring flows to be relatively constant. We determined that inter-annual variation in open water extent was moderately positively influenced by annual rainfall, and that intra-annual open water extent was strongly negatively related to temperature. Furthermore, we determined that open water area was anomalously high for the two most recent years, suggesting that removal of invasive species may have reduced evapotranspiration. Our current research at Dalhousie Springs is analysing airborne hyperspectral imagery and digital photography to detect and map the extent of invasive date palms within Dalhousie, using advanced approaches to feature recognition within the images.

These combined studies demonstrate the power and benefit of complementary remote sensing approaches to reveal new information about the composition, function and dynamics of this important ecosystem, and point the way to cost-efficient, spatially-explicit wetland monitoring tools.

How can managed inundation and groundwater manipulation affect River Murray floodplain soil salinity and vegetation health? An insight provided by numerical modelling

Li, C. and Green, G.

Science, Monitoring & Knowledge, Department of Environment, Water and Natural Resources

Presenter: Chris Li

The ecological health of the River Murray floodplains has deteriorated substantially over several decades, due to river flow regulation resulting in reduced flooding frequency and elevated groundwater salinity. The South Australian Riverland Floodplain Integrated Infrastructure Program (SARFIIP) is to establish infrastructure that will enable management options including managed surface inundation and manipulating and maintaining the freshwater lenses in the watertable aquifer through groundwater pumping.

One of SARFIIP's objectives is to enhance ecological conditions to promote health and resilience of flora and fauna. This requires the establishment and maintenance of root zone salinity conducive to the health of floodplain vegetation. To enable the potential salinity benefit to the root zone to be assessed, modelling was undertaken to examine the variation of vertical water and salt fluxes in the unsaturated zone under the proposed management methods.

A suite of unsaturated zone models representative of various floodplain conditions was developed using LEACHM, which is a one-dimensional process-based model of water and solute movement in variably saturated media. Since the floodplain environment is highly heterogeneous, different combinations of soil profiles, vegetation rooting depths and watertable depths were considered. Management scenarios simulated included (i) no actions; (ii) groundwater freshening; (iii) managed surface inundation and (iv) groundwater freshening and inundation combined.

The model results show that if no actions are undertaken, soil salinity near the surface will keep increasing due to capillary rise and evapotranspiration. Where freshening of saline groundwater occurs, the lower soil profile benefits from slightly reduced salinity but upper soil layers (0–2 m) remain saline for the duration of a 100-year simulation. Where managed surface inundation occurs, significant freshening of a previously saline soil profile is possible. Where groundwater freshening and inundation occur in combination, the salinity of the entire soil profile can be reduced in the long-term. However, the success of this combination of management actions is highly dependent on the spatially variable permeability of the floodplain's clay soils and is moderated by the presence of deep rooted vegetation, which may draw saline groundwater upwards.

Microbial Old Friends: looking for 'win-wins' in biodiversity management and human health

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Presenter: Craig Liddicoat

Emerging evidence suggests that environmental microbes may provide an important ecosystem service that is essential to human health. Humans have evolved in close contact with biodiverse microbiota (communities of microorganisms) from soil, vegetation, animal, freshwater and ocean sources. These environmental microbiota overlap and interact with our own human microbiota (associated with the gut, skin, airway and other barrier tissues) and provide beneficial stimulation and education of the human immune system.

In recent decades, particularly in western countries, the rising pandemic of allergic, autoimmune and chronic inflammatory diseases, and other microbiota-related diseases such as obesity, depression and some cancers, have been partly attributed to a loss of contact with microbial diversity and/or critical microbial species from the environment. 'Microbial Old Friends' is the term given to the group of microorganisms, with which humans have co-evolved, that complement normal immune functioning—and these are supplemented from our ambient surroundings.

With the advent of next generation DNA sequencing technologies, we now understand that different types of plants, soils and animals are associated with different compositions of environmental microbiota. Loss of macro- and landscape-scale biodiversity also translates to a loss of microscale/ microbial biodiversity. Given the connection between environmental microbiota and human health, we should be able to improve public health outcomes through environmental management

that enhances environmental microbiota linkage mechanisms, while at the same time improving biodiversity outcomes.

However, this is a relatively new area of multidisciplinary science with many knowledge gaps. It is difficult to know where and how the most cost-effective outcomes will be achieved, or where research efforts should be prioritised. New research is attempting to identify key associations between landscape-scale environmental attributes, features and change scenarios, and health outcomes that have a plausible underlying microbial linkage. This will help build insight into these mechanisms, provide early clues on designing new green space health treatments, and help prioritise environment x health relationships that should be targeted for follow-up detailed multidisciplinary research to unveil causal mechanisms.

Imaging submerged structures along the Adelaide coast line using an airborne small footprint bathymetric laser scanner

Lieff, W., Hacker, J.M., Ewenz C.M., McGrath, A.J.

Airborne Research Australia

Presenter: Wolfgang Lieff

To gain full insight into coastal processes, it is necessary to include the coastal waters and, perhaps even more importantly, knowledge about the features on and just above the seafloor – at least off-shore from the high water mark for several hundreds of meters. This is particularly important, where the coastal waters are very shallow for considerable distances off-shore, such as for instance along the Adelaide Coast line. A new tool has become available at Airborne Research Australia – ARA for rapidly and cost-efficiently surveying such features at high spatial resolution and at 3D – a "green" small footprint LiDAR for both, bathymetric as well as terrestrial targets. Main tools for such surveys have been multi-beam acoustic sounders mounted on boats or vessels, or for very small areas, observations taken by divers. Although multi-beam sounders can map the seafloor at very high spatial resolution, the process is comparatively slow and only available if the waters are accessible by boat. Airborne LiDAR bathymetry does not have such limitations. We present first results from trials using the bathymetric lidar, including examples from the Murray Mouth, southern Adelaide Beaches and saline pools near St. Kilda.

Operating Principle

While the basic principle of rapidly repeated 'time-of-flight' measurements of laser pulses of known origin and direction is the same, bathymetric lidar (Figure 18) is significantly more complex than purely 'dry' systems, the key obstacles being:

a) As commonly used infrared wavelength are strongly absorbed by moisture, a green laser, close to the best transmissivity of water, needs to be used.

b) Due to refraction, the propagation vector of the laser pulses changes direction at the air/water interface, which needs to be accounted for (and is also dependent on factors like temperature, salinity and their respective gradients).

c) Small particles and air bubbles suspended in the water cause a great number of return signals at intensities comparable to water surface and bottom, requiring significant filtering. (but in the process also yield a measure of the particle load present in the water).

d) As the receiver telescope needs to be highly sensitive to visible light, it can be 'blinded' by sun-glint, requiring appropriate scheduling and orientation of flight patterns.

ARA's trials of the VQ820G system

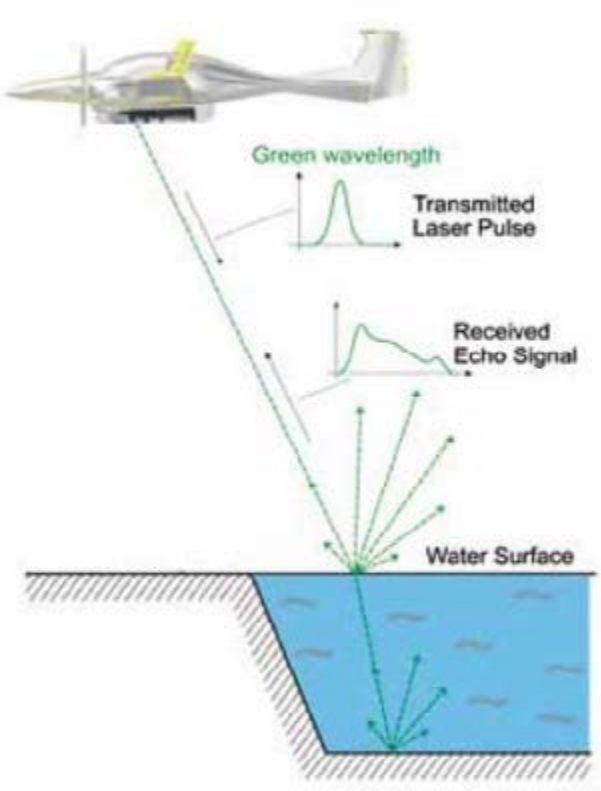

Figure 18. Airborne LiDAR bathymetry.

The Riegl VQ820G unit is one of the first (if not currently the only) bathymetric lidar system small enough to be carried by quiet and efficient light aircraft with a very small environmental footprint (the latter being a very important consideration for measurements in ecologically sensistive areas).

After successfully integrating the system into one of it's ECO-Dimona aircraft, ARA performed a number of trials over the Christmas/New Year period 2015/16, covering an number of coastal and similar shallow water/land interface situations.

Examples of first Results

An overlay of a digital elevation model generated from the lidar data measured at Sellicks Beach and aerial photography (Figure 19) illustrates the seamless continuation

Figure 19. Overlay of a digital elevation model generated from the lidar data measured at Sellicks Beach and aerial photography.

of the coastal topography from land to the intertidal zone and into the permanently submerged area (useful return signals were recorded up to about 7.5 m water depth)

A similar overlay of data from the Murray mouth (Figure 20) clearly shows the submerged scars of recent dredging and also illustrates loss-of-signal situations caused by foam, spray, etc., which would require multiple overpasses and mosaicking/ stacking in order to recover sufficient data in disturbed areas.

Managing and adapting to secondary salinity and altered hydrology in a Ramsar listed lake suite – Lake Warden wetland system case study

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Presenter: John Lizamore

Sections of the Lake Warden Wetland System were listed as a wetland of international importance under the Ramsar treaty on 7 January 1990. The system, which consists of 8 major lakes and more than 90 satellite lakes, are fed by a catchment of around 212 000 ha. Of this catchment, more than 80% has been cleared for agriculture and less than 15% remnant vegetation remains. In November 1996, the Lake Warden catchment was included under the State Salinity Action Plan as a Recovery Catchment to manage the threat of secondary salinity. Management authorities need to test and set hydrological management objectives, within the uncertainty of climate change, covering salinity and other water quality parameters, not just lake levels, to ensure this and similar sites can remain valuable bird habitats into the future.

Figure 20. Overlay of a digital elevation model generated from the lidar data measured at the Murray mouth and aerial photography.

Over a period of a decade, several research initiatives identified and confirmed altered hydrology, including secondary salinity, as the biggest threat to the ecological character of the Lake Warden Wetland System. As a result, several engineering and management interventions were assessed, recommended and implemented. These include revegetation of priority areas identified .within the catchment, drainage works to reduce excessive high water levels and the removal of various anthropogenic hydrological flow constraints within the catchment. This led to the successful achievement of management objectives with regard to target water levels within the system and some recovery of vegetation and waterbird composition and abundance, especially at Lake Warden. As the system started to recover, a review of the historic monitoring data in 2012 revealed a number of potential issues, which included the potential inaccuracy of the previous data (specifically the water balance model); the possibility of incorrect surrogates used as environmental indicators (e.g. lake depth); and the possibility of a more rapid decline of the system health than what was previously envisaged as a result of secondary salinity (mainly experienced in one of the major lakes of the system, Lake Warden).

In 2013 it was confirmed that further recovery of waterbird assemblage was being limited by the increased salinity due to additional salt loading which affected shorebird food resources (aquatic invertebrates). As a result, further research and monitoring was conducted, aimed at informing future management interventions. This included evaporation monitoring of various saline lakes; improving the understanding of the groundwater and surface water interaction within the system; research into why pink lakes are pink; and how pink lakes could possibly be recovered if altered (e.g. Pink Lake, which has not been pink for more than a decade).

In August 2014, the Recovery Program entered a care and maintenance phase and all research ceased. However, continued financial support from South Coast Natural Resource Management and University of Western Australia ensured the *Pink Lakes Project* ran to fruition in May 2015. Currently, the results of the research is in process of being written up, but conclusions include the confirmation that Pink Lake's iconic pink colour can be recovered

if the salinity level in the lake were to be restored; Lake Warden's shorebird assemblage recovery can be ensured through more active management of the surface water level and/or salinity levels; and Electrical Conductivity as a surrogate measurement for salinity levels within hyper saline systems are inaccurate and measurement procedures must be adapted to reflect and/or correct this aspect

Botany 2016 — Past, present and future

Restoring South Australia's native vegetation

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Presenter: Andy Lowe

With less than 10% of native vegetation remaining in some areas, habitat restoration is a key conservation activity in South Australia. However several issues remain problematic with these activities. First, rather than restoring a pre-clearance "Garden of Eden", how do we establish habitat that is going to be resilient to the future challenges of climate change. Second how do we avoid establishing restoration plantings that are "genetic ghettos", when we only have a fragmented landscape from which to source seed. And third how do we rapidly and effectively monitor restoration success and the functional return of ecosystems, beyond the simple counting of stems per hectare? This talk will address and present some options for each of these issues.

A landscape approach to invasive species management

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Presenter: Miguel Lurgi Rivera

Biological invasions are not only a major threat to biodiversity, they also have major impacts on local economies and agricultural production systems. Once established, the connection of local populations into metapopulation networks facilitates dispersal at landscape-scales, generating spatial dynamics that can impact the outcome of pest management actions. Much planning goes into landscape-scale invasive species management. However, effective management requires knowledge on the interplay between metapopulation network topology and management actions. We help fill this knowledge gap using simulation models to explore the effectiveness of two common management strategies, applied across different management extents and according to different rules for selecting target localities in metapopulations with different network topologies. These management actions are: (i) general population reduction, and (ii) reduction of an obligate resource. The reduction of an obligate resource was generally more efficient than general population reduction for reducing populations at landscape-scale. However, the way in which local populations are selected for management is important when the topology of the metapopulation is heterogeneous in terms of the distribution of connections among local populations. We tested these general findings using real-world scenarios of European rabbits (Oryctolagus cuniculus) infesting agricultural landscapes in Western Australia. These tests confirmed that when metapopulation structure is highly homogeneous, for example in large metapopulations with high proximity and connectivity of neighbouring populations, different spatial management strategies yield similar outcomes. Therefore directly considering spatial attributes in pest management actions will be most important for metapopulation networks with heterogeneously distributed links. Our modelling framework provides a simple approach for identifying the best possible management strategy for invasive species based on the metapopulation structure and the amount of control capacity at hand. This information can be used by managers trying to devise efficient landscape oriented management strategies for invasive species and can also generate insights for conservation purposes.

Investigating the offshore migratory movement of southern right whales: addressing critical conservation and management needs

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Presenter: Alice Mackay

The southern right whale (*Eubalaena australis*) (SRW) has a southern hemisphere circumpolar distribution between latitude 16°S and 65°S. Between May and October, a portion of the Australasian population aggregates at calving grounds in coastal Australian waters before migrating to offshore feeding grounds. However, the timing and route taken to these feeding grounds is unknown. Nine individual adult SRW were satellite tagged at the Head of Bight (HOB), South Australia, in September 2014. There was high variability in tag performance, but sufficient data were received to describe the migratory movements of three

adult females accompanied by calves. Two whales migrated directly south from HOB, while one, after a period without data transmissions, moved west from Albany, Western Australia, into the Naturalist Plateau. Individual movement tracks were related to oceanographic features associated with areas of upwelling or high productivity. This study highlights the need for further information on offshore movements of SRW from Australia, to inform the conservation of this species and management of anthropogenic activities, particularly as populations continue to recover.

Of life and land; the journey of Pinery fire recovery and the role of NRM

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Natural Resources Adelaide and Mt Lofty Ranges, Department of Environment, Water and Natural Resources

Presenter: Taryn Mangelsdorf

The Pinery fire started November 25 2015. It burnt 85,000 hectares of prime cropping country in seven hours with a perimeter of 265 km. It destroyed at least 91 houses, 271 farm buildings, 17,986 sheep and numerous other livestock.

With a considerable disaster comes significant consideration to engaging people. Experiences show that multiple levels of engagement are required to cater to community demand for information and resources at different stages of their recovery journey. Following on from our learnings of the recent Eden Valley and Sampson Flat fires, a range of engagement strategies and information materials are being employed, including media releases, fact sheets, web content, community events and individual property visits. Each method of engagement is designed to move landholders through stages of attitudinal change; in some cases simply making individuals aware of information is the goal, while in others engagement aims to result in changes to, and maintenance of, land management practices.

The diversity of information across various platforms ensures easy access for the community and caters for different levels of ability, interest and in their own time. Particularly early in the recovery process, information delivery needs to be as simple and targeted as possible to convey key messages and avoid an information overload.

Engagement strategies are tailored to the different demographics within the fire scar including lifestyle farmers, industry and agricultural groups. The farmers affected are generally long-term farming families, highly skilled and well-connected. They are self-reliant and work within their trusted communities. Without our established relationships with the agricultural bureaus, our ability to provide assistance and be accepted by the farming community would have been limited.

Recovery is long-term and multi-facetted. One step to recovery for people and land is to see vegetation back in the landscape. Natural Resources are working with local councils and other organisations to provide 20,000 native plants to fire affected landholders. These wind break packages will mitigate soil erosion by altering wind patterns, provide shelter for stock, and psychologically aid people's recovery by seeing 'green' across the barren plains.

The region has been using no-till farming practices for 20-30 years. This retains soil moisture over summer, provides protection for future crops to be established. It also reduces wind and water erosion, and helps soil retain health and structure with minimal disturbance.

The fire came through mid-harvest and burnt all crops and stubble that normally cover the landscape. Wind following the fire has mobilized the unstable soil and has resulted in significant soil erosion. This is a major concern for farmers who have significantly improved the soil health through best practice no-till farming methods. It also makes living conditions challenging, affecting both the farming land and residential properties.

To counteract the erosion potential, farmers have been cultivating paddocks and have called this 'emergency tillage'. Cultivating creates ridges that lighter soils can be trapped in. It also brings up soil with a higher clay content where the clay layer is accessible to the cultivator.

Cultivating is not an option for sandier soils where the clay layer is deeper. Natural Resources have partnered with PIRSA Rural Solutions to start spreading clay on the sandier patches in the landscape. This clay is typically sought from on-farm to reduce costs and is tested for pH to ensure it's the right mix. Clay is spread across the paddocks at a considered rate to help stabilize the sands. Closer to sowing time, it is cultivated into the top layer of the soil to change the soil composition to one more favourable to growing crops.

This year the farmers with cultivated paddocks are faced with how to sow this year's crop. Can they continue with the no-till sowing methods, or do they revert to sowing methods from years gone by?

Another issue is available machinery, with so much lost in the fire. On top of this, they have insurance to work out, lives to rebuild, and families to take care of. All of these are considerations when Natural Resources are effectively engaging with fire-affected landholders.

Farmers have an intrinsic connection to the land, and their personal recovery from fire is deeply connected through the recovery of the land. Through case studies, we will discuss how successful partnership with landholders and groups can lead to practice change with those who have lived through this fire.

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Deriving hydro-ecological relationships for temporary rivers: a trait-based approach

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Presenter: Sally Maxwell

Temporary rivers are ubiquitous globally yet generally poorly represented in worldwide research. General principles describing relationships between hydrology and ecology in these systems are only just emerging. Temporary rivers are particularly vulnerable to climatic and anthropogenic disturbance and general relationships are required by managers to determine the amount of water which can safely be taken for agricultural use. Trait-based macroinvertebrate metrics show promise for determining relationships between hydrology and ecology. They are likely to provide a more mechanistic understanding of response than traditional structural metrics bounded by taxonomic classifications. We used long-term macroinvertebrate monitoring data to derive trait-based functional groups to test key relationships between hydrology and ecology. We predicted that species richness and traits associated with resilience mechanisms would respond negatively to increasing levels of flow intermittency where as those associated with resistance would increase. We determined that there were clear relationships between increasing flow intermittency and macroinvertebrate trait groups where dominant trait states were associated with resistance and resilience strategies. Species richness declined with increasing flow intermittency. In general, groups with resistance dominated trait states increased whereas groups with resilience dominated trait states decreased in response to flow intermittency. The general relationships discovered in this study support our hypotheses of macroinvertebrate response to increasing intermittency of temporary rivers and contribute to the emerging understanding of the structure and function of temporary rivers.

Translating restoration goals into functional trait targets: comparing remnant communities to early restoration outcomes

Maxwell, S.E., Jellinek, S., Willoughby, N. and Meffin, R.

Presenter: Sally Maxwell

Determining the success or otherwise of restoration activities is a key requirement for land managers and ecological practitioners. Broad-scale clearance of land for agriculture and other purposes has resulted in degraded ecological communities through loss of biodiversity and function.

Restoration programs require clear goals and carefully chosen metrics to be able to demonstrate restoration success or otherwise both in the short and long term. Functional targets are increasingly the goal of managers who aim not only to conserve species, but the functional components and ecosystem services provided. Species traits provide an important link to the function of ecosystems.

We assessed the recovery trajectory of a landscape scale restoration project using key 'soft' traits to determine functional diversity of revegetated plots varying in age from 1 to 5 years since planting compared to remnant vegetation. We hypothesised that the older plantings would be more similar to remnant than newer plantings.

Contrary to prediction our results showed that years which were planted most recently were more similar to remnant. This is likely due to the short time since planting and the conditions in the specific years of planting as well as practitioners' ability to manage adaptively. Clear functional targets were developed for comparison in subsequent years by determining which traits and trait values achieved restoration goals.

The effects of permanent netting enclosures on fruit production and water efficiency

May, M.

Presenter: Mark May

Natural Resources South Australian Murray-Darling Basin, Department of Environment, Water & Natural Resources.

Growers of high value crops understand the benefits permanent and temporary netting enclosures bring to their produce due to the protection offered. What is less understood is the effect netting has on water usage and water use efficiency. This project has been established to quantify water efficiency gains and improved fruit quality production that is often subjectively observed by growers when permanent netting enclosures are used in horticultural production systems.

Natural Resources South Australian Murray-Darling Basin (Natural Resources SAMDB) and Primary Industries and Regions South Australia (PIRSA) have teamed up to fund a three year study showing the benefits and challenges investing in permanent netting structures brings.

The project is working with both an apple producer and citrus producer who have invested significantly in enclosing a large amount of their producing fruit trees with netting covers in the South Australian Riverland. More than 100 hectares of highly productive fruit trees have been netted in recent years and starting to show substantial benefits. With large water usage decreases being made over the previous decade through drip irrigation technology, could netting infrastructure of this type be the next practice responsible for making further savings?

Whilst there have been anecdotal reports of significant increases in crop quality and water savings, there is yet to be a study which quantifies this information in Riverland horticulture production systems.

The study will look at:

- crop water requirements and water use efficiencies between netted and un-netted trees
- cost benefit analysis of the investment in netting
- benefits netting enclosures can bring to production systems, comparing this to return on investment
- influence the nets have on fruit yield, quality and fruit characteristics
- consequence of change in climate under netting and what this means for the fruit produced

Weather stations and soil moisture monitoring equipment have been installed within the netted areas and in adjacent un-netted orchards on the producers' properties.

The weather stations will monitor climate from within the enclosures and compare this data with weather stations from Natural Resources SAMDB weather station network. These weather monitoring devices measure basic climatic information such as; temperature, wind speed and direction, humidity, rainfall, soil temperature and global solar radiation. The basic measurements are used to further calculate growing degree days, chill hours, evapo-transpiration, delta T, dew point, apparent temperature and frost. Since September 2015, the weather stations have been recording climate data every fifteen minutes from within the netting enclosures and comparisons have been made with the local stations outside of the netting enclosures.

Both project sites have soil moisture monitoring systems where the data collected will compare measurements for soil probes installed within the netted areas against probes in adjacent un-netted soils. Water usage will be audited to show actual water use per hour and used in conjunction with the properties irrigation scheduling to monitor actual water use per site at a range of depths through the soil profile.

Further analysis will be able to identify the benefits or challenges to fruit quality, production and water use.

Collaboration of two government departments, research and development organisations, industry, agribusiness and producers has established the direction of the project and will provide a wide ranging set of skills and resources to the project.

The Adelaide University will analyse the collected data, with Renmark horticultural, irrigation and consultancy company, AgriExchange to provide technical support to the study. Citrus Australia South Australia (CASA) and Apple and Pear Growers Association of South Australia (APGASA) have provided a means to sourcing supporting literature which will value add to the project. Both industry groups will provide the platform for the information and results to be extended from.

The study will run for three years, beginning August 2015 and conclude 30 June 2018. A summary report will be produced for each growing season. The final report will discuss the benefits the investment brings to water usage and fruit production along with the challenges and limitations discovered.

A priority of the South Australian Murray Darling Basin Natural Resources Management Board is to support producers to better understand where future water savings can be made in their farming systems and increase their water use efficiencies. Investing in these practices will sustain more productive and profitable operators now and into the future whilst improving water use efficiency and reducing irrigation water requirements per unit of crop production.

Is planting arrangement important? The influence of population density and aggregation on seed production in a revegetated woodland

McCallum, K., Paton, D., Breed, M. and Lowe, A.

The University of Adelaide, School of Biological Sciences

Presenter: Kimberley McCallum

Biodiversity loss and land degradation are particularly evident in temperate southern Australia as a result of extensive vegetation clearance for agriculture. Large scale revegetation has been promoted to counter this, but re-creating ecosystems is a complex process and needs to move away from simply returning trees to the landscape. To date, revegetation success is often measured by the number of individuals planted or the area restored, rather than ecological outcomes and as such, concern surrounds the effectiveness of many revegetation attempts.

Re-creating more natural plant arrangements has been promoted as a way to improve revegetation outcomes. In natural systems plant arrangements influence a range of ecological processes such as pollination and competition, but the role of planting arrangement in revegetated sites is poorly understood. Seed production in revegetated *Eucalyptus leucoxylon* (Blue Gum) was measured to determine the influence of planting arrangement on pollination. Seed production was assessed as a function of population density, aggregation and distance to neighbouring *E. leucoxylon* trees. Seed number per capsule was highly variable between trees, but in general nearest neighbour distance and aggregation were better predictors of seed number per capsule than population density. There was a trend for aggregated individuals or those with a near neighbour to produce more seeds per capsule than dispersed individuals. Consequently, more careful consideration of the fine-scale arrangements of plants during revegetation works may be necessary to improve pollination and seed production in revegetated systems.

More's the MERI-er: Application of the MERI framework to describing and managing the CLLMM region

McEvoy, P.

Department of Environment, Water and Natural Resources

Presenter: Paul McEvoy

As the Coorong, Lower Lakes and Murray Mouth (CLLMM) site emerged from the dual challenges of the Millennium Drought – with eight years of mostly less than the long term median flow - and more than a year of flows at the 75th to 95th percentiles - the NRM approach shifted in terms of both the information base and the level of understanding to support site management.

In a project jointly funded by the Australian and South Australian governments under the CLLMM Recovery Project from 2011 to 2016, the quantity of 'information monitoring' relative to 'understanding monitoring' that the program sought to invest in was managed via the MERI process; with the balance changing in a manner comparable to a regime shift. Monitoring in the early and middle phases was characterised by traditional survey and analysis of findings that were discrete to scope. However, since mid-2014, the purpose for monitoring investments moved from one of a generic question of: '*What is there?*' to one of: '*How does it work?*'

The change in monitoring purpose saw investment in data collection and analysis within ecosystem components become a lesser priority. A correspondingly-increased emphasis was placed upon the development of synthesis reports, conceptual diagrams and other infographics with leading experts in a range of NRM disciplines. These outputs are far better suited for assisting the management of the Ramsar site's Ecological Character. Examples of the re-framed monitoring questions and the synthesized understanding of ecosystem workings (for waterbirds, fish, water quality and estuarine invertebrates) will be presented and discussed.

A future step will involve unifying thinking across disciplines regarding integrated conceptual models of site 'working' and the interpretation of ecological information related to temporal changes. Initiatives in train for future production are report cards, monitoring frameworks, as well as technical, popular and community publications.

The utilisation of MERI tools in this manner – through: adopting the practice of ongoing, cumulative conversion of information to understanding, evidence gathering and using an evaluation/learning-while-doing approach, are considered best practice. We seek your consideration for embedding them in NRM Science endeavours.

How to get higher precision in ecological field surveys (and a comparison of formulas for estimating confidence intervals for the systematic survey sample mean)

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Presenter: Richard McGarvey

We statistically evaluate common choices for implementing ecological field surveys using quadrats or transects. Using simulation, we estimated the precision delivered by various field survey design combinations in populations of organisms that cluster in 2-dimensional space. Three common design choices are evaluated: random or systematic sample allocation, sample plot shape, and sample size. Specifically, we address the following questions: (1) Which is more precise, simple random or systematic sampling? (2) If systematic sampling is substantially more precise (in clustered populations), why is it not always used? (3) For systematic surveys, how can we best estimate the sampling variance (which gives confidence intervals on the survey sample mean)? (4) Regarding sample plot shape, which is more precise in clustered populations, long thin transects or square quadrats? The (to some, surprising) outcomes can assist the design of field surveys by quantifying the potential for large improvements in survey precision. The precision comparisons of random with systematic sampling depended on the spatial scale of population clustering and sample size. Some of these results were given in Ecological Applications 26:233–248.

Practical guidance on representing uncertainty in hydrological predictions

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Presenter: David McInerney

Understanding the uncertainty in hydrological model predictions is critically important for risk assessment and managing water resources. The appropriate statistical representation of residual errors (i.e. differences between simulated and observed flows) is essential for accurate and reliable probabilistic predictions of streamflow. Residual errors of hydrological predictions are often (i) heteroscedastic, with magnitude of error increasing with magnitude of runoff, and (ii) persistent, with errors exhibiting temporal autocorrelation. In this talk we will illustrate why heteroscedasticity

and persistence are important, and how different representations of these characteristics can influence predictive performance. Importantly, for hydrological practitioners, our findings will provide practical guidance on the selection of approaches for modelling heteroscedasticity and persistence. This will enhance their ability to provide hydrological probabilistic predictions with the best reliability and precision for different catchment types.

Botany 2016 — Past, present and future

Molecular and isotopic insights into botanical history in South Australia

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Presenter: Cesca McInerney

The isotopic and molecular signatures of plants reflect their environment, physiology and phylogeny and can be used to understand both modern and ancient ecosystems. Carbon isotope ratios of leaves record photosynthetic pathway (C3, C4 or CAM), water stress and closed canopy environments. As a result, carbon isotope ratios are used to examine these features in agricultural, wild and fossil plants. The composition and isotopic ratios of leaf waxes similarly can reflect photosynthetic pathway, plant habit and climate. Leaf wax compounds are particularly valuable in reconstructing ancient ecosystems as they are ubiquitous and can be preserved in sediments for millions of years. In order to interpret these chemical signatures in both modern and ancient ecosystems, we examine: (1) a single species (*Dodonaea viscosa*) along a climatic gradients in South Australia; (2) dominant plant taxa and soils along SA and the NT, including TERN AustPlots and TREND sites; and (3) carbon isotope ratios of fossil leaf cuticle to reconstruct canopy structure in Cenozoic forests.

In our study of Dodonaea viscosa across SA, we find aridity is correlated with carbon isotope signature, leaf wax composition and leaf morphology. These results suggest that these leaf traits are correlated with climate, such that they may be useful for examining responses to future climate change and for reconstructing palaeoclimate.

To understand the processes influencing leaf wax records in sediments, we compare the composition of leaf waxes accumulated in soils to the composition of the dominant plants from a latitudinal transect across Australia. We find that the leaf wax signatures in soils do not correspond to the dominant plant taxa. This discrepancy could result if plant communities changed substantially over the duration of the soil's development.

We use carbon isotope ratios of fossil leaves to examine forest canopies in Eocene-Miocene (56 – 5 Million year old) forests in southeastern Australia. Closed canopy forests lead to larger ranges in carbon isotope ratios due to the diversity of light environments and the range in atmospheric CO_2 carbon isotope ratios from the understory to the upper canopy. We find that the Eocene, Oligocene and Miocene forests all indicate highly closed canopy structures, with both angiosperms and gymnosperms occupying a wide range of canopy environments.

Diversity and fire: a conservation conundrum in understory plants from two Kangaroo Island mallee communities

McKenna, D.J.

Department of Environment, Water and Natural Resources

Presenter: David McKenna

Widespread disturbances such as bushfire have the capacity to affect processes that influence variation in community composition (beta-diversity), leading possibly to convergence (low beta-diversity) or divergence (high beta-diversity) in community structure across the landscape. Recent research has shown that changes in beta diversity occur as a result of either spatial turnover of new species, a nested subsampling of existing species, or a combination of both. Identifying the underlying components of beta diversity variation is important as these have different conservation implications.

In this study, spatial and temporal changes in plant community composition were examined at 16 mallee sites from two vegetation communities across western Kangaroo Island. Surveys were conducted in 2002 and 2004, prior to a large scale bushfire in December 2007 that burnt 96% of the native vegetation in the area, providing an opportunity to measure the post-fire changes in 2010 and 2013. Plant species composition was compared and total beta diversity was partitioned into turnover and nestedness components to better understand the site to site variation across both space and time.

I found a total of 186 species across all sites. Mean site species richness was variable depending on the site, season and vegetation type, but increased significantly for both communities following fire (+45% for *E. remota* sites and +130% for *E. diversifolia sites*), although *E. remota* sites had higher species richness both before and after the fire.

For each vegetation type, spatial beta diversity patterns were similar across sample years, although sites were less similar in *E. diversifolia* than in *E. remota*. Site to site variability was generally high, with differences strongly driven by species turnover rather than subsampling in a nested fashion. Mean beta diversity components of single site analysis before and after fire revealed that 38% and 25% of the species were unique to the pre-fire samples respectively. Temporal changes at a site were less than between sites in any year, with nestedness a stronger component of total beta diversity between times.

From a conservation perspective, high mallee spatial variability means consideration of the location of conservation actions may be important. The implications for maintenance of ecological fire regimes in this landscape will be discussed given the difference in diversity and composition between the two mallee communities, which are not differentiated at the Major Vegetation Subgroup level used for determining these regimes.

Fire management for Red-tails

Ezis, D. and McKenna, D.J.

Department of Environment, Water and Natural Resources

Presenter: David McKenna

Fire and Flood Management in the Department of Environment, Water and Natural Resources (DEWNR) has responsibility for the implementation of the prescribed burning program across DEWNR managed lands and other lands deemed appropriate for landscape-scale risk reduction in South Australia. As well as risks to life and property, environmental risks from natural and prescribed fires are given extensive consideration in the fire management process. Significant threatened or pest species for which fire is a critical threat or management tool are given particular attention through the development of ecological fire management strategies (EFMS). The objective of the strategies is to develop a consistent approach to ecological fire management (across all tenures) for the particular species or issue. The strategies are developed using the same risk assessment methodology applied in DEWNR fire management planning.

Here we outline the development and implementation of an EFMS for the Red-tailed Black Cockatoo. Inappropriate fire regimes are second only to land clearing as a threat to avifauna in Australia. The South-eastern Red-tailed Black Cockatoo is one of these species susceptible to decline under certain fire regimes. However, DEWNR incorporates the ecological requirements of the Red-tail into fire management decisions and actions.

The strategy seeks to synthesise current knowledge of the role of fire in relation to the Red-tail and structure an approach to the management of fire to assist the conservation of the Red-tail. It defines ecological fire management practices and how these will be implemented throughout the Red-tail habitat.

The process highlights the importance of knowledge sharing and engagement across numerous state and local stakeholders in identifying the critical issues and developing a roadmap for species persistence in its fire-prone habitat. Furthermore, we outline the importance of collaborative networks, fostering active participation, learning through practical experience, and establishing effective means of communication when applying and evaluating the strategies objectives.

Conservation biology of the endangered sandhill dunnart (*Sminthopsis psammophila*)

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Presenter: Amanda McLean

Arid and semi-arid species are subject to a number of threatening processes, such as habitat loss, changing fire regimes and introduced predators. However, the biology of many arid mammal species is little known, making effective conservation management problematic. One such species is the nationally endangered sandhill dunnart (*Sminthopsis psammophila*). The species is known from a small number of individuals inhabiting three disjointed populations; two in South Australia and one in Western Australia. This study used a combination of ecological and genetic information to investigate 1) movement patterns and population connectivity and 2) habitat preferences of *S. psammophila* in a core population on Eyre Peninsula. We found evidence to suggest that individuals are highly mobile, presumably to track food pulses created by large rainfall events across the landscape. As such, conservation management strategies should aim to protect large areas of suitable continuous habitat to maintain viable S. psammophila populations.

Our investigation into the habitat preferences of *S. psammophila* revealed that the three most important habitat variables for predicting *S. psammophila* abundance was the number of logs (≥ 5 cm diameter), the average height of *Triodia* hummocks and the overall complexity of the vegetation. We also explored the influence of time since fire on the determination of habitat preferences, however, we did not detect a preference for a specific age of vegetation post fire. The lack of a preference for a specific age of vegetation may be due to the limited number of fire ages available in the study, however, the preference of *S. psammophila* for structurally complex habitats suggests that frequent burning of habitat may be detrimental to the species. This study has highlighted the importance of considering a range of habitat variables including *Triodia* structure and the overall complexity of the vegetation when identify potential *S. psammophila* habitat. Future research should focus on the foraging behaviour of *S. psammophila* to gain a greater understanding of how the habitat is used and identify critical habitat used during poor resource years.

The Riverland Rangers Working on Country project – Most Significant Change Evaluation

Arnold, B., Koolmatrie, C., Lee, A.,
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Natural Resources South Australian Murray-Darling Basin, Department of Environment, Water and Natural Resources

Presenter: Phil McNamara

An evaluation of the Riverland Rangers Working on Country (WOC) project has demonstrated that Aboriginal involvement in natural resources management programs can result in a range of important social outcomes for Aboriginal people, including social changes for those involved, their families and the broader Riverland Aboriginal community. The process also demonstrated the value of the Most Significant Change technique[1], developed by Rick Davies and Jess Dart, as an appropriate tool for evaluating the social outcomes of natural resources management projects and programs.

The Riverland Rangers Working on Country (WOC) project at Calperum and Taylorville Stations near Renmark employs six Aboriginal Rangers to undertake a range of land management activities to protect the area's important environmental and cultural values. The project also has two social objectives that focus on building the capacity of participants (through their employment and training) and the wellbeing of participants, their families and the Aboriginal community.

Although the land management activities of the project are relatively easy to record (for example, how much fencing has been built or how many trees have been planted), the social outcomes of the project are more difficult to measure.

The participatory and qualitative evaluation technique 'Most Significant Change' was used to investigate these harder to measure social outcomes. The aims of the evaluation were to:

- Learn about the broad range of changes resulting from the project
- Identify opportunities for project improvement
- Learn about other peoples' perspectives on what they value most about the project
- Communicate the findings to the participants, project partners and (if appropriate) to the broader NRM community

The evaluation initially involved interviewing a wide range of people involved in the project, from which 21 stories of change were created from transcripts. Stories were discussed and analysed at a workshop to identify common changes experienced under three 'domains of change': changes in the participants' lives, changes in the participants' family, and changes in the Riverland Aboriginal community. Workshop participants included members of the First Peoples of the River Murray and Mallee, South Australian Murray-Darling Basin Natural Resources Management (NRM) Board and NRM Group members, State and Australian Government representatives, and Department of Environment, Water and Natural Resources staff. Participants broke into small groups and participants took turns to read a story aloud. Notes were made in response to the following questions.

1. What important changes does the story illustrate for:

- The participant
- The participant's family
- The Aboriginal community
- Other?

2. Does the story highlight any important:

- Things that are working that we don't want to lose?
- Issues / areas for improvement?
- Future directions or actions?

3. If the story is considered the most / one of the most important – why?

The workshop found that the project is resulting in a range of important social outcomes. Rangers have developed increased capacity, pride and confidence, their families have experienced an increased sense of pride and financial security, and the rangers have become positive role models within the wider Riverland Aboriginal community. From the 21 stories, three were chosen as the 'most significant' because they most strongly demonstrated these social outcomes of the project.

Following the workshop, a secondary analysis of the findings was undertaken to:

- Identify the most frequent changes observed across all 21 stories.
- Identify the most frequent changes within each of the domains of change.
- Identify what is working well, what can be improved and future directions.

This involved thematic coding of the workshop comments, which were assigned their story number and assigned to categories (or themes) that accurately reflected the underlying meaning of each comment. This analysis highlighted a range of common direct and flow-on outcomes from the project, and verified many of the above workshop findings. The secondary analysis also identified a number of areas where the social outcomes could be further developed, and these have become recommendations for the project. They include:

- Maintain the project into the future
- Improve pathways into the project
- Improve career development and pathways out of the project
- Improve project communications
- Strengthen links to the First Peoples of the River Murray and Mallee Region
- Continue to monitor and evaluate social outcomes
- Promote social outcome evaluation and the use of MSC

The evaluation confirmed that the Riverland Rangers WOC program contributes significantly to social changes for

those involved, their families and the broader Riverland Aboriginal community, and has demonstrated the value of the MSC technique for evaluating the social outcomes of natural resources management projects and programs.

The findings of the evaluation have been communicated using the unpublished report 'Riverland Working on Country project: Most Significant Change evaluation 2015'. The report summarises the evaluation technique and process used, presents and discusses the most significant stories identified, highlights the range of social outcomes that have resulted from the project, and makes a number of recommendations to improve the project in the future.

The Riverland WOC project is a partnership between the Australian Landscapes Trust and Natural Resources SAMDB and is supported by the SA Murray-Darling Basin NRM Board through funding from the Australian Government.

Reference:

(1) Davies. R and Dart J. (2005) Most Significant Change Technique: A Guide to Its Use http://www.mande.co.uk/docs/MSCGuide.pdf

From scrawny to brawny; Beefing up natural resource reporting

Meakin, C., Page, B., Wiebkin, A., Bald, M., McKenzie, J., Christiansen, N., Ryan, K., McLeay, L., Smith, J., Scholz, G., Grear, B. and Carruthers, S.

Department of Environment, Water and Natural Resources

Presenter: Craig Meakin

The SA Government has implemented a robust and consistent method to report on its State Natural Resource Management (NRM) Plan, and recently released a series of almost 300 report cards on the condition and management of natural resources. The scale of this achievement is unparalleled in Australia. The single-page report cards are available on the EnviroData SA website (data.environment.sa.gov.au/NRM-Report-Cards/Pages/Home.aspx). They provide an up-to-date and simple stock take of information on resource condition and management by identifying the trends in natural resource condition and related management issues across the state. The report cards cover a broad range of topics including aquatic and terrestrial resources, invasive species, community involvement in natural resource management, climate change, primary resources and tourism.

This talk aims to create a greater awareness of the report cards, and highlight the strategic approach that has been implemented to report on the state and condition of our natural resources. These report cards, if produced over a sufficient time to establish trends, will play an important role in providing information to underpin better environmental policies. The report cards will also inform state-wide investment strategies and track progress of NRM investments into the future.

The production of report cards required an expansive audit of the existing data and information. This increased our understanding of the strengths and limitations of existing information. Most importantly, this project created opportunities to better coordinate data collection and fill data gaps with new monitoring and research programs. The report cards represent the first comprehensive report on the State NRM Plan and allow for comparisons across different natural resources and across different parts of South Australia.

This talk also outlines how the report card project is continuing to develop and build on its original publication. The talk will also discuss how this project creates reporting opportunities for the next State of the Environment report, and how it is being adopted by other high profile programs in DEWNR.

Rural landscapes, stakeholder networks and biodiversity conservation: a structural analysis from Eyre Peninsula

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Presenter: Wayne Meyer

Effective collaboration and knowledge sharing between natural resource management (NRM) stakeholders is essential to achieving successful NRM outcomes. In this project, we study the structure of the collaboration network of stakeholders working on biodiversity conservation on the Eyre Peninsula and explore how this structure contributes to achieving management outcomes. Network theory has become a popular tool to describe and analyse the structure of interactions of collaborating stakeholders. With this approach, stakeholders are represented as nodes in a network connected by links representing their collaborations with other stakeholder nodes.

Based on interviews and questionnaires, we modelled the collaboration network of 129 individuals (from 24 different organisations) working on biodiversity conservation projects on the Eyre Peninsula (SA). The resulting stakeholder network displays distinctive clusters of collaboration amongst groups, and allows us to identify areas of effective collaboration within the network. Our results show a strong predominance of local collaborations in the network, and highlight the key role of the regional NRM board in acting as a broker between geographically remote, or otherwise marginalised, groups. Additionally, we exemplify how reinforced collaborations between certain institutions could promote better learning and more efficient program implementation in the long term. Overall, this study demonstrates that the application of network analysis can objectively identify elements of social-ecological systems that are working effectively and highlight those roles and connections that likely need conscious strengthening.

Regional engagement and spatial modelling for natural resource management planning – Eyre Peninsula as an exemplar

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Presenter: Wayne Meyer

Increasing global population and consumption are placing unprecedented demands on agricultural production and the use of natural resources. Agriculture has already displaced substantial areas of natural ecosystems resulting in species loss and biodiversity declines. Competing land uses are influenced by changing climate and market conditions, which makes planning for adaptation extremely challenging.

In the Mediterranean type climate regions of southern Australia, such as the Eyre Peninsula (EP), climate change projections fairly consistently indicate warmer temperatures accompanied by a decrease in rainfall. Rainfall in these regions is already the most limiting factor for crop growth. In addition to affecting crop production, rainfall reliability also influences species distributions. The Eyre Peninsula Natural Resources Management Board (EP NRM Board) has recognised that climate change is a fundamental and increasing influence on native ecosystems, production systems and water resources.

It is difficult to understand the complexity of the interacting environmental, economic, and social processes in regional social–ecological systems. Increasingly, there is a need to identify key system drivers and explore variation across multiple future scenarios for supporting decisions. Integrated solutions to the management of natural resources are required for regional land use planning to assist adaptation to increasing rates of change in climate, markets and social needs.

The purpose of this presentation is to demonstrate the application of the Landscape Futures Analysis Tool (LFAT) to the EP NRM region using a series of climate, market and biodiversity scenarios. The outputs are used to suggest planning responses to facilitate successful adaptation through land use changes. The LFAT allows users to investigate alternative future scenarios to understand likely outcomes and develop options for planning purposes rather than generate an arbitrary optimised land use configuration. An example output indicates that with a moderate warmer and drier climate, the area used for carbon sequestration will increase in all rainfall zones and it will not displace wheat in the lowest rainfall areas. In addition, weed populations will change and there will be greater competition between conservation and agricultural production priorities in the medium to high rainfall areas.

Evaporation of perennial semi-arid woodland in south eastern Australia is adapted for irregular but common dry periods

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Presenter: Wayne Meyer

Measurements of evaporation (E) from a semi-arid, *Eucalyptus* species dominated woodland (Mallee) were made during a three year period using eddy covariance instruments mounted on a 20 m high tower. There have been no previous long term, detailed measures of water use in this ecosystem. The measurement system was programmed to estimate the latent energy flux (Fe) on a half hourly basis and these values were converted to the combined soil and plant evaporation (E_{Fe}) of the site.

Total E_{Fe} for the measurement period was 70% of site rainfall implying that deep drainage below the root zone was up to 30% of rainfall. Previous measures of recharge rates are much lower than implied here and this may indicate that E_{Fe} is underestimated. Additional measures are needed to resolve this. Estimates of potential E were calculated from a suitably parameterized Penman–Monteith (EP-Mo) equation. At times immediately after rainfall, E_{Fe} rates were the same or exceeded the EP-Mo estimates. Apparent free water E from plant interception and soil evaporation was about 2.3 mm and lasted for 1.3 days following rainfall in summer, while in autumn E was 5.1 mm that lasted over 5.4 days. To examine seasonal trends in E_{Fe}, daily values were compared with reference E calculated from a wind function calibrated Penman equation (EP-Me). For periods immediately following rainfall, the leaf area index (LAI) needed to adjust the EP-Me equation to match the E_{Fe} values could be back calculated. From this, it was possible to generate an estimate of the seasonal change in LAI which varied from 0.12 to 0.46. The inferred seasonal trend in LAI compared well with that of the Normalised Difference Vegetation Index (NDVI) obtained from routine satellite derived data and LAI calculated from digital cover photography (DCP).

The validation of calculation methods used to estimate water use by the sparse vegetation of the Mallee ecosystem will enable improved estimates of water balances in these extensive, semi-arid ecosystems. Hence implications for groundwater recharge, persistence of vegetation and shifts in distribution of species can be better projected associated with climate and land use change. These insights should be incorporated into the next generation of landscape planning tools used to inform regional NRM plans.

A mapping strategy for the assessment of habitats within South Australia's Marine Parks

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Department of Environment, Water and Natural Resources

Presenter: David Miller

South Australia's Marine Park network has been fully operational since October 2014 and is divided into zones that provide different levels of protection. A basic level knowledge of the habitats and species present in the parks is fundamental to managing them effectively. South Australia's marine park system covers around 40% of state waters and the task to develop comprehensive habitat maps presents a significant challenge both in time and resources. This process has only just begun and may take years to complete, however, in some cases information is needed more immediately.. Therefore, we require a mapping strategy that combines the need to have eventually full cover mapping of benthic habitats while also being able to provide habitat information more rapidly from high priority area as needed.

This talk will describe the approach being undertaken to collect habitat information to meet management needs in SA's marine parks. This approach includes a variety of mapping methods including underwater video survey, swath sonar mapping and mapping from aerial and satellite imagery. It also prioritises sanctuary zones, the highest level of protection in the marine park system.

In particular we will focus on the development of a rapid habitat assessment method being used in the states sanctuary zones to quickly provide a basic level of knowledge about the type and extents of habitats present in zones that are currently unmapped. The information being produced with this technique will then be used guide future benthic mapping and support management decisions more broadly.

Sustainable management of the Kangaroo Island koala population

Molsher, R.

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Presenter: Robyn Molsher

Koalas were introduced to Kangaroo Island (KI) in the 1920s and quickly became overabundant, causing impacts to native vegetation through overbrowsing. In 1997, the KI Koala Management Program was initiated by the then Department of Environment and Heritage to reduce koala densities through sterilisation and translocation in order to reduce browsing pressure. Since then, >12,000 koalas have been sterilised, of which >3,000 koalas have been translocated back to their historic range on the mainland of South Australia. The population has been reduced from an estimated 29,247 koalas in 2000 down to 13,660 in 2010 (*n* =102 sites).

Although criticised as an expensive approach, the Program has significantly reduced koala densities and improved tree condition in areas where management has been focussed. However, two emerging issues are now undermining the effectiveness of the program. These are: (1) koala population numbers building up in commercial blue gum plantations where management is difficult; and (2) an increasing number of landholders restricting access to their properties now that the koala population is smaller. This is allowing pockets of koalas to breed up and disperse into neighbouring vegetation. Koalas are capable of doubling in number every four years and it is paramount that these issues be addressed as quickly as possible. Continuing landscape scale sterilisation is critical to maintaining the gains that have been achieved to date.

This paper will present the recently updated koala population estimate for the island (2015), and discuss proposed approaches to current challenges and recommendations for future koala management on KI.

Remote cameras extend monitoring of pest control and native fauna populations, Bounceback Program, Flinders Ranges

Mooney, T., Brandle, R., Koerner, D. and McKenzie, D.

Natural Resources South Australian Arid Lands Department of Environment, Water and Natural Resources

Presenter: Trish Mooney

The Bounceback Program has undertaken more than 20 years of broadscale fox control through a quarterly program that now consists of ground and aerial 1080 baiting, covering around 750 square km across the Flinders, Gawler and Olary Ranges. Previously feral fox and cat numbers have been monitored through quarterly spotlight surveys, mainly limited to *Ikara*-Flinders Ranges National Park (I-FRNP). These surveys provided long term trend data but are labour intensive and, as researchers elsewhere have found, may not detect feral predators that are more vigilant or present in low numbers. They are also limited in the area that can be covered.

We present results from systematic remote cameras surveys that commenced in I-FRNP in 2015 but are being extended to other reserves, using transects stratified across habitat types. Reconyx® cameras were deployed for 21 days in late-winter spring, covering the northern two thirds of the park. The results confirm the continuing effectiveness of fox control, with only 3 detections across 1176 camera trap nights (detection rate = 0.24%).

A number of studies in arid areas have demonstrated increases in feral cat abundance and on-going predation of native fauna following effective fox control (Christensen and Burrows 1995; Read and Bowen 2001; Morris et al. 2004; Moseby and Hill 2011). This is supported in IFRNP by spotlight survey data which indicate that, in the absence of foxes, rabbit numbers increased post-RHDV producing a cascade effect on cats. Camera results confirm the current widespread presence of

feral cats (average detection rate 2.94%), with some variance with habitat. Results are compared with detection rates in the southern section of IFRNP, where additional camera transects have been deployed as part of the Flinders fauna reintroduction.

Macropods, principally euros and red kangaroos, were detected at all sites, peaking at a detection rate of 88% in *Triodia* grasslands. Rabbit detection rates ranged from <1% in *Triodia* grassland to >20% in *Callitris/Dodonaea* habitats. This data which will be used to reduce reliance on current herbivore spotlight surveys and walking transects, providing further labour economies.

Camera surveys will also provide data re long term trends in emu, echidna, which appear to have benefited from long term fox control, and reintroduced western quoll and brush-tailed possum populations. The latter are likely to move into the areas covered in this I-FRNP survey in the next few years. Camera monitoring will be extended to at least two additional reserves in the Bounceback footprint in 2016.

Assessing herbivore impact to inform herbivore management programs – a rapid method to guide effective management of feral goats, Bounceback Program

Mooney, T. and Brandle, R.

Natural Resources South Australian Arid Lands Department of Environment, Water and Natural Resources

Presenter: Trish Mooney

Property managers and funding bodies require a rigorous approach to assessing browse impact by feral herbivores on perennial shrubs. Impacts of feral goats, for example, can result in the decline and ultimately the disappearance of palatable perennial plants, e.g. species of *Acacia*, *Santalum* and *Eremophila*. This can significantly alter vegetation community structure in rangeland areas with potential flow on effects to dependent fauna. Goats also remove short-lived plants which are important for survival of Yellow-footed Rock-wallabies and other fauna during drought periods.

The Bounceback Program is a broadscale ecological restoration program that has operated across the Flinders, Gawler and Olary Ranges for over 20 years. The program has been trialling a method that documents damage caused by feral goats, rabbits and other herbivores, focussing on perennial plants. The method involves assessing at least three shrub or tree species that are known to get browsed per site, with at least three sites per location needed to assess impact at a landscape scale (20–50 km²). Damage to plants is assessed at the end of summer though two measures: the structural form of browsed plants which provides information on past to recent grazing impact, and browse intensity, represented by the diameter of browsed tips, which reflects the current severity of grazing.

Herbivore identity and activity are also recorded through observing browse characteristics and recording dung in the vicinity of browsed plants. Simple proportional analyses enable the areas most impacted to be identified as well as the impact across a property, and repeat visits in subsequent years can be used to track vegetation recovery trends.

Examples drawn from properties assessed in the Flinders and Gammon Ranges during 2015 will be used to illustrate the method which has been well received by land managers, as it provides a robust, repeatable assessment that reports on the effectiveness of their current and long term feral goat control efforts.

Answering the big questions – the role of research in the Marine Parks MER Program

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Presenter: Robyn Morcom

In October 2014, South Australia's network of 19 marine parks and associated 83 sanctuary zones were fully implemented. The monitoring, evaluation and reporting program of the Department of Environment, Water and Natural Resources will assess the effectiveness of the marine parks network against a number of evaluation questions. Inventory mapping, baseline characterisation and ongoing monitoring of ecological and socio-economic indicators will help to answer part of the question of whether the parks are working, but not all of it. Monitoring aims to detect changes over time whilst research increases our understanding of how and why things change. The marine parks research program has been developed to identify knowledge gaps and provide a mechanism for Researchers and Research Institutions to focus on the development of partnerships which fill these gaps. In addition, the research program should improve our knowledge and understanding of South Australia's marine park network and the biodiversity that exists there. The Forging the Links document was developed to invite researchers to participate, partner and collaborate on projects under three key themes, *Ecological systems; status and pressures, Communities; social, cultural and economic*, and *Management effectiveness*. The results of current and future marine park research projects will assist with evaluating the effectiveness of the parks as well as informing the monitoring program.

Trial reintroduction of the western quoll and brushtail possum to the Ikara-Flinders Ranges National Park

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[3] University of Adelaide

Presenter: Katherine Moseby

Western quolls and brushtail possums formerly occupied the Flinders Ranges region in northern South Australia but became extinct during the last 150 years. An ambitious project to return the two species to the region was initiated after the success of the DEWNR Bounceback program reduced fox and goat populations and allowed yellow-footed rock wallaby populations to recover. The reintroduction program was originally championed by Dr David Peacock and led to the formation of a conservation partnership between FAME and DEWNR. This partnership is aiming to raise over a million dollars over 5 years and has facilitated the reintroduction of 79 possums and 78 quolls in 2014 and 2015.

Initial results are presented including the survival, movement and ecology of the two species in the national park. Approximately one third of the released quolls were preyed on by feral cats within 3 months of release but the remaining animals quickly established home ranges and bred in their first year. We now have F1 and F2 individuals in the population with recent trapping results yielding a trap success rate of 7.8%. Possum mortality has been low with no confirmed predation events. Most female possums were translocated with small pouch young, all of which survived translocation and later emerged from the pouch. Reproduction is so far continuous rather than seasonal in the released possums, possibly a response to new colonization of an area uninhabited by resident possums.

To date, results are promising with both species still extant and populations starting to increase. However, population sizes are small and the long term success of the program is unlikely to be determined until we have experienced a range of environmental conditions (wet years and droughts) and measured the interacting effects of rainfall, rabbits and feral cats. Rabbit abundance is currently high and the arrival of new strains of RHDV could lead to prey switching by feral cats. The high survival of adult possums suggests this species is more threatened in other areas by foxes than feral cats. If successful, this release will constitute one of the few successful mammal reintroduction projects outside of fenced reserves in arid Australia.

The drought isn't over yet: Prolonged recovery of acid sulfate soils and water quality in the Lower Murray

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Presenter: Luke Mosley

An extreme "Millenium Drought" occurred from 2006–2010 in the Lower Murray with severe water quality, soil, ecological, and socio-economic effects. There is a high likelihood of increased droughts in the future in South Australia due to climate change but there has been limited research on the ability of systems to recover from drought. We analysed soil and water quality data to assess recovery from the Millenium Drought, and investigated causes for the observed patterns. The results show that despite hydrological drought recovery, the soil and water quality in large parts of the region has not recovered, and in many areas remains in a hazardous state. Three case studies are presented. Firstly, pyrite in acid sulfate soils under the Lower Murray agricultural floodplains oxidised during drought resulting in severe soil and water acidification (pH < 4). pH has showed very little change over the 5 year post-drought period. A highly acidic (pH 3.5–4.5) layer is still present between approximately 1–2.5 m below ground level (Figure 21) with highly acidic drainage water returned to the River Murray. The acid drainage results in environmental impacts (Figure 21).

Secondly, groundwater under Lakes Alexandrina and Albert (the "Lower Lakes") is still acidic in several locations due to acid sulfate soil exposure during the extreme drought period. Some recovery is occurring although pH is still below the ANZECC guideline of 6.5 at many sites (Figure 22). The causes of slow recovery of acidic soils appear to be (a) lack of available organic carbon to drive microbial sulfate reduction that consumes protons, and (b) slow flushing of acidity from deeper soil layers and (c) presence of relatively insoluble forms of acidity such as the mineral jarosite. Thirdly, water quality and phytoplankton community structure in Lake Albert has not recovered to pre-drought conditions with elevated salinity, nutrient and cyanobacteria levels. This appears due to the terminal nature of the lake limiting water exchange and return of pre-drought phytoplankton community structure. The implications of the results

are that acid sulfate soils, water quality, ecological and infrastructure impacts may not recover in inter-drought periods. Effects of recurrent drought in systems which have not recovered are uncertain at present but will likely vary not only with their duration and severity but also drought-proofing management practices.

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Protecting groundwater-dependent ecosystems through innovative policies on Eyre Peninsula

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Presenter: Kerri Muller

The water allocation plan (WAP) for the groundwater resources of the Southern Basins and Musgrave Prescribed Wells Areas (PWAs) on Eyre Peninsula has among other objectives, the aim to minimise the impact of authorised taking of water on groundwater dependent ecosystems (GDEs). The scarcity of potable water resources on Eyre Peninsula means that the groundwater is the principal source of water for public, irrigation, stock and domestic water supplies. Groundwater is also the principal water resource for GDEs, such as wetlands, marine discharges and red gums. The community were strongly engaged in the WAP review process and provided extensive inputs on current GDE locations and the historic decline of GDEs. There was very limited data to determine what might have led to these losses or what drives current GDE water regimes. It is known, however, that the main driver of groundwater recharge on Eyre Peninsula is rainfall, a factor that cannot be managed under the WAP.

The environmental water needs of the GDEs were determined by evaluating scant local data and extensive literature for the resident plant species in other Australian ecosystems. Wetland plants were divided into functional groups along elevations from which the amount of water required to sustain them was determined as groundwater depth variables. The red gums on Eyre Peninsula generally do not occur on watercourses or wetlands, as is typical of the most-studied red gums, but rather occur in minor depressions across the PWAs. Conceptual models of their life cycles with dependence on sporadic heavy rainfall to support germination and establishment and groundwater to support growth and maintenance were developed. Even less was known about near-shore marine discharges but again conceptual models of acceptable groundwater depth variables were developed. From these GDE models, Environmental Protection Zones (EPZs) were calculated based on transmissivity ranges, specific yields and acceptable levels of drawdown by groundwater extraction. These EPZs were used to generate maps of areas where new wells cannot be constructed in the PWAs. Together with the use of trigger levels to control take from existing wells, these EPZs will protect and maintain the GDEs within the WAP areas within the limits of rainfall driven recharge.

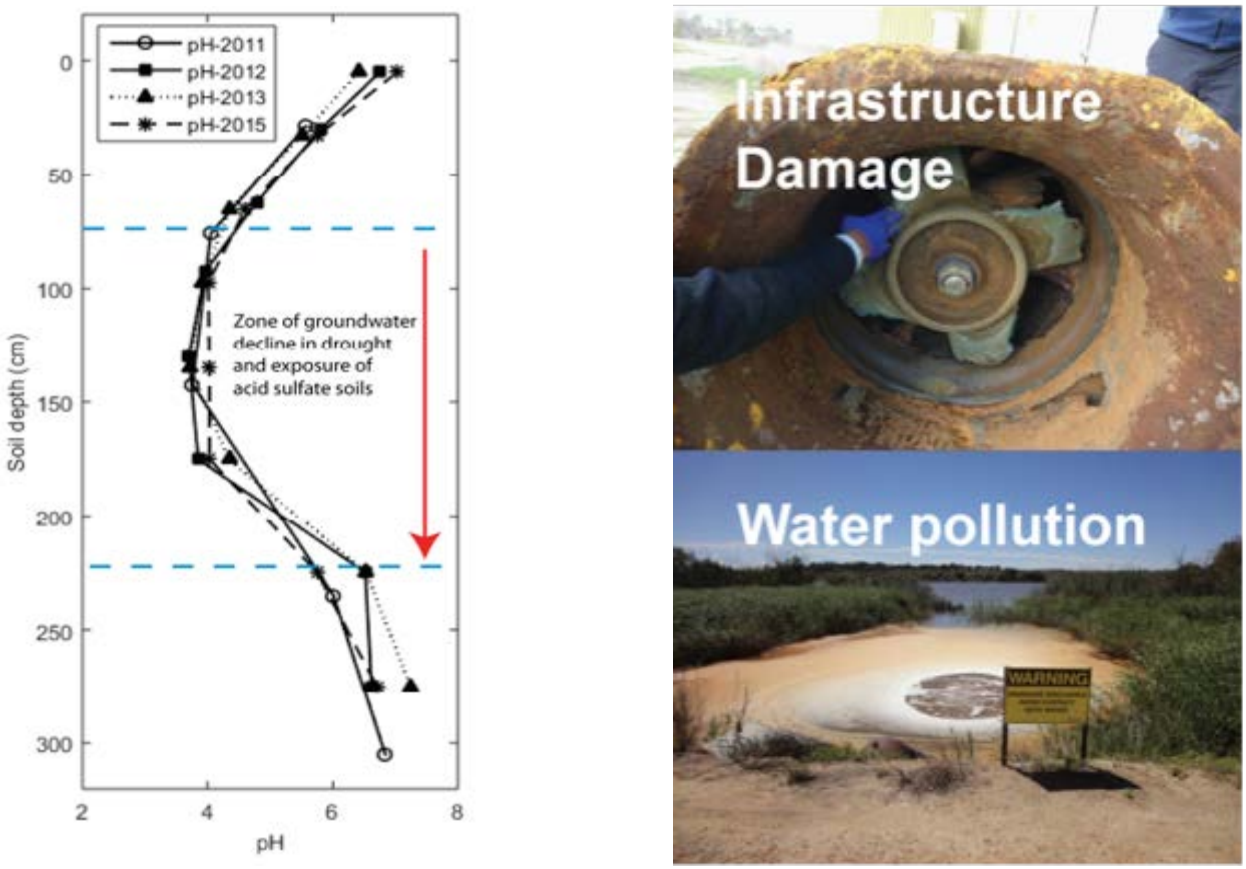

Figure 21. (left) pH in a resubmerged soil profile at Long Flat sampled repeatedly (2011-2015) after the Millennium drought ended and groundwater levels returned to pre-drought conditions (approx. 70 cm soil depth), and (right) ongoing environmental impacts arising from the acid drainage.

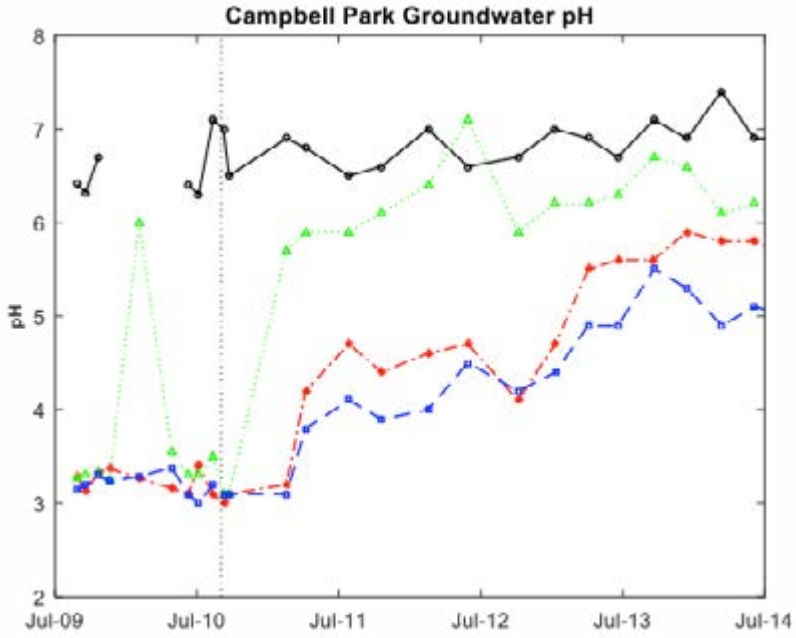

Figure 22. pH in groundwater at Campbell Park (Lake Albert) between 2009 and 2014. The vertical dotted line represents the return of surface water levels to pre-drought averages.

Quantitative modelling of spatio-temporal changes in floodplain settings using airborne geophysical data – an example from the Riverland South Australia

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Presenter: Tim Munday

The advent of "calibrated" airborne electromagnetic (AEM) systems, coupled with effective ground-based standardisation procedures and more robust inversion tools that can account for system geometry, have given added impetus to their deployment as tools to aid the quantitative monitoring of variations associated with floodplain ecosystems, and in particular spatio-temporal processes connected with surface water and groundwater interactions. Arguably this has implications for understanding the consequences of floodplain management in settings such as the floodplains of the River Murray in SE Australia.

In a pilot study in the Riverland of South Australia, we report on spatio-temporal variations observed in the near surface (top 20 m) determined from multi-temporal monitoring of Clark's Floodplain, adjacent to the Bookpurnong Irrigation area, with AEM data. Several co-incident airborne EM surveys have been acquired over this floodplain between 2008 and 2015. Spatial changes in ground conductivity, attributed to changing groundwater quality have been observed in particular locations adjacent to the river and over the floodplain. They indicate areas where water levels associated with the underlying saline groundwater system have changed. These variations are attributed in part, to floodplain management strategies, including an operational salt interception scheme (SIS) and to changes in the regulated height of the river. The results also suggest that in some parts of the river, adjacent to the floodplain, the geometry of the hyporheic zone may have changed. Whether this is indicative of the SIS operation requires further investigation. Overall, these results suggest that airborne EM systems should now be considered as one means for quantifying spatial changes in the amount of salt stored on the floodplain, and for monitoring the effects of particular management strategies, and for understanding floodplain process.

Four Catchments project – Protecting and enhancing riparian vegetation in priority catchments of the Southern Flinders and Northern Mt Lofty Ranges

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Presenter: Jennifer Munro

Department of Environment, Water and Natural Resources

The Southern Flinders and Northern Mount Lofty Ranges forms the watershed for the four catchments of the project (total area 14,600 km^2): Willochra; Broughton; Wakefield; and Light. This 2012-17 project is supporting landholders with on-ground works in riparian areas to reduce the impacts from weeds and stock, and implement revegetation. The project has established baseline monitoring sites for riparian flora and fauna targeting bushland condition (40), permanent pools (13), river red gums (62), birds (25), and fish (19).

Bushland Condition Monitoring was undertaken by Nature Conservation Society in spring of 2014 and 2015. Overall, sites have contained high weed presence, variable grazing impacts, low-medium diversity of native species and have been representative of quality habitat.

Permanent pools have been monitored annually in spring by Natural Resources staff. Water quality records have consistently shown low levels of nitrate and phosphate with near-neutral pH and high salinity. Macroinvertebrate samples have produced good diversity and abundance with sensitive species commonly present.

River red gum monitoring has been a continuation of an annual program commenced in 2008 by Dr. Anne Jensen (conference poster). Results have shown improvement in stress and die-back within communities, but critical recruitment failure. Healthy seed crops are being produced, but mass germination of seedlings has not been observed. Level of tree stress varies widely among individuals within communities.

Bird surveys were done in autumn of 2014 and 2015 by Dave Potter using standard methodology of BirdLife Australia. Surveys have recorded more than 70 bird species, mostly native including a number of rated species.

The fish survey undertaken during April 2014 by South Australian Research and Development Institute (SARDI) included sites in the Broughton and Wakefield catchments. Fourteen of the 19 sites sampled supported fish. In total, 56,259 fish were collected comprising two endemic native species (common galaxias and western blue spot goby), one translocated native species (eel-tailed catfish) and five exotic species (brown trout, European carp, mosquito fish, goldfish and rainbow trout). Mosquito fish (*Gambusia holbrooki*) were observed at all fish sites and comprised 94% of the total catch. Presence of non-target taxa collected was also recorded.

The project on-ground works to-date have included implementation of riparian land management by 63 private and several public (Local Governments, Crown Lands, National Parks) landholders. By project completion in 2017 the total of works will be 52km of fencing, 23 stock watering points, 4000ha of weed control, and 440ha of revegetation. This has been possible due to a highly successful collaborative partnership with Greening Australia, Trees for Life, Conservation Volunteers Australia, private contractors and Natural Resources Adelaide Mount Lofty Ranges. The ultimate outcomes of the project will be landscape-scale protection and enhancement of riparian habitats

and vegetation communities across the four catchments. In conjunction with strengthened and sustained management and appreciation of riparian areas by the catchment communities.

The investigation of the confined unconfined aquifer interaction in the SA-VIC border sharing zones; managing a single or two separate aquifer systems?

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Presenter: Saad Mustafa

Groundwater is the main reliable water source along the South Australia-Victoria border. The area is underlined by two regional aquifers, the unconfined Tertiary Limestone Aquifer (TLA) and the confined Tertiary Sand Aquifer (TCSA). The groundwater resources are managed between the two states through the Border Groundwater Agreement that established the Designated Area, which is a strip of 40 km wide centred on the border and extending for its full length. It is divided into 22 Zones, 11 in each State.

Previous works highlighted that the Nangwarry forest area is a recharge zone to the TCSA where connection between the TLA and TCSA is likely to occur. A joint study between the two States natural resource agencies was carried out by expanding the study area into Victoria part of the Designated Area to investigate the level of connectivity between the two aquifer systems. The study was funded by the National Water Commission.

Eight sites were selected; four sites in each State. The investigation involved a drilling program followed by in-situ data collection and analysis. At each site a number of wells were drilled targeting different units of the TLA, aquitard and the TCSA. Aquitard core samples were recovered from all sites except site VIC 3, where the aquitard was missing.

Constant rate discharge pumping tests were carried out at all sites for a period of three days and monitored for 24 hours of recovery. Water samples were collected before and after the pumping test and sent to the laboratory for chemical and isotope analyses.

The results of the laboratory permeability analysis indicates that the vertical coefficient of permeability (Kv) of the aquitard core samples ranged from 6.9E-05 to 4.23E-04 m/day. The results of the hydraulic and chemical analysis of the TLA and TCSA indicates that there is a moderate to good hydraulic connection (at least at two sites) between the TLA and TCSA aquifers. This expanded understanding of the degree of inter-aquifer connection may have implication for future resource management.

Managing rabbit damage in the era of myxomatosis and rabbit haemorrhagic disease

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Presenter: Greg Mutze

Australia has introduced two diseases for control of the European rabbit (*Oryctolagus cuniculus cuniculus*), myxomatosis in 1950 and rabbit haemorrhagic disease virus (RHDV) in 1995. Both diseases were initially extremely effective in controlling rabbits, providing combined agricultural benefits estimated to have been worth $AU70 billion. However, the effectiveness of both diseases has changed over the years, due to development of genetic resistance in the rabbit and associated genetic changes in the viruses. In addition, a benign calicivirus (RCV-A1) was recently described and found to have some protective benefits against RHDV, particularly in high rainfall areas of south-eastern Australia. A new Korean strain of RHDV (K5) has been identified that may help overcome the protection of RCV-A1 and is scheduled for possible release later in 2016. In addition, another European strain, RHDV2, has become established in southeastern Australia in the past 9 months. RHDV2 appears to overcome protection from vaccination in pet and farmed rabbits, and is likely to be fatal to wild rabbits that have survived an earlier infection from the earlier field strains of RHDV or RCV-A1.

Although Australia may never again have classic 'rabbit plagues', recent research has highlighted the extremely low tolerance of palatable Australian native vegetation to even moderate rabbit densities. Less than 1 rabbit per hectare is enough to prevent recruitment in species particularly attractive to rabbits such as drooping sheoak (*Allocasuarina verticillata*), purple-wood wattle (*Acacia carneorum*), narrow-leaved emu bush (*Eremophila alternifolia*), mulga (*Acacia aneura*) and a range of native pasture species. Apart from their huge initial impacts on naïve rabbit populations during the original outbreaks in 1950 and 1995-96, the biological control agents have generally been unable to keep rabbits below these critical levels. This talk will discuss the results of ongoing demographic and epidemiological studies of RHDV and myxomatosis, and the interactions, timing and variable impacts of these two biological control agents on rabbit populations and rabbit damage. These data highlight the continuing need for the 'tried and tested' physical control methods to maintain rabbits below the critical threshold for palatable Australian plants and their dependent fauna.

Effects of climate change and ocean acidification on Australian marine fishes

Nagelkerken, I.

School of Biological Sciences, The University of Adelaide

Presenter: Ivan Nagelkerken

Ocean acidification and climate change are predicted to have detrimental effects on a wide range of species, but we know little about how they might affect temperate Australian fish species, particularly those that are of recreational or commercial interest or play important ecological roles. Based on various laboratory and mesocosm experiments, literature reviews, and field studies, this presentation will discuss the various ways in which global change can affect Australian marine and fisheries species. Overall, ocean acidification mostly has negative effects on a suite of critical animal behaviours that are needed for survival and population replenishment. Climate change often affects individual fitness via altered foraging, growth and survival rates. Moreover, global stressors like warming and acidification often have synergistic or additive effects when they occur in concert, making it difficult to forecast future species responses based on the predominantly single stressors studies that are currently available. Our results suggest that many species will be negatively affected by global change, although some species will turn out as winners. There is increasing evidence that some common species will increase in abundance but that many less common species will disappear, leading to a simplification of fish communities and potential loss of fisheries productivity.

A spatial decision support system for natural hazard risk reduction policy assessment and planning

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[3] Bushfire and Natural Hazards CRC

Presenter: Jeffrey Newman

The challenges facing environmental policy makers grow increasingly complex and uncertain as more factors that impact on their ability to manage the environment and its risks need to be considered. Due to a large number of influencing environmental and anthropogenic factors, natural hazard risk is difficult to estimate accurately, and exaggerated by large uncertainty in the future socio-economic consequences. Furthermore, resources are scarce, and the benefits of risk reduction strategies are often intangible. Consequently a decision support system assisting managers to understand disaster risk has great advantage for strategic policy assessment and development.

The tool presented is being developed in collaboration with several SA Government departments and funded by the Bushfire and Natural Hazard CRC. The spatial decision support system (SDSS) integrates multiple hazard models with a land use model which includes information on population and building stock to consider long term spatial and temporal dynamics of natural hazard risk. The integrated SDSS, operates at a 100m resolution with a time-step of 1 year and can be used to model 20-50 years into the future. Hazards included in the SDSS include riverine flood, coastal inundation, bushfire and earthquake. Each is modelled dependent on the relevant physical properties of the hazard and include the impacts of climate change on hydro-meteorological and bushfire hazard. The land-use model is driven by land-use demand (population and jobs), and allocates land throughout the region.

The SDSS can be used to explore risk reduction options such as prescribed burns, levees, building hardening, land-use planning, and education/ awareness programs. The options can be assessed through SDSS calculated risk reduction indicators and environmental and social indicators along with a cost-benefit-analysis. The SDSS is presented with a simple to use GUI allowing managers to explore long-term risk and the impacts of policies. Options exist for the DSS to also be applied to broader questions involving strategic land use and infrastructure planning, ecosystem management and water resource planning and management.

Getting the 'wet' into wetlands: delivering environmental water to wetlands and floodplains of the Riverland in South Australia

Nickolai, C.A.

Natural Resources South Australian Murray-Darling Basin, Department of Environment, Water and Natural Resources

Presenter: Callie Nickolai

Each year, the Natural Resources SA Murray-Darling Basin Wetland and Floodplain Team deliver environmental water (e-water) to temporary wetland and floodplains adjacent to the River Murray in South Australia. The Wetland and Floodplain Team has delivered approximately 17 gigalitres (GL) of environmental water to-date since 2012. Each year poses new challenges and therefore the logistics of pumping at each site is revised and modified as required for each event. This involves substantial project management to ensure successful e water delivery can be achieved. This presentation will discuss some of the challenges and strategies employed to ensure the successful delivery of e-water to priority sites.

Each wetland and floodplain is unique, with a no "one size fits all" approach. The factors that need to be considered for each wetland include:

- Topography of wetland/floodplain
- Distance from the river or water source
- Elevation from water source to the pump location
- Rainfall in the 12 months prior to the pumping event
- Site preparation
- Timing of delivery
- Logistics of delivering all sites in a specific time frame for specific ecological outcomes
- Complementary on-ground works – pest plant and animal control

A significant aspect of planning and successful delivery of e-water at each wetland, has been the now long standing relationship with the pumping contractor. Having a competent contractor can mean all the difference to implementing a successful e-watering program, especially when proposing new projects. Additionally, the collaborative relationship between wetland community groups and landholders supported by the Wetland and Floodplain Team have been vital to the success of these projects.

Defining habitat use by declining woodland birds to inform restoration programs

Northeast, P.

The University of Adelaide

phil.heather2@bigpond.com Presenter: Phil Northeast

Declines in woodland bird species across southern Australia is an ongoing concern, despite massive reductions in the rates of native habitat clearance. Species decline is particularly evident within the more isolated regions, such as the Mount Lofty Ranges (MLR) in South Australia. Within the MLR, a suite of woodland bird species are currently in decline, while a number of more common species are also now showing signs of being in trouble. It has been predicted that within the MLR, around 35 to 50 woodland bird species will eventually suffer local extinction under a status quo scenario. Proactive efforts aimed at addressing species decline and looming species loss need to be implemented. One such venture is the Para Woodland Reserve revegetation scheme.

This 321 ha Reserve located within the north-central zone of the southern MLR, consists of cleared farming land that has been set aside for the re-establishment of woodland habitats through revegetation. The goal for these new woodlands, once established, is to attract and then support individuals of numerous woodland bird species that are currently in decline within the local region.

The first aim of my project was to determine if particular woodland types are better than other woodland types in supporting declining woodland bird species, or whether different species of woodland birds associated with different woodland types. If the latter, a mix of different woodland types would need to be reconstructed to maximise the range of bird species that the revegetated Para Woodland Reserve is likely to eventually support. Further, within a certain type of woodland, there is likely to be considerable spatial, structural and/or floristic heterogeneity that in turn may also influence which parts of that woodland will be used by individuals of different bird species. The second aim of this thesis was to document the extent of any heterogeneity within a woodland type and to determine if use by specific bird species was associated with specific habitat features within that woodland. Armed with such knowledge, a deliberate program that is aimed at incorporating specific habitat heterogeneity within the planting regime could be implemented to increase the likely use of new habitats by a suite of declining bird species.

Several novel approaches for surveying birds were employed during my project. In contrast to the popular twenty-minute / two-hectare survey method that is often used to infer broad habitat associations by birds, this project used survey areas that incorporated ten hectares. The strengths of this method are that the habitat associations of bird species are reported at the scale of the surveyed area, and that the results do not need to be extrapolated beyond the habitat areas being surveyed (i.e. no assumptions are made regarding unsurveyed habitat for birds). Also, most bird surveys are concentrated on periods of peak bird activity (usually mornings) and are limited to times of fine weather conditions only. Instead, for the fine-scale habitat use surveys within individual home ranges, the birds were intensively surveyed for sustained periods between dawn and dusk over multiple days, regardless of the weather conditions. This approach avoided the typical survey biases mentioned above and helped to expose a more holistic view of habitat use by the birds. Much of the information that was gained from using this technique would have otherwise been missed had traditional bird survey methods been employed. The key findings of this project include, 1) certain bird species responded to one (or two) particular woodland types, seemingly regardless of where within the landscape that woodland was located, 2) a relatively homogeneous woodland at ten hectares contained significant structural habitat heterogeneity, 3) numerous bird species were statistically associated with specific components of habitat structure within ten hectare sites, 4) the minimum home range requirements of birds belonging to several declining woodland species within the MLR were much larger than expected (i.e. 12–36 ha), 5) habitat use by birds within individual home ranges varied appreciably, in both time and space, 6) specific habitat attributes associated with either high use habitat areas (i.e. hot-spots) or low use habitat

areas (i.e. cold-spots) helped to explain habitat associations by individuals of various bird species, and 7) these same habitat attributes helped to differentiate habitat use between birds of different species that co-existed within a common habitat area.

Recommendations for both the revegetation works on the Para Woodland Reserve and more broadly include, 1) revegetation should provide habitat areas that cover at least tens, if not hundreds, of hectares, 2) plant a variety of woodland types at large spatial scales (e.g. 10 ha each) to cater for a broader suite of locally declining bird species, 3) within each woodland type, incorporate structural (and floristic) heterogeneity at fine spatial scales (e.g. 30 m × 30 m), 4) identify and incorporate the habitat needs of individual bird species at fine spatial scales (e.g. multiple patches covering approximately 30 m × 30 m each), and 5) provide for multiple co-inhabiting bird species by planting a repeated mosaic of different habitat patches at these finer-scales, with each patch "type" catering to the individual habitat needs of one (or a few) pre-determined bird species.

The waterbird response to environmental watering of Tolderol Game Reserve

Oerman, G. and Mason, K.

Natural Resources South Australian Murray-Darling Basin, Department for Environment, Water and Natural Resources

Presenter: Gareth Oerman

Prior to the millennium drought, Tolderol Game Reserve was considered one of the most ecologically diverse wetlands in the internationally important Ramsar listed Coorong and Lower Lakes region. Tolderol's regulated artificial bays supported an abundance of waterbirds, especially migratory waders. In 2008, due to low flow conditions, the annual water allocation for the wetland was restricted to zero. Low flows and the inability to deliver water to Tolderol because of extremely low lake levels resulted in the bays remaining dry for over six years. In November 2014, an environmental watering trial conducted by the Wetlands and Floodplains team at Natural Resources South Australian Murray-Darling Basin returned water to the wetland.

A total of 415.7 megalitres of water were delivered to Tolderol over 27 hectares in 2014/15, and a greater volume of water is expected to be delivered by the end of the 2015/16 season. The objective of the watering is to provide foraging habitat for migratory waders from late spring to early autumn, and thereby re-instate Tolderol's capacity as a significant ecological asset in the region.

Ploughing of a wetland bed, whilst an unsuitable practice for natural wetlands, has been used in the past to create foraging grounds for migratory waders in Tolderol's artificial bays. To determine whether this practice has improved forage for migratory waders, the three environmentally watered bays were spilt in to two ploughed bays and one un-ploughed bay for comparison. Regular bird surveys and observations by volunteers recorded the response of waterbirds, particularly migratory waders, to the environmental watering and habitat manipulation.

Since the delivery of environmental water to Tolderol in November 2014, a total of 56 wetland dependent bird species have been observed within the watered bays. This includes two nationally threatened species: the endangered Australasian bittern and critically endangered curlew sandpiper. In addition to this, 16 internationally migratory species have been observed, of which 13 were migratory waders. Environmental watering has been particularly beneficial for the sharp-tailed sandpiper, with flocks of up to 3,000 individuals foraging on the watered basins.

Over the duration of the watering season, the extent and density of the sedge, *Bolboschoenus caldwellii*, has increased to the point where vast swathes of the watered bays are now covered. As a result, the habitat and associated bird community have shown gradual change over the watering season. Coverage of *B. caldwellii* has reduced the foraging habitat for migratory waders, however has provided suitable habitat for cryptic species, such as the Australasian bittern.

The results of the habitat manipulation trial clearly showed that ploughed bays supported far greater numbers of migratory waders. It is believed that ploughing increases the productivity of the wetland bed while allowing migratory waders to forage un-impeded and with clear vision of predators. Within vegetated areas of bays, Latham's snipe were observed which, unlike other migratory wader species, favour wetlands with extensive cover. Therefore, unploughed areas will be included in future management to ensure a mosaic of habitats are available to support an array of species.

The project is supported by Birds SA, the Conservation and Hunting Alliance of South Australia and the South Australian Murray-Darling Basin Natural Resources Management Board, through funding from the Australian Government's National Landcare Programme and the NRM Levy. The continued support of the many volunteers, notably Christopher Eckert, along with the Goolwa to Wellington Local Action Planning Association and Natural Resources SA Murray-Darling Basin in the collection of this data and on-going support is gratefully acknowledged.

What's the Role of Science in the political process and how do we use the political process to get scientific outcomes

Greg Ogle

South Australian Council of Social Service

Presenter: Greg Ogle

The question of how to get policy properly informed by scientific advice is a political question, not a scientific one. Accordingly, we should look to politics – not science – for the answers. If we [continue] to look at the question based on science we will lack effectiveness, fail to properly understand the role and potential of conservation NGOs and be left to counterproductively lament the "irrational" political "interference" with conservation science.

Policy will always be informed by a range of inputs – history, culture, ideology, moral values, economic and social theory, and plain self-interest. Resolving these is the definition and the business of politics.

This presentation takes a political campaigner's view of the uses of science in conservation policy. In this paradigm, science has a unique role in informing the conservation agenda, identifying issues and potential solutions. But once that is done, we enter the political process where the input of scientists is only one tool among many for a campaigner. Depending on where the campaign or policy process is at, science may be peripheral (eg. cutting a deal with a business interest), it may be central (eg. recognising climate change), or anywhere in between (eg. The Wilderness Society campaigns to protect Yellabinna or marine parks).

This is a realm where political analysis is more important than scientific analysis. Indeed, even good science may be politically counterproductive. If we direct our efforts at science rather than power, and if NGOs (or good government officers) see their role as simply articulating science in the hope of a "rational" policy process, then we are working on a faulty hypothesis and we won't mobilise the support and political power needed to get the conservation results we want.

Understanding the different realm of science and politics – and how they relate together – allows us to act strategically, to know how and when to engage politically and with what tools. It won't guarantee success, but it beats the hell out of writing endless scientific reports, minutes and submissions to little or no avail.

Contaminant Transport from Horticulture in the Mt Lofty Ranges

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Presenter: Danni Oliver

Introduction

The Mt Lofty Ranges (MLR) are important socially, economically and ecologically to South Australia. The MLR catchments provide significant water resources to a range of stakeholders, including agriculture. Off-site transport of contaminants in the form of nutrients, sediment and pesticides from agricultural practices is of concern to landholders, regulatory agencies and the general public. In this study two major horticultural land uses in the MLR were monitored for off-site transport of a range of contaminants. The objective of the study was to gain a better understanding of the nature and extent of off-site migration of contaminants (pesticides, nutrients and sediment) particularly in relation to their transport mechanisms (i.e. attached to colloidal material or in the dissolved phase) and hydrological events.

Materials and Methods

Sites in two major horticultural land uses in the MLR, namely apple and cherry production, were instrumented with flow gauges and automatic water samplers. These sites were chosen because they were located at the top of catchments and were hydrologically isolated. This allowed the contaminant load being measured to be ascribed to the specific land use. Water samples were collected on a flow-weighted basis at the edge of field from creeks draining the orchard. Concentrations and loads of contaminants were measured in each runoff event over a three year period. The growers also provided their spray-diaries for the orchards for each year, which allowed the determination of the loads of pesticides moving off-site as a percentage of the amount applied.

Results and Discussion

Contaminant loads in the first-flush event versus persistent release

Transport of some of the pesticides showed a strong relationship with hydrology. For example, the highest percentage of total load of carbaryl and fenarimol from the apple orchard and pirimicarb from the cherry orchard moved off-site in the first runoff-event (Figure 23). However, results were inconsistent over the three year period. Other pesticides, such as penconazole from the apple orchard and procymidone from the cherry orchard, showed an increasing percentage of the total load moving off-site with subsequent runoff events (Figure 23). This showed that not only insecticides but fungicides were moving off-site. Fungicides are increasingly being recognised as potentially mobile pesticides.

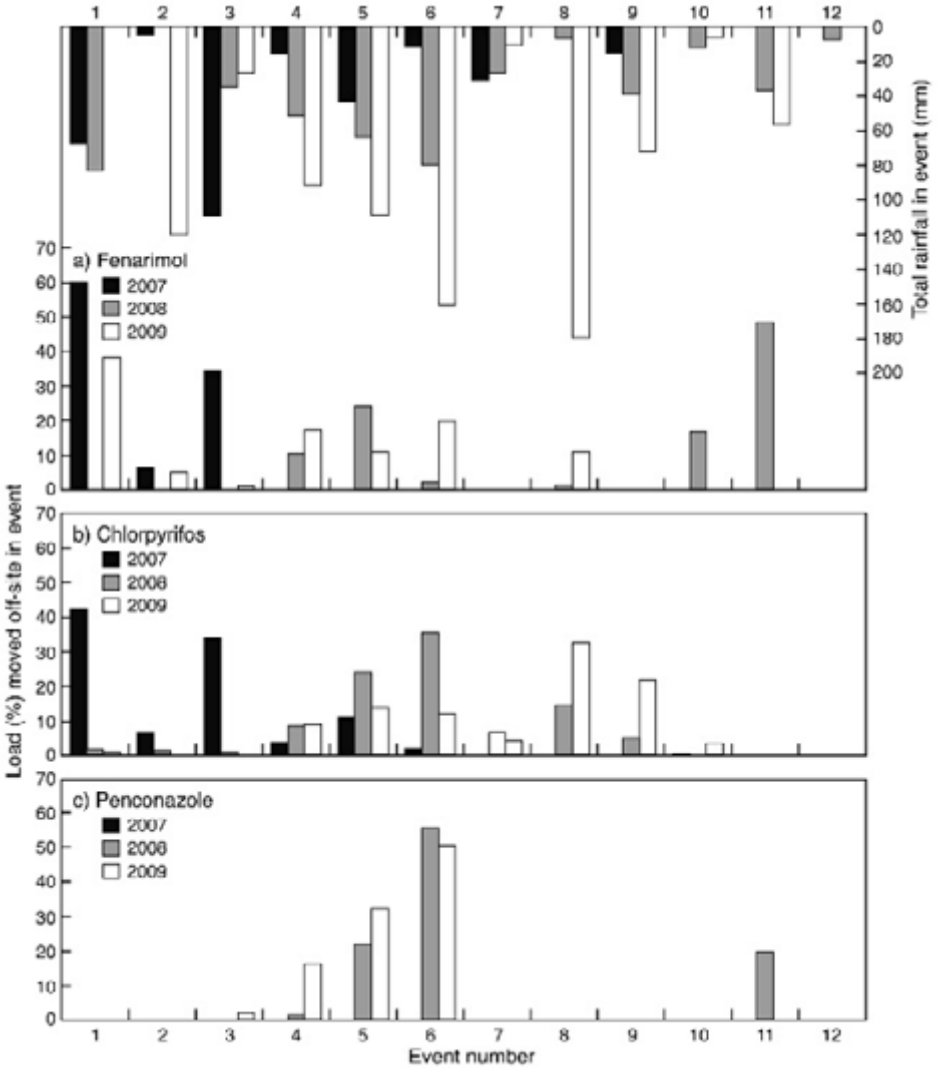

Figure 23. Proportion (%) of total annual load of a) fenarimol, b) chlorpyrifos and c) penconazole that moved off-site over the three years for specific runoff events and the total rainfall associated with the event.

The total nitrogen (TN) and total phosphorus (TP) that moved off site in an event was strongly linked to the total volume of water in that runoff event however, the TN concentrations occasionally remained high even after flow declined.

Persistence of pesticides after spraying

The growing period (and hence spraying period) for horticultural crops in the MLR commences in late spring and may continue through summer when there is little rainfall and the crops are irrigated. The high temperatures over summer would normally be expected to result in the pesticides degrading before the first runoff event occurring in early to late autumn. However, several pesticides were persisting for >100 days after the last application.

Conclusions

The lack of a consistent trend between pesticide transport and runoff events has implications for mitigation strategies to improve water quality. Some areas divert the first flush of water to minimise the load of contaminants being transported and while this would be effective for some pesticides (azinphos methyl, carbaryl, bupirimate and procymidone) and TP, it does not appear to be effective for other pesticides (penconazole, fenarimol and chlorpyrifos) or TN. This study found some pesticides and TN continue to move off-site in surface drainage water for several months after the first runoff event. Work is currently underway to establish the effectiveness of various mitigation strategies.

Management and conservation issues of the Southern Hairy-nosed Wombat. What do we know and what evidence is lacking in order to safeguard the future of the species?

Ostendorf, B. and Taggart, D.

University of Adelaide, School of Biological Sciences

Presenter: Bertram Ostendorf

The Southern Hairy-nosed Wombat is an iconic species which is protected under state and federal legislation. The species is

under increasing pressure from a variety of threats including land clearance and degradation, habitat fragmentation, changed drought frequency and duration, disease, inbreeding and increased competition with humans, feral animals and domestic livestock. These issues are of growing concern as populations fluctuate in health, growth and stability in response to changes in environmental conditions.

In agricultural production areas, the wombat is considered one of the major threats to farm viability and is considered a pest species. Wombats cause monetary loss in agricultural lands mainly due to their burrowing activity. Burrowing can result in damage to farm machinery, fences, tanks, troughs, pipelines, roads and buildings. Collapsing burrows can also present an injury risk to farm workers and may increase soil erosion. It is thus crucial for the conservation and management of this species to evaluate the extent of wombat habitat and its overlap with agricultural land, to identify areas of significance for conservation and those with the greatest potential for human-wombat conflict.

This presentation reviews our knowledge about the spatial and temporal abundance of the southern hairy-nosed wombat, addresses the limitations of historic research methodology and examines the potential of modern spatial techniques to provide information for evidence-based decision making. Preliminary results in include a new distribution map that shows that the spatial extent of the West Coast population is ~ 30% larger than previously recognized, a significant increase in estimates of the Murraylands population size compared to previous estimates, and a 75% reduction in animal abundance during the last two decades at our intensive study site at Kooloola Station in the Murraylands.

We have completed a detailed map and ground-based population estimate of the second largest of three isolated population areas (Murraylands). Results show that the species distribution is extremely patchy. Nearly half (43%) of the population is concentrated in 4.6% of the area. As much as 12% of the population is found within 0.3% or a mere 32 km^2. The extremely skewed spatial distribution pattern observed is non-random with most of the habitat specificity seemingly related to soils and geology. Furthermore, current mapping from the Far West shows that the species range stretches about 300 km into Western Australia. This was previously unknown because state-wide funding stops at state boarders.

Results from a coarse, broad-scale study of the Nullarbor population shows that the species distribution is extremely constrained by temperature. Whilst the species is resilient at lower temperatures, no warrens are found above 18.3°C mean annual temperature. Half of the areas occupied by warrens are found between 17.6 and 18.3°C, suggesting that suitable conditions for occupancy occur across an extremely narrow temperature range.

Combining these observations foreshadows an uncertain future of the species. Whilst much current research is related to fine-scale management issues (i.e. animal health, control and conservation), the study shows a need for long-term conservation thinking as much of the habitat area currently suitable for this species may disappear within a few generations. The study also indicates that there is an urgent need for more detailed maps of biophysical conditions in species distribution modelling. Potentially suitable habitat for the southern hairy-nosed wombat may thus be significantly over-estimated if it is based on maps of biophysical conditions at insufficient spatial resolution.

The paper concludes that we currently have insufficient data to produce accurate estimates of wombat number across their distribution and that even the best data sets currently available will not allow prediction of future climate change impacts on this species.

Currently we cannot predict the areas of greatest conservation concern for this species into the future as our capacity to examine future changes in core habitat areas is limited. Modern spatial technologies (satellite remote sensing, digital terrain models, and digital soil mapping initiatives) however, allow wombat activity (burrows) to be detected from space and thus enable wombat burrows to be mapped across the entire species distribution. This in turn will enable the development of species distribution maps at a detail and an accuracy unsurpassed for any other mammal species world-wide and will lead to development of very accurate population estimates. The southern hairy-nosed wombat will therefore the potential to serve as an excellent model species for the development and testing of species distribution models more broadly.

Hey Dad, money does grow on trees: a new model to track change in the extent of native vegetation across SA

Page, B.[1], McIntyre, A.[2], Royal, M.[1], Wiebkin, A.[1], Scholz, G.[1], McKenzie, J.[1], Smith, K.[1], Peters, K.[1], Rix, R.[1], Bond, T.[1], Jenkins, C.[3], Wouters, M.[1], Kinloch, M.[1], Watts, J.[1], Waycott, M.[1,4], Rogers, D.[1] and White, M.[5]

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Presenter: Brad Page

The healthiest and most productive landscapes include a good amount of native vegetation. It provides character and ecosystem services by way of better water quality, richer biodiversity and a sense of wellbeing brought about by stately gums and beautiful parrots. Protecting and enhancing native vegetation is a legacy we all want to pass to the next generation. Unfortunately, the majority of pressures that degrade native vegetation are not as obvious as those of bulldozers, whose impacts are easier to detect, communicate, comprehend and stop. The impacts of slow-acting pressures, such as inappropriate grazing and fire regimes, weeds, pest and over-abundant native animals, plant

diseases and firewood collection, are easy to overlook, and they are costly to detect using traditional field based methods.

Information on changes in vegetation extent provides a powerful tool to engage community members and government about these less-immediate pressures, and to demonstrate how vegetation improves agricultural productivity and increases the value of tree-change properties. Information held by the Government of SA on native vegetation, weeds and agriculture is outdated in many areas, and the expense of collecting new data using traditional methods is prohibitive.

To address the requirement for this type of information in a cost effective manner, several Government of SA agencies, the 8 NRM boards in SA, Geoscience Australia and the Victorian Government invested in a modelling project to track changes in native vegetation and other land cover features across SA and Victoria between 1987 and 2015. In SA, we summarised and modelled 21 terabytes of data from the Landsat archive to map and track land cover features (including seagrass and revegetation) across South Australia, with outputs delivered in 5 year periods. The scale of this modelling effort is globally significant – there are few vegetation analyses at these temporal and spatial scales in the literature. This project has dramatically improved the availability of information on native vegetation and other vegetation features.

The layers of land cover extent are simple, quantitative and freely-available measures of change that will be available for the evaluation of NRM investments, Government reporting, and University research. Research topics we are scoping include relationships between native vegetation extent, property values and human health and the distribution of animals. In addition, future work will investigate where ecosystem services, including livestock shading, soil erosion or recreational values, are being degraded or improved. This talk will showcase the freely-available model outputs and opportunities to use them to assess management and research questions, such as survival rates of paddock trees or impacts of policies that facilitate the clearance of larger fire breaks around buildings. The model will also improve our understanding of the value of native vegetation.

To feed or not to feed fish in marine parks?

Pearce, D. and Wilson, J.

Department of Environment, Water and Natural Resources

Presenter: David Pearce

There is an inherent challenge in managing multiple use in marine parks if we are to successfully provide for both tourism and conservation. How do we find the sweet spot where tourists can have a memorable and engaging experience while still protecting the wildlife and habitat that the experience depends upon. The SA marine parks team is currently addressing an issue in a marine park sanctuary zone where visitors have historically fed fish. The resolution of this issue is has policy, compliance, social, ethical, ecological and economic implications. We will consider these issues in the light of contemporary best practice, research and nature-based tourism expectations. How do we shape a robust decision making model in the light of so many variables? Or do we acknowledge the conflicts are un-resolvable and accept the need for 'sacrificial sites' to provide wildlife interactions? Find out what other states are doing and what environmental and social science tools we can use to help marine park outcomes.

Optimising low flow releases to meet sustainable development objectives of a water allocation plan

Savadamuthu, K., Penney, D., Sims, C. and Greenwood, A.J.B.

Department of Environment, Water and Natural Resources

Presenter: Daniel Penney

The water resources of the Mount Lofty Ranges have been subject to management under water allocation plans (WAP) since 2013. WAP objectives include achieving triple bottom line outcomes in sustainable resources development. Earlier work undertaken to underpin regional water allocation planning identified that water allocations could be optimized and environmental targets could be met if low-flows were returned to streams around patterns of farm development identified in the WAPs. Moreover, ensuing work identified preliminary indications that environmental targets may be also met by returning low flows around different configurations of farm dams, with potential to optimise investments in achieving sustainable water resources management and underpin further policy development. However, this work was conducted on a limited number of small headwater catchments and was not able to identify any generic patterns which could be used to regionalise decision-making in prioritizing the location of low flow devices. This paper describes work undertaken to extend earlier efforts by developing a whole of catchment model in Source platform, containing model nodes for each of its 1000 farm dams and watercourse extractions, and exploring scenarios to develop generic rules of thumb which could be used to inform decision-making. General results of the work confirm the earlier hypothesis that it is feasible to achieve the environmental targets set out in the WAPs with fewer than required low flow releases, by strategically locating them across the landscape. The results also indicate that it is possible to develop generic rules of strategic location of low flow releases across landscape that meet the environmental targets. Further work across a range hydrologically diverse catchments is proposed to validate the generic rules.

Assessing water and salinity risks to viticulture production in the Riverland, South Australia

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[1] South Australian Research and Development Institute (SARDI)

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Presenter: Vinod Phogat

South Australia produces 48% of Australia's wine grape crush and 93% of vineyards use supplementary irrigation. The Riverland is the most important region, producing 30% of the state's grapes. However, the region is vulnerable to production losses due to its high dependence on irrigation water from the River Murray. The irrigation industry in the Riverland and Lower Murray in South Australia has undergone a significant transformation in the last 20 years. The area under irrigation has increased particularly under new plantations of high water requiring horticultural crops e.g. almond; however, the volume of water available for irrigation has not increased (500 GL at full allocation). Growers have limited options if water allocations are reduced and any long term reduction in irrigation volume and quality will affect grape and wine production. Hence, there is a need to evaluate the long-term water and associated salinity risks to viticulture so that necessary management options can be explored.

A finite element numerical model (HYDRUS-1D) was used to evaluate long term (2004–2015) climatic variability and irrigation volume on the water balance of vines at Loxton, Murray Bridge and Waikerie. In addition salinity risks to viticulture grown on both light and heavy textured soil were assessed. The irrigation was triggered at 60 kPa (standard), 65 kPa (reduced) and 70 kPa (greatly reduced) water suctions. Increasing irrigation triggers represent reduced irrigation application which could lead to below normal irrigation application. The irrigation is triggered when the desired water content level is reached in the soil profile, depending on various daily climate and plant water requirements. The trigger point for viticulture was set at 20 cm soil depth which coincides with the maximum root activity for the vines.

The hydraulic functions for each soil were estimated from the soil properties acquired from the ASRIS database and other information for the dominant soil groups of the region. The climate parameters (rainfall, ET_0) for 3 locations (Loxton, Murray Bridge and Waikerie) were assessed from SILO data base. Crop coefficients were obtained from IRES irrigation scheduling software developed by Rural Solutions SA and used to estimate the crop evapotranspiration (ET_C). The daily estimates of potential evaporation (E_s) and transpiration (T_p) were estimated from ET_C and leaf area index (LAI).

Domain depth for vines was selected depending on the maximum rooting depths (100 cm) reported in the literature. Water content initial conditions was assumes at field capacity for all simulations and non-saline conditions were observed in the beginning of the simulations. The soil solution concentration was linearly distributed between 0.5 to 1.5 dS/m from top to the bottom of the domain. All simulations were performed for 11 years from 1st July 2004 to 30th June 2015. This period represents all climatic variations including severe drought during 2007 to 2009, heavy rainfall during 2010 and normal conditions at other times.

Modelling results revealed that the grapevine seasonal transpiration (T_p) at Loxton decreased drastically in light textured soil when irrigation was triggered at 70 kPa compared to 60 kPa. However, with similar volume of irrigation at 70 kPa there was a 63% higher T_p in heavy textured soil as compared to light soil. The seasonal transpiration in heavy textured soil remained unaffected by the increasing trigger levels because a similar amount of irrigation was triggered at all suctions. Average T_p at Murray Bridge and Waikerie was similar to Loxton for all irrigation triggers. The results suggests that vineyards planted in light textured soils could be more vulnerable to reduced water applications.

Seasonal drainage (*Dr*) at Loxton was 41–46% of applied water at 60 kPa in light textured soil. However, *Dr* was reduced by 43% if irrigation was not triggered until the soil suction reached 70 kPa (compared to 60 kPa). On the other hand, *Dr* was small under grapevines grown on heavy textured soil at all triggers. The amount of *Dr* increased at Murray Bridge in both soils as compared to Loxton. However, the magnitude and pattern of *Dr* at Waikerie was similar to Loxton. Little drainage or restricted drainage as is the case of heavy textured soil can pose a serious water induced salinity risks and significant level of salt build up in the rootzone. A similar situation can arise where less water is available for irrigation due to severe climatic stress and reduced water allocation.

Seasonal evaporation (E_s) at Loxton was reduced by 16% when irrigation was triggered at 70 kPa rather than 60 kPa. The reduction in irrigation application at increased irrigation trigger (70 kPa) had comparatively less impact on the seasonal evaporation in light textured soil compared to the level of impact observed in other water fluxes (transpiration and drainage). However, the E_s doubled for grapevines grown in heavy textured soil compared to light soil. Evaporation losses under grapevine were higher at Murray Bridge compared to Loxton and Waikerie, where losses were similar. Increased evaporation provide less opportunity for water to be taken up by the grapevine leading to greater risk of water lost to unproductive uses.

Irrigation induced soil salinity is a serious threat to irrigated agriculture especially in arid and semi-arid regions where the amount of precipitation is inadequate to leach salts out of the soil system. In light textured soil, a 50% reduction in irrigation during a period of drought (2007–2009) resulted in doubling of the root zone salinity (EC_{sw}), however, it was below the threshold EC_{sw} (4.2 dS/m) that causes problems for grapevines. A 10% reduction in irrigation during 2004–2015 slightly increased soil salinity during summer months (December-January). In heavy textured soil, EC_{sw} increased above the threshold during summer months of drought years (2007–2009) for the standard irrigation. Application of 10% less irrigation and a 50% reduction during a drought period resulted in rapid increase in EC_{sw} above the threshold. These observations suggest that a small reduction in

irrigation application in viticulture in heavy textured soils could result in serious water induced salinity risks which can take much longer to bring down to normal condition. At Murray Bridge, summer salinity peaks were slightly lower than at Loxton and Waikerie where EC_{sw} in both soils was similar. Higher rainfall at Murray Bridge than at Loxton seems to have played a key role in regulating the salt movement in the soil. It shows that rainfall amount and distribution plays a crucial role in root zone salinity build up and significantly impact the irrigation induced salinity risks.

This study suggests that vineyards established in light textured soils in the Riverland may experience high deep drainage losses (i.e. water is being applied at the wrong time). Whereas soil salinity in heavy textured soils could have severe influence on vineyards especially during draught period or sustained stress conditions which can affect long-term productivity of viticulture.

Science Model Warehouse – Supporting robust water resource management in South Australia

Pierce, D., Hancock, M., Bushaway, K. and Green, G.

Science, Monitoring & Knowledge, Department of Environment, Water and Natural Resources

Presenter: Daniel Pierce

Numerical models have become essential tools for supporting national and state-wide water resource management. They require substantial capital investment as they are time-intensive and involve specialist skills and the analysis of extensive scientific data. In recent years, the Science Unit of the Department for Environment, Water and Natural Resources (DEWNR) and the Goyder Institute for Water Research have invested significant resources into developing numerical models for groundwater, surface water, water ecology, water quality, simulation and optimisation, statistical and agricultural production systems. The model products and associated data have generally been archived using different methods, with no secure central repository for the resulting intellectual property. The Science Model Warehouse is a new service provided by DEWNR that provides a solution to these issues. It builds on previous experience by DEWNR who have operated a service for developing and archiving groundwater models since 2011.

The systems and protocols established for the Science Model Warehouse produce a consistent, logical archiving of numerical models that can be followed by third parties and which enables maintenance of these models and their further use in other water resource management applications (Figure 24). They facilitate making these knowledge assets visible and accessible to external parties under the Declaration of Open Data made by the Premier in 2013, which provides transparency for evidence-based policy and decision making by the State Government. The discoverability and release of models helps to prevent duplication of work across the state and potentially reduce the cost of projects that involve water affecting activities (e.g. managed aquifer recharge schemes; mining).

Ecological Literacy in South Australia: How much do we know about nature … and who knows?

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Presenter: Sheryn Pitman

Critical to the health and survival of any human society is knowledge and understanding of the natural ecological systems that underpin and support life. Ecological literacy encompasses the capacity to know and understand places as ecological systems including how they function and connect with other systems. It is argued that changed relationships between many human societies and the natural world have affected the capability of many communities to make well-informed decisions about how to live sustainably. This presentation discusses the findings of an ecological literacy assessment and survey of over 1000 South Australian adults from industry, government, non-government, business and volunteer organisations. Levels of ecological knowledge and understanding were shown to vary significantly with a range of socio-demographic factors and life contexts and experiences. This research has led to valuable findings in relation to the diverse factors associated with how well individuals and groups within our community know and understand ecological systems, and it provides insights into the challenges and opportunities for developing greater ecological literacy within our citizenry and governing bodies.

Prescribed burning urbanises bird assemblages in the Mount Lofty ranges

Prowse, T.A.A.[1], Collard, S.J.[2], Blackwood, A.[3], Delean, S.[1], Cassey, P.[1], O'Connor, P.J.[4], Barnes, M.[5] and Possingham, H.P.[5]

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Presenter: Thomas Prowse

Prescribed burning to protect human life and assets from high-intensity bushfires in peri-urban landscapes is often implemented with incomplete understanding of biodiversity consequences. We quantified current trends and the effects of fire on avian abundance and diversity in the woodlands of the Mount Lofty

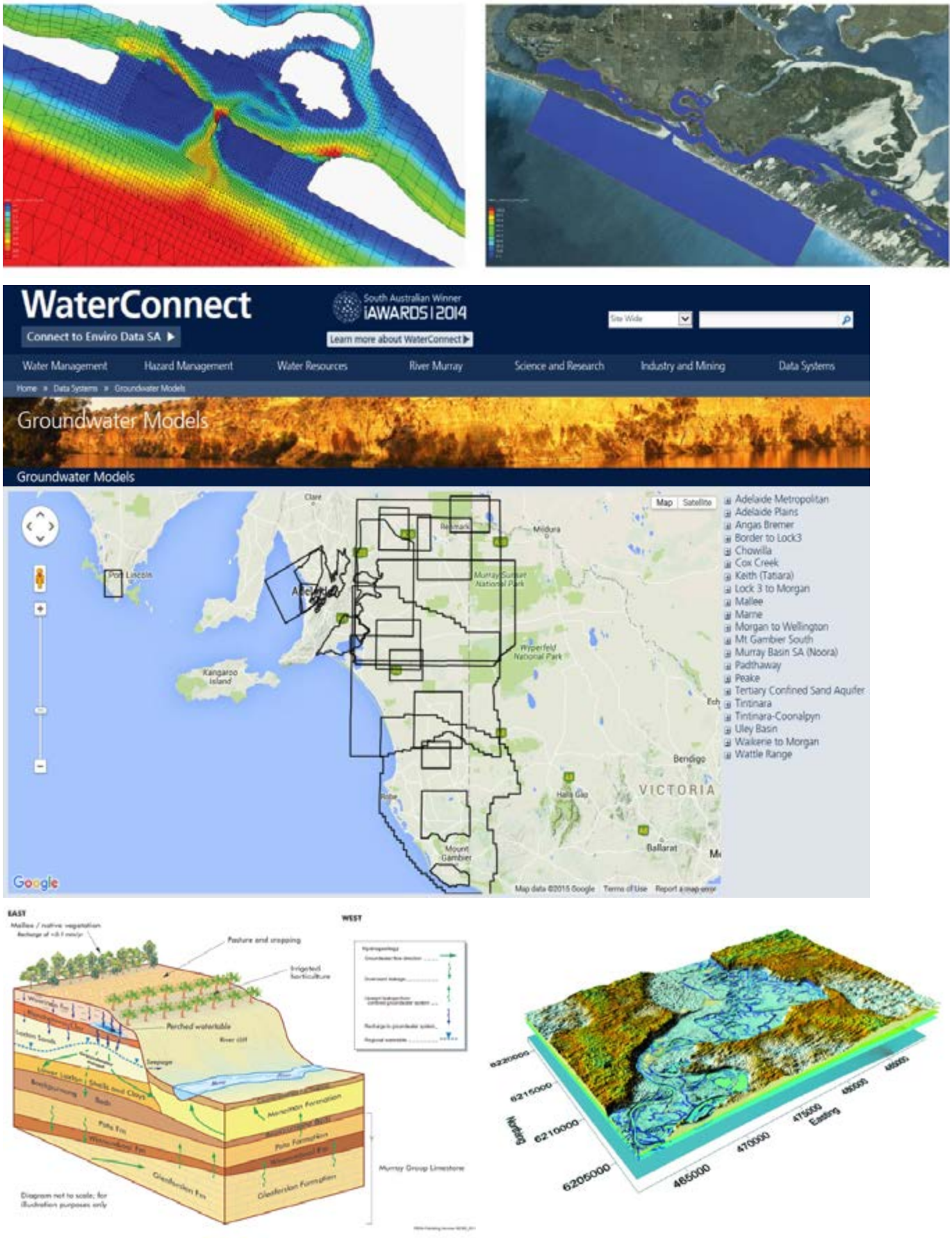

Figure 24. Interactive map on DEWNR's WaterConnect *website showing the modelling regions and providing access to the relevant model briefs and reports for model information.*

Ranges, South Australia, over a 14-year period. Bird abundance has declined non-linearly over time, from a peak of 36 birds site^{-1} in 2001 to 20 birds site^{-1} in 2014. After accounting for this non-linear trend, we estimated that bird abundance was 2.7 birds higher at unburnt sites than at those that have been burnt in recorded history. Fire did not strongly affect avian Shannon diversity but clearly affected the composition of bird assemblages, favouring large carnivorous birds that preferentially feed on the ground. Of 59 species considered, 37% are both declining and negatively impacted by recent fires. Moreover, fires are expected to reinforce increasing trends in 27% of species, including large 'generalists' (e.g., magpies, wattlebirds, ravens) that are common in urban environments. The potential homogenisation of urban and woodland bird assemblages and associated declines in smaller 'specialist' species should be considered when developing policies for fire management and peri-urban expansion.

Groundwater model for managing a saline floodplain at Pike, South Australia

Purczel, C., Riches, V. and Woods, J.

Department of Environment, Water and Natural Resources

Presenter: Carl Purczel

The South Australian River Murray floodplain is naturally saline, but river regulation, land clearance and irrigation have exacerbated the salinity, leading to ecological degradation in some areas. The South Australian Riverland Floodplains Integrated Infrastructure Program (SARFIIP) aims to improve the health of selected floodplains through saline groundwater management works and the construction of environmental regulators to inundate large floodplain areas.

One of the selected floodplains is at Pike River, South Australia, south of Renmark. A groundwater model has been constructed of the floodplain with the initial aim of improving conceptual understanding. Prior modelling studies of the region have focused on salt flux to the river, while neglecting the impact to the floodplain. Floodplain processes are generally not well understood and are rarely included in any detail, especially within a regional scale groundwater model, primarily due to the complexity of these processes.

This model incorporates the current understanding of floodplain processes with particular emphasis being placed on recharge and evapotranspiration. This required simulation at finer spatial and temporal scales than previously attempted for the site. Groundwater flow is simulated in the model using MODFLOW 2005 and could be extended to simulate the transport of salt in the floodplain via a solute transport model using MT3D.

Model construction required careful representation of river level change, evapotranspiration, inundation recharge and solute transport. The model is informed by detailed LiDAR topography, remote sensing of actual evapotranspiration, soil surveys, electromagnetic geophysical surveys of various kinds, bore logs, aquifer tests, aquifer monitoring, unsaturated zone modelling, surface water models, and a series of generic groundwater process models. The construction and calibration process is detailed. The model will continue to be updated to incorporate the findings of ongoing fieldwork at Pike Floodplain.

The model is being used to assess the salinity impact of proposed works and measures on the floodplain, such as groundwater pumping on the floodplain and adjacent areas, managed inundation, and surface water infrastructure. The model estimates changes in watertable level, evapotranspiration (and hence salt accumulation in soils), and movement of saline groundwater into the river. The model is of particular interest to managers, as it permits the investigation and assessment of management options prior to on-ground works commencing.

A perfect storm? – Natural variability and climate change impacts and implications for natural resource management

Ray, D.

Bureau of Meteorology,

Presenter: Darren Ray

Australia has experienced significant variability in natural climate influences over recorded climate history. Multi-decadal periods (20–30 year timeframes) see variations in the ratio of wetter and drier phases of the El Nino Southern Oscillation (ENSO) climate influence, with periods of more El Niño like (drier phase) background conditions, indicated by positive values of the Pacific Decadal Oscillation (PDO) / Inter-decadal Pacific Oscillation (IPO), persisting in the Pacific Ocean, alternating with periods of more La Niña like (wetter phase) background conditions, indicated by negative values of the Pacific Decadal Oscillation (PDO) / Interdecadal Pacific Oscillation (IPO). As well as natural variability, climate change impacts on weather patterns and rainfall in southern Australia have become apparent over recent decades, with significant declines in April to October rainfall in much of southern Australia, with subsequent impacts on water availability.

Over the last 20 years, background conditions in the Pacific Ocean have been more La Niña like, at the same as climate change impacts have emerged. But Australia is yet to experience the combination of El Niño like background conditions and recently emerged climate change trends. Positive PDO/IPO values and trends towards El Niño conditions since early 2014 suggest a possible shift which may persist over several decades. The impacts and implications of this combination of variability and climate change trends is explored, focussing on the Murray Darling basin and South Australian region, suggesting major impacts worth factoring into water management and planning, and ecological system management. Other factors such as warming trends in sea surface temperatures which may offset some of these impacts, and more extreme ENSO events from climate change present a complicated picture.

Burning for environmental benefit – do assumptions and theories always stack up?

Naomi Rea

Burning is becoming a more popular management tool to reduce the risks to people, property and environments. The widespread assumption that fire plays a fundamental role in restoring and maintaining functional landscapes has gained mainstream currency. However, counterproductive outcomes such as a more flammable landscape, less resilient ecosystems and species threatened with local extinction can result. Assumptions that underlie statements such as 'fire is part of the Australian landscape' and the 'bush needs a burn' are examined. The role of science is to resolve uncertainty and clarify assumptions. This presentation draws from theoretical plant ecology to identify knowledge gaps where research could inform more effective ecological and prescription burning. Other than ignition from lightning, bush fire is a human activity. However, is it an essential plant requirement? The difference between plant adaptation and tolerance to fire is discussed as well as the role of language and its (mis)interpretation. Research questions and hypotheses based on plant and ecosystem theories are proposed.

Satellite imagery – A tool to improve productivity

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Presenter: Patrick Redden

Satellite imagery, matches land use to land capability, using spatial information and a farmers local knowledge to develop management plans for specific zones within paddocks.

Measuring leaf greenness or NDVI (Normalised Difference Vegetation Index), differences indicate zones of management to improve production or potential limitations. The advantage of using satellite imagery is the ability to link with other data tools such as yield maps, biomass or variable rate equipment.

Satellite imagery can provide regular updates during critical periods of crop or pasture development. Using images a farmer is able to measure remotely crop progress, identify underperforming areas which need attention and examine long term trends of farm paddocks.

In 2014, twelve Murray Mallee farmers trialled a number of different treatments within different management zones identified through historical biomass imagery.

Case Study

A trial was conducted near Pinnaroo within a 70 hectare paddock sown to Grenade wheat after producing wheat in 2013. Satellite imagery determined three management zones based on historical biomass images taken in 2011 and 2007 (Figure 25). The map below shows the three zones – Zone 1 – Sand hill (yellow), Zone 2 – Mid slope (brown), Zone 3 – Flats (blue).

Treatments were applied to investigate and assess nitrogen and sulphur treatments to improve productivity.

Biomass Imagery

The following in-season biomass images were taken 6/08/2014 and 22/08/2014 respectively (Figure 26). Noticeably, is the area of dark green decreasing during this time, possibly due to frost damage. Despite evidence of healthier growth on the left hand side of the sand hill, a visual inspection of the paddock did not show this as decisively as the satellite image.

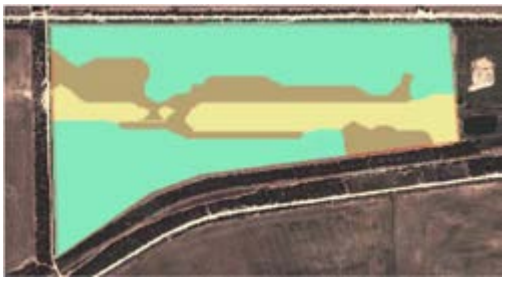

Figure 25. Management zones based on historical biomass images. Zone 1 – Sand hill (yellow), Zone 2 – Mid slope (brown), Zone 3 – Flats (blue).

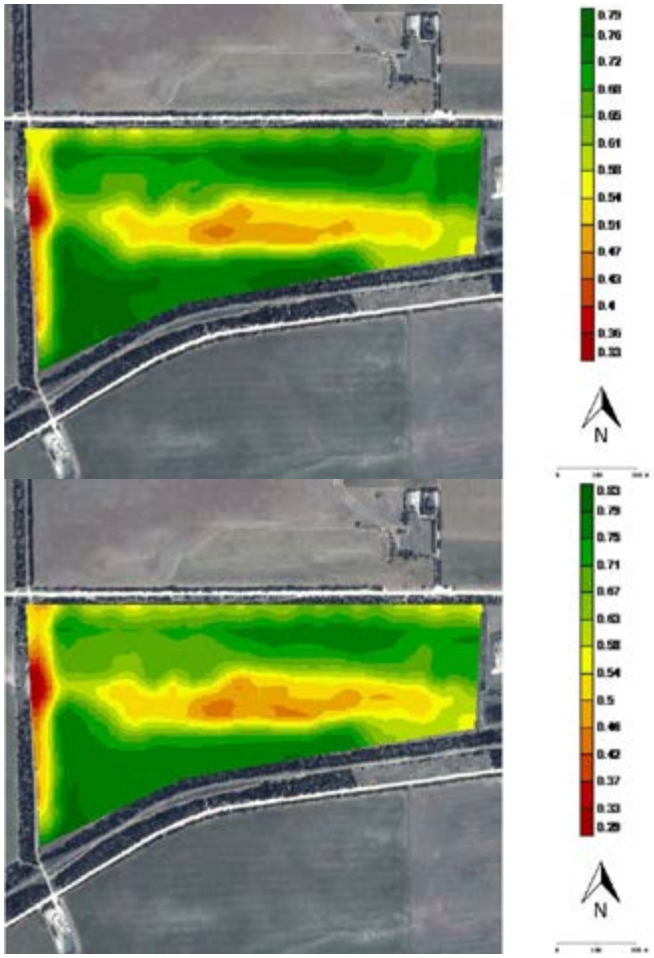

Figure 26. In-season biomass images.

Conclusions

The biomass imagery has defined the management zones in the paddock accurately, supported by the results from soil testing, in season biomass imagery and yield results. Differences in yield within the zones are likely due to different responses to sulphur and to a lesser degree nitrogen on the sand hill.

The trial demonstrated a benefit to managing the sand hill differently for 2014 conditions, with a higher gypsum rate generating a better return. Extrapolated to whole paddock an economic benefit of $7,874 from implementing the best treatment versus the standard for each zone is demonstrated, highlighting the potential financial benefits from variable rate applications of key inputs in clearly defined management zones.

Continuing with a sulphur program on this paddock is recommended. Depending on other seasonal conditions, responses demonstrated in 2014 season may not be repeated and other constraints apart from sulphur on the sand hill may be an influencing factor such as water holding capacity. However based on the results is worth considering incorporating sulphur into future fertiliser programs.

Land use change under uncertainty: real options analysis of biomass agroforestry in agricultural land. What conditions will trigger land use change from agricultural food production to sequestering carbon?

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Presenter: Courtney Regan

Biomass production for use in electricity generation (BEG) has been promoted as having broad environmental benefit as well as providing a valuable diversification option for landholders. However, landholders often display considerable reluctance to convert land use away from conventional agriculture, despite indications of profitability according to discounted cash flow analysis (DCF) that most commonly uses net present value (NPV) as the indicator. One reason may be that DCF models largely neglect the effects of uncertainties of price, yield and policy settings on landholder decision making. To examine the effects of such interacting uncertainties we use a simulation-based real options model to analyse for the dollar value that would be most likely needed to trigger a change in land use from current agricultural production to BEG. Our focus is on the effects of spatially varying risk differences across climatically diverse regions of southern Australia, and payment policies including alternative treatments of risk in payment policy.

Our results indicate that real options analysis provides valuable insight into how the risk premium required to motivate land use change differs with spatially-varying risks. Furthermore, we demonstrate how incentive policies that reduce risk can reduce the returns required to trigger land use change, and where the magnitude of these effects may be most and least pronounced. The important implications for policy makers and firms are around the potential to design lower cost spatially-targeted policies and incentive structures through more realistic accounting for landholder risks as can be calculated by using real options analysis.

An investigation of the importance of little penguins in the diet of long-nosed fur seal (*Arctocephalus forsteri*)

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[2] South Australian Research and Development Institute (SARDI Aquatic Sciences)

Presenter: Sarah-Lena Reinhold

Little penguins (*Eudyptula minor*) are currently classified as "common" across South Australia, however some populations have been seriously declining over the past decades. Whilst there are several threats that need to be considered recovering long-nosed fur seal (*Arctocephalus forsteri*) populations have more than trebled within South Australia since the 1980's, leading to increased concerns regarding their impact on little penguin populations. To date, fur seal dietary studies have only focused on breeding colonies, with little investigation of non-breeding animals, which are most likely to interact with little penguins, fisheries and other species of conservational significance in coastal waters. This study examined the diet of long-nosed fur seals at 10 haulout sites and two breeding colonies across three regions (Kangaroo Island, Fleurieu Peninsula, Yorke Peninsula) in South Australia using hard part analysis of 326 faecal samples. This research focused on the predation of little penguins and importance of commercially fished species and compared the dietary profiles between fur seals at breeding colonies versus haulout sites. In total, 21 taxa (species, genera or family) were identified including leatherjackets (Monacanthidae), garfish (*Hyporhamphus melanochir*; a commercially fished species), myctophids (Myctophidae and *Symbolophorus* sp.), calamari (*Sepioteuthis australis*; a commercially fished species) and little penguins. Key prey species varied regionally both in numerical abundance and overall prey biomass. This study identified marked variation in the importance of little

penguins in fur seal diet across the regions; evidence of penguin predation was found in 4% of scats from Kangaroo Island, 10% Yorke Peninsula and 42% Fleurieu Peninsula. These results suggest that little penguin predation may be opportunistic and the abundance of little penguins within each region may not be the only factor driving their importance in long-nosed fur seal diet.

Using diatoms to assist in setting water quality guidelines in south-east South Australia and the Mount Lofty Ranges

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Presenter: Jenny Richards

Stream water quality is important as it affects biodiversity, stream-based recreational and commercial activities, and the quality of drinking water. However, adequately assessing stream water quality is difficult since chemical "spot" sampling can be unrepresentative of the full range of variability while commonly used macroinvertebrate assessments are often more affected by local habitat than water quality attributes. Diatoms are a class of aquatic algae and are highly sensitive to a variety of water quality parameters (e.g. pH, nutrients, salinity). As a result, we investigated if diatoms could be incorporated into stream water quality programs and used to help identify changes in algal assemblages that may in turn be used for setting water quality guidelines for South Australian streams.

Diatoms were collected in spring and autumn from streams in south-east South Australia and the Mount Lofty Ranges in 2014 and 2015, respectively, using an artificial substrate (frayed rope). Diatom samples were also collected from mud and rock in the Mount Lofty Ranges in spring 2015 to determine whether the sampling substrate affects the composition of diatoms and thus if the deployment of rope was a necessary exercise.

Changes in diatom composition are predominantly driven by salinity (conductivity), except for in the spring Mount Lofty Range samples. Conductivity thresholds for the south-east have been established using Threshold Indicator Taxa Analysis (TITAN) and will be tested on the autumn Mount Lofty Range samples to investigate if there are different threshold responses in the different regions sampled.

Diatom composition from artificial substrate (rope), mud and rock have statistically significant differences in species composition and significant differences in diversity on both a local scale (samples taken from within a 10m2 section of the stream) and an inter-site scale. However, when examined along a nutrient gradient, there were limited differences between the substrates were found on the inter-site scale. This suggests that for studies investigating stream health on an inter-site scale the deployment of rope was not significantly beneficial and other natural substrates could have been used.

Cat Tracker: Understanding cats through citizen science

Roetman, P. and Tindle, H.

Discovery Circle, University of South Australia

Presenter: Philip Roetman

Domestic cats are one of most popular pets worldwide and they play an important and much-cherished role in the lives of many South Australians. Cats can provide great enjoyment and companionship. While well-managed cats may provide many benefits, some cats are not well managed. These cats can be a nuisance to neighbours and may have a negative impact on native wildlife. The Cat Tracker project is exploring the movement and management of domestic cats in South Australia. It is a "Citizen Science" project, where members of the public are directly involved in scientific work – in this case, the tracking of cats. The project has two main phases, a questionnaire and the cat tracking activity. The questionnaire asks pet owners about their cats and how they manage their cat's indoor-outdoor movement. This survey includes a "cat personality test", where owners answer a series of questions about their cats in order to generate a personality profile of the cat. People who complete the questionnaire nominate if they would like to participate in the second phase of the project, the cat tracking. During the cat tracking phase, we are distributing GPS tracking devices to track 500 domestic cats in South Australia. Cat owners use the equipment to track their own cats. The GPS equipment is then sent back to the research team and the tracking data are uploaded to a public webpage (http://www.discoverycircle.org.au/projects/cat-tracker/tracks/). Preliminary results of the tracking phase, with 306 cats tracked, include an average home-range of 1.8 ha (95% MCP). Preliminary results of the survey phase include a 5-factor model of cat personality, with little difference between indoor-only cats and cats that spend time outdoors. Preliminary results also include the views on cat management of 2,219 survey respondents.

Little corellas in South Australia: a citizen science approach to social and ecological research for management

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[2] Conservation & Land Management, Department of Environment, Water and Natural Resources

Presenter: Philip Roetman

In South Australia, little corellas (*Cacatua sanguinea*) naturally form large flocks in urban and rural areas and can cause considerable

problems that include: damaging trees, buildings and crops; disturbing residents with loud vocalisations; displacing other wildlife. A range of lethal and non-lethal management strategies are available, but their sporadic use to date has had little effect in reducing these problems. Substantial public contention regarding little corella management exists. Despite the large range and seasonal movements of little corellas, management is rarely coordinated regionally. This project has been designed to provide direct input into a Little Corella Management Plan for South Australia, and to help all stakeholders make informed decisions about little corellas. The project has five main phases. In phase one, members of the public were surveyed about their experiences with little corellas. By February, 2016, over 1,300 people had provided information about where and how they experience little corellas (a map is available at: http://www.discoverycircle.org.au/projects/little-corellas/). In phase two, community workshops were used to model drivers of sites where little corellas are problematic. The models are available online, and can be downloaded and refined by members of the public who can provide further information back to us (http://www.discoverycircle.org.au/projects/little-corellas/community-models/). Phase three involves the collection of empirical data (site characteristics) at problem and non-problem sites, which will allow us to test and refine the models (phase four) and explore management options for inclusion in a Statewide Management Plan. Finally, phase five will involve reporting of results to all stakeholders. This project engages the community to define a complex problem and move towards developing more cohesive, acceptable and regionally coordinated management outcomes.

Assessing and developing citizen science projects

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[2] Science, Monitoring & Knowledge, Department of Environment, Water and Natural Resources

Presenter: Philip Roetman

Citizen science projects engage members of the public (citizen scientists) in scientific research in partnership with professional scientists. The citizen scientists make hands-on or intellectual contributions to the research, usually including data collection or analysis, with benefits for both the research and the citizen scientists. Examples in South Australia include the *Great Koala Count*, *Water Watch* and *Cat Tracker* projects. The interest in citizen science and the number of projects is growing locally, nationally and internationally. While there are many quality projects with excellent outcomes for research, education and community engagement, there are also projects that do not achieve their planned outcomes. Over the last year we have been working on a standard process to assess and develop citizen science project ideas. This work began with a workshop to assess the value of citizen science projects to DEWNR's Marine Parks Performance Program. Through that workshop we developed a project assessment template with three important elements. First, a program brief to describe the project, its aims, and how it aligns with departmental or program objectives. Second, an assessment of the desired outcomes. Third, an analysis of the management of the project, including elements such as costs, data management, communications, and temporal commitment. We will introduce the template and discuss its use and development at a citizen science workshop held the day before this conference.

A framework for nature conservation under future climates, to inform climate adaptation planning in regions of the Murray Basin, south-east Australia

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Presenter: Dan Rogers

There is strong evidence that a warming global climate is impacting on biodiversity, and will continue to do so. However, these directional changes are not impacting on biodiversity the same way everywhere, and, importantly, are not acting in isolation of other drivers. Historic, current and future land-use (including vegetation clearance), pest plants and animals, inappropriate fire regimes, and water diversions for human use are but some of the important drivers that impact on the ability of biodiversity to respond to climate change. Furthermore these can act on biodiversity in ways that are not completely independent of climate change. The response of biodiversity to climate change, therefore, will depend not only on the direct responses of biota to climate variables, but also on the capacity of the biota to respond (or resilience) to change. The variable nature of this response will have important implications for how we respond with respect to management intervention.

Building on existing adaptation frameworks, we present an applied framework for identifying the relative impact of climate change to biodiversity, and the subsequent adaptation options under this variable impact (Figure 27). This framework assesses the risk and adaptation responses of systems under future climates based on two criteria: the biota's "vulnerability" to future climates (the expected rate of climate change, with respect to the climatic tolerance of biota), and the biota's "resilience" (capacity of biota to adapt to change, including climate change).

While this framework can be applied at different levels of biotic organisation (species, ecosystem, landscapes), by way of example we have applied this framework at a landscape scale to the subregions of the to the Murray Basin Cluster NRM regions. This large area encompasses a high diversity of post-European modification and climate vulnerability. At a landscape level, therefore, the likely response of biodiversity to climate change – and the nature of intervention required to conserve biodiversity – will also vary significantly across this region, from the relatively resilient landscapes of the Australian Alps (green) to the highly sensitive landscapes of the western ranges and mallee (red; Figure 28). The recommended responses to climate change at this scale are equally diverse, ranging from maintenance using existing programs, to the need for transformative change. We discuss how these broad landscape analyses of climate adaptation need to be considered in the context of other levels of biodiversity, such as ecosystems and species, as vulnerability and resilience may differ among these levels, even if they are located within the same landscapes.

An overview of research and monitoring of highly migratory pelagic sharks in South Australia

Rogers, P. and Drew, M.

Threatened Endangered and Protected Species (TEPS) Sub-Program, Marine Ecosystems Program, SARDI Aquatic Sciences

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Presenter: Paul Rogers

A key focus of research and monitoring conducted by the Threatened Endangered and Protected Species (TEPS) Sub-Program is to support integrated fisheries, tourism and ecosystem-based management of threatened and protected pelagic sharks in South Australia. We use electronic tags, genetic and photographic identification techniques to investigate the movements, habitat use, population structure and linkages between pelagic sharks and marine industries. Focal species include the white shark, shortfin mako, bronze whaler, blue shark and common thresher. This presentation provides an overview of our current projects that target national, state and regional research and monitoring priorities in South Australian gulf, continental shelf and oceanic ecosystems. These include residency of white sharks in the Neptune Islands Group (Ron and Valerie Taylor) Marine Park, overlaps between pelagic sharks and marine industry activities in Spencer Gulf, and the biodiversity and habitat use of pelagic sharks in the Great Australian Bight. We will conclude by identifying our future research priorities for key pelagic shark species in the South-west Marine Region and South Australian state waters.

Mapping the distribution of the European rabbits (*Oryctologus cuniculus*) in Australia using occurrence data from targeted field studies and citizen science

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Presenter: Emilie Roy-Dufresne

European rabbits have been well studied in Australia since their introduction. Nevertheless, very few studies have investigated the environmental conditions that influence the distribution of rabbits in Australia. This information is important for reducing the economic losses and widespread environmental degradation caused by rabbits in Australia. Recently we compiled a spatiotemporal data set describing over 100 years of rabbit demography from expert and citizen science programs (e.g., Feral Scan). We matched the occurrence records in this data base to climatic and environmental predictors. We used species distribution models to quantify the geographic range of rabbits in Australia and identify favourable (and unfavourable) habitat conditions. We tested whether rabbit location data from citizen science programs can be used alone or combination with data collected by experts, to predict rabbit occurrence. We found that citizen science can in some circumstances provide an important source of data for modelling species range dynamics, including invasive species.

Introduction of *Dactylopius ceylonicus* Green (Hemiptera: Dactylopiidae) to South Australia

Rutherford, H.

Natural Resources Adelaide and Mount Lofty Ranges, Department of Environment, Water and Natural Resources

Presenter: Henry Rutherford

Drooping pear, *Opuntia monocantha* (Willdenow) Haworth is native to Brazil (Watson 1889) and Uruguay (Dodd 1925), and was initially introduced into Australia in 1788 (Dodd 1940). In 1913 the Queensland Prickly Pear Travelling Commission experimentally introduced the cochineal insect *Dactylopius ceylonicus* Green (Hemiptera: Dactylopiidae) into Queensland to control various weedy populations of *Opuntia* (Cactaceae) (Dodd 1940). A comprehensive biological control program followed from 1920 to 1939. It was delivered by the Commonwealth

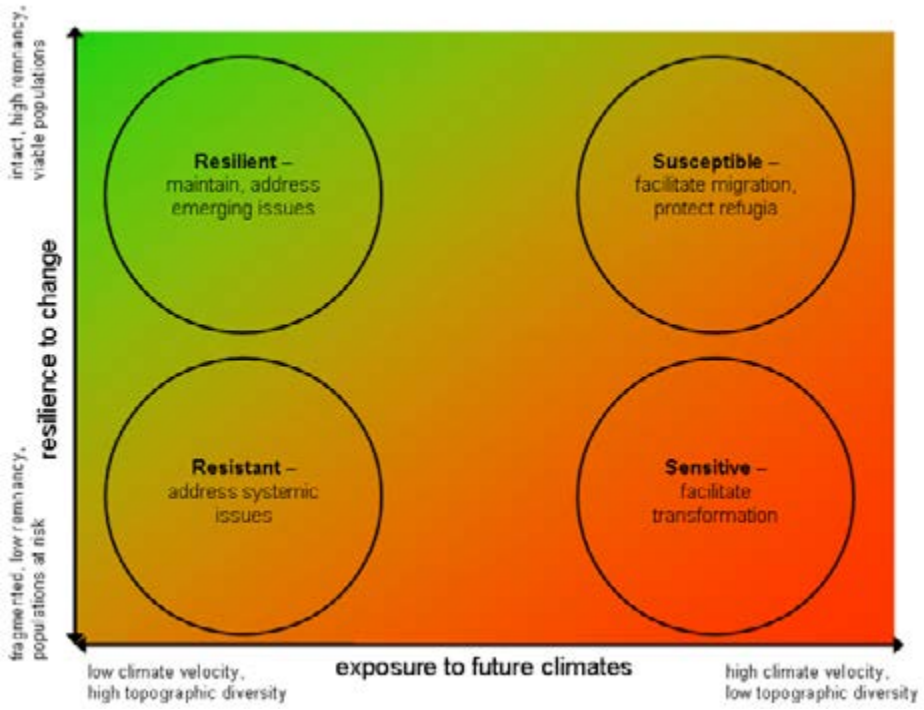

Figure 27. Framework for assessing the nature of response to climate impacts on biodiversity.

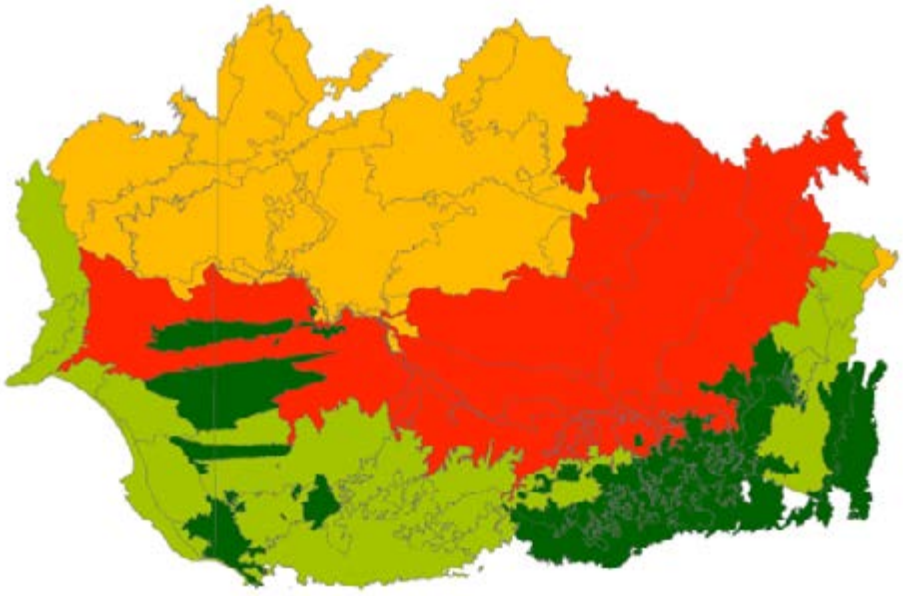

Figure 28. Map of SE Australia, classifying the biotic landscapes with respect to the framework presented in Figure 27 (dark green – resilient; light green – resistant; orange – susceptible; red – sensitive).

Prickly Pear Board, who sent an envoy to the Americas to source biological control agents for the common prickly pear, *Opuntia stricta* (Haworth) Haworth, including the cochineal insect, *Dactylopius opuntiae* (Cockerell) (Dodd 1940).

In 2012 Natural Resources Adelaide and Mount Lofty Ranges (NR AMLR) infected populations of *O. monocantha* along the Gawler and Onkaparinga Rivers with a locally-sourced cochineal insect *D. opuntiae*. These insects established but their impact was not substantial. Then, during the May 2013 National Invasive Cacti Forum, Hahndorf, South Australia, it came to light that NR AMLR had matched an incompatible agent/host relationship (*D. opuntiae*) / (*O. monocantha*), and that *D. ceylonicus* was needed for *O. monocantha* (Zimmermann pers. comm.).

The Department of Primary Industries, NSW, provided a collection of *D. ceylonicus* hosting on *O. monocatha*, arriving in South Australia in late 2014. NR AMLR reared the insects through the hot summer of 2014–2015 in garbage bins inside a shed at Wittunga House, Blackwood. These insects multiplied

rapidly, expanding from an initial infected pad volume of c. 1 litre to an infected pad volume of c. 720 litres within four months. The abundance of insects led to two field nursery populations being established in the AMLR region, at Port Elliot and the Gawler River. Bins of nursery insects were also kept at Wittunga over the winter of 2015, where they suffered considerable degradation, probably due to the poor condition of the heavily-impacted host material. The population on the Gawler River was also impacted by the dumping and subsequent clean-up of refuge on top of the release site. Meanwhile the population at Port Elliot persisted through the winter of 2015.

In late winter 2015 insects were collected on healthy host plant material from the Port Elliot field site and reared in an uncontrolled glass house at the Wittunga Botanical Gardens, Blackwood. Through late autumn and into spring the temperature within the glasshouse was around 10°C above ambient outside temperatures. While the insects did not breed as rapidly as in the previous summer, the condition of both the host material and insects remained markedly better. In October and November 2015 insects were introduced to field nursery sites along the Gawler and Onkaparinga Rivers. As at March 2016, the populations are now well established with noticeable impacts on the host plants. By comparison, the field site at Port Elliot did not recover well from the harvest event in August 2015. In March 2016 the impact on the host at the spring 2015 release sites was considerably greater that at the harvested site.

A study by Sullivan (1990) on the population growth of *D. ceylonicus* showed that at temperatures below 16°C the insects remained dormant, and that increasing reproduction, growth, and mortality correlated with increasing temperature. Sullivan suggested that a productive stable relationship exists between reproduction and mortality, and the ideal temperatures for breeding *D. ceylonicus* is 26-30°C.

Observations from the two breeding programs at Wittunga and the field nursery site at Port Elliot, support Sullivan's conclusions. Populations incubated in the shed (> 30°C) and glasshouse (25°–30°C) at Wittunga grew much more rapidly, than those at the field site (15°–20°C) at Port Elliot; and the population incubated in the glasshouse (25°–30°C) and appeared healthier than those incubated in the shed (> 30°C).

First instar female *Dactylopius* hatchlings disperse by a combination of crawling and wind assisted relocation. This docile method of dispersal limits its potential effectiveness as a biological control agent, requiring manual relocation to improve efficacy (Hosking et al. 1994; Foxcroft and Hoffmann 2000).

The introduction of *D. ceylonicus* to South Australia has benefited from artificially warming insects in late winter, to stimulate reproduction prior to a field release. New hatchlings are then readily available for release in spring. Consideration should be given to selecting warmer microclimates for release sites, to maximise insect growth and efficacy. Transferring host pads too late in autumn should be avoided. Late releases can result in poorer host pad condition and nutrient value, and disrupt the breeding cycle, as female insects are entering cold-induced dormancy. Consideration needs to be given to the minimum sustainable population size that should be left at a nursery harvest site.

Acknowledgements: Thanks to Helmuth Zimmerman, Plant Protection Research Institute, Pretoria, South Africa, Paul Sullivan NSW Department for Primary Industries, Tamworth, and John Heap Biosecurity SA for their encouragement and mentoring support.

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Effect of aquifer sediment mineralogy and stormwater chemistry on transport and removal of viruses

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[3] National Centre for Groundwater Research and Training, Adelaide

Presenter: Salini Sasidharan

Managed Aquifer Recharge (MAR) is the process of storing a water source, such as treated wastewater or stormwater, in aquifers under controlled conditions for withdrawal at a later date. Enteric viruses are one of the major concerns in water reclamation and reuse. Understanding the process of virus attachment to aquifer sediments under various chemical and physical conditions will provide an insight into the selection of appropriate MAR site and helps to assess the risk of contamination of recovered water. In this study, we investigated the fate and transport of three different bacteriophages (ΦX174, MS2 and PRD1), as surrogate for human pathogenic viruses, in columns packed with aquifer sediment from the Parafield aquifer, which is a sedimentary limestone aquifer. Stormwater is the rain/runoff water collected and stored in the Urrbrae wetland. The stormwater was either directly used in the experiments or was first equilibrated with the limestone sediments, which resulted in a high calcium concentration. A

control experiment was conducted using clean river sand and 10 mM Na+ electrolyte with a pH adjusted to 7. More than 2 log virus removal due to attachment to the aquifer sediment was observed when the stormwater was directly used in the experiments. Attachment efficiency increased with increasing calcium concentration implying that virus attachment may increase as water travel further away from the injection well. We also observed that the virus attachment was irreversible, that is, negligible detachment occurred when the flow velocity was increased and the pH was increased to 10. This finding suggests that attached viruses might have quickly inactivated or were irreversibly attached to the sediment surfaces. Our results suggest that a limestone sediment has a great capacity to remove viruses. We demonstrated that the sediment mineralogy was the key parameter influencing virus attachment and transport in the sediment.

The ecology of Lake Eyre basin fishes: Hydro-climatic drivers and fish assemblage dynamics in Australia's desert river basin

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South Australian Research and Development Institute, West Beach

Presenter: David Schmarr

Lake Eyre Basin (LEB) is the largest endorheic basin in Australia. Its catchment is entirely arid or semi-arid with all major rivers either disappearing completely beneath desert sands or draining into ephemeral salt lakes including Kati Thanda-Lake Eyre. During large floods, however, the system is flushed with enormous volumes of fresh water enabling biota to reconnect across landscapes from critical aquatic refuges such as deep waterholes or artesian springs. Fish, being entirely aquatic, are an excellent indicator of the climatic and hydrological drivers that control ecosystem dynamics in this unique, unregulated and largely unimpacted Basin. Over the past decade, fish surveys have been conducted at multiple scales across the LEB by regional, State and crossjurisdictional projects using common methodologies and sites. Data from Lake Eyre Basin Rivers Assessment (LEBRA), SA Arid Lands NRM Board projects and ARIDFLO data to enable a Basin-wide assessment of the relationship between climate, hydrology, refuge habitat and fish population dynamics in the LEB. This project has enabled the analysis of a unique combination of broad scale spatial and temporal data. Data analysis was undertaken as part of the Goyder Institute for Water Research's GLEB project to investigate approaches for assessing environmental condition and help inform the LEB Ministerial Agreement. Analysis of data revealed discrete functional zones across the Basin where fish assemblage dynamics responded in similar and potentially predictable ways to environmental drivers. Functional zones corresponded closely with patterns in hydrology, fluvial geomorphology and refugial dynamics and provided an opportunity for using long-term monitoring data to assess Basin-scale environmental condition within the hydro-climatic context of LEB.

Impact of mineral exploration on ecosystem characters and mallee vegetation of Pinkawillinie Conservation Park, South Australia

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Mineral exploration in Pinkawillinie Conservation Park, South Australia, has resulted in 240 km of exploration tracks being formed in sand dunes by a tractor towing a concrete roller squashing the vegetation to enable vehicle access for operations. Pinkawillinie CP is an important semi-arid area of remnant, intact vegetation with 70% of the total floristically mapped vegetation on Eyre Peninsula and consists of 45 mallee plant communities. This area is, in the main, not impacted upon by human activities. It has significant ecological value due to the large amount of the surrounding area being cleared for agriculture. The vegetation in the area of this study is characterised by an upper strata of mallee eucalypts, mainly *Eucalyptus incrassata*, and *Callitris verrucosa*, while the mid layer is dominated by *Melaleuca uncinata* (broombush) and the ground layer features *Triodia* spp. Pinkawillinie CP is situated within the Gawler Craton, in particular, the Central Gawler Gold Province, which contains mineral resources of gold, copper and silver. Linear disturbances such as exploration tracks have a larger effect on ecological systems than their actual extension due to their low interior to edge ratio and the zone of effect radiating outward from the route. There has been a considerable amount of research carried out on the environmental impacts of mining operations, but much less on the impact of exploration. This is an important gap in our knowledge, as exploration, which may not have as great a local disturbance on the land as mining, nevertheless affects a much larger area.

In this study disturbed areas were compared with closely adjacent undisturbed areas and the physical, chemical and vegetation characters were assessed. Paired measurements and samples were taken in the main topographic positions (crest, slope, footslope and swale) along approximately 100 m of each of three tracks, and closely adjacent undisturbed sites. The tracks were sampled across microtopographic features: centre, wheel rut and shoulder. Measurements of physical characters of soil included compaction, bulk density, structure, water content and erosion. Chemical characters assessed were soil nutrients, pH, conductivity and total soil carbon. Vegetation composition

and processes were characterised by measuring soil seedbank emergence, identification and abundance of plants, seed predation by ants, effect of litter on seedling emergence, weed invasion potential, perennial plant regrowth on the tracks and growth of planted seedlings, soil crust and mycorrhizae.

Compaction was higher on the tracks than in undisturbed areas particularly in the wheel ruts. Soil moisture was higher on the tracks than off them, particularly in the swale. There was a larger movement of soil along the tracks down the dune than in the undisturbed area, particularly in Track 2, which had a higher elevation than the other tracks. For the three tracks combined there was more potassium and total nitrogen in the swale than in the crest, but this was not statistically significant. Annual plants were the main contributors to the germinable soil seedbank and more seedlings emerged from swale soils from the tracks than from undisturbed soils. The number of species of annuals and cover decreased from the swale to the crest in the undisturbed area as well as on the tracks where it was more pronounced. The species composition, growth and survival of perennial seedlings on the tracks showed the pattern of colonisation and there were no perennial seedlings observed in the undisturbed area. The weed invasibility experiments showed a slightly higher potential on the tracks than off, particularly in the swale. The addition of litter had no consistent effect on seedling numbers and seed predation by ants was also independent of topography or disturbance. The survival of colonising perennial plants on the tracks over 28 weeks as assessed by tagging plants was low at all positions along the tracks. Overall, more deep rooted dicot perennials survived than shallow rooted monocots, particularly at the swale and slope. To assess for weed invasion potential a phytoassay using *Carrichtera annua* resulted in higher growth in swale soils and overall slightly higher in soils from the tracks than in the undisturbed area. Planted seedlings of *Eucalyptus incrassata* reached higher biomass in the undisturbed area in the swale and slope than those on the tracks. Biological crusts were more intact in the undisturbed area and the mycorrhizal content was higher on the tracks.

To summarise, the main effects of the clearance of access tracks: 1. There was greater compaction and more soil erosion on the tracks than off. 2. More nutrients in the swale of the tracks than in that section of the undisturbed area. 3. There was very little perennial recruitment in the disturbed area. 4. There was greater recruitment of annual vegetation and potential for weed invasion in the swale on the tracks than off of the tracks.

To minimise these impacts the practice of rolling the vegetation, as used in this instance, is better than scraping off the top layer with a bulldozer as is commonly used. This enables the seedbank to be kept intact. More vegetation is left on the tracks to provide some nutrients when it breaks down and the environment for windblown seeds to germinate. Plants such as the perennial *Melaleuca uncinata* have a greater chance of growing back from the lignotuber beneath the surface. It is best if the tracks are not cleared straight up and over the dunes in a perpendicular fashion, but at less of an angle across the dune face. Where possible the tracks should be cleared around major trees. This not only saves some of the important vegetation, but makes the tracks less straight. These strategies would reduce the amount and speed of runoff during rain events and therefore lessen soil movement including nutrients, seedlings and seeds down the slope. With the possibility of heavier summer rain falls occurring in this region in the future as a result of climate change minimising erosion potential will limit the area of disturbance. The swale is the most important area to be monitored for weeds as this was shown to be the main place of annual germination and in growth experiments swale soils showed the highest growth of weedy annuals. Soil compaction can be alleviated by shallow tillage in the most compact areas. The vegetation that had become dislodged during the clearing of the tracks if pulled back on to the tracks can provide some stability to the surface, and so reduce the impact of erosion and provide some sites for the germination of windblown seeds and those dislodged by water and soil movement down the slope. Lastly, the entrances to the tracks should be disguised as much as possible to prevent recreational use by local people.

A continental and consistent water mapping product from Geoscience Australia: South Australia applications of WOfS

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The University of Adelaide, School of Biological Science, Spatial Information Group

Presenter: Ramesh Raja Segaran

To manage Australia's wetlands we require an understanding of the extremely variable and complex natural inundation regime of these systems, especially as we move into a hotter, dryer future. However, there is little or no historical data on inundation regime for the vast majority of Australian wetlands. Fortunately, Geoscience Australia have recently produced the Water Observation from Space (WOfS) product, which extracts multi-temporal inundation from almost 30 years of Landsat imagery for all of continental Australia.

In this presentation we discuss our use of these products at three temporal scales to gain a better understanding of inundation regimes of water hole persistence and genetic connectivity paths for fish in the Lake Eyre Basin (LEB), and wetland inundation regimes in South Eastern South Australia. We used the WOFLs dataset to determine the inundation status for Neales-Peake catchment waterholes in the LEB for four ends of dry periods. The WOfS dataset was used to compute least cost paths between fish sampling sites in the LEB to identify high value refugia and potential barriers to genetic dispersal between them. In the South East, a thorough evaluation and analysis of the WOfS product was performed, giving invaluable additional information on the inundation regimes (frequency, seasonality, extent and duration) of the South East's 18,000 wetlands and the Coorong at 25 metre resolution.

We discuss the promise and caveats the dataset offers for further work related to developing a better understanding of Australia surface water hydrology.

The WOfS product is an exciting illustration of the potential of the new Geoscience Australia DataCube. The availability of the WOfS product shifts the focus of remote sensing studies from time consuming and computationally expensive processing to asking and answering management-relevant questions.

Ecosystem Services Dynamics in the Murrumbidgee Catchment

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Presenter: Claire Settre

River regulation has significantly altered the volume and frequency of overbank flooding in many river basins world-wide. In the semi-arid arid Murray-Darling Basin, climate change is likely to further alter the quantity and variability of freshwater supplies. Under these conditions, the allocation of scarce resources to the environment in a way which maximizes ecological benefit and minimizes impact on consumptive users is a key challenge. Central to this challenge is the difficulty of predicting and communicating the benefits of environmental water allocations in a way that can facilitate trade-offs and inform decision making.

One way of addressing this difficulty is the use of the *ecosystem services cascade* which provides a link between ecological response and economic value. To investigate the utility of the *ecosystem services cascade* in informing environmental watering decisions, we build on a stylized hydro-economic model (Connor et al. 2013) of the lower Murrumbidgee sub-catchment. We employ the *ecosystem services cascade* to quantitatively describe the link between the hydrological regime, biophysical response, and economic value. We frame our investigation within the context of annual environmental water trade by an Environmental Water Holder (EWH) who is charged with the mandate of managing water for maximum ecological benefit.

A three-state carbon sequestration model is developed for the lower Murrumbidgee River Red Gum (*Eucalyptus camaldulensis*) floodplain forests. Carbon sequestration potential is defined as a function of tree health. A relationship between overbank flooding frequency and tree health are developed using published data for Yanga National Park. Transpiration is used as a proxy for tree health and carbon sequestration is valued using the market price and social cost of carbon.

Early preliminary results indicate that policies that policies which increase the frequency of overbank flooding, such as annual EWH trade, have utility in maintaining the health of floodplain forests in the lower Murrumbidgee catchment. This is achieved by altering the inter-annual distribution of environmental water supply and avoiding critical temporal thresholds by delivering water when it is most needed for the environment. When the ecological health of the floodplain is maintained through timely watering deliveries, the economic benefit is greatest due to the tangible value of carbon sequestration.

Our approach demonstrates the utility of the ecosystem services framework in the context of a hydro-economic model to communicate ecological and economic trade-offs salient for decision making. Further, we suggest that static methods of valuing the environment omit important consideration for dynamic value of floodplain ecosystems. We suggest that there is merit in expanding the discourse about environmental water to include a more robust consideration of value characteristics, particularly the temporal value of environmental flows to maintain ecosystem services.

Acknowledging the uncertainties of ecological responses and economic valuation challenges, sensitivities and limitations of this approach are analyzed and discussed.

Controlling risk of regime shift in clear freshwater wetlands of national importance in S.A.

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Presenter: Margaret Shanafield

Ecosystem resistance to regime shift is controlled by multiple interacting stressors. Clear water wetlands dominated by macrophytes are fragile systems with the potential to drastically respond to changes in environmental conditions, resulting in a sudden regime shift. Regime shift could lead to an ecosystem of lower diversity, dominated by pelagic and benthic algae and to loss of habitat for endemic species.

Ewens Ponds, in Southeast South Australia, is a karst, groundwater-fed wetland of national importance, habitat for endemic and endangered species. The Ponds represent a rare example of a clear, fresh surface water system in this dry state, and attract thousands of divers each year. Recent occurrences of cyanobacterial bloom and filamentous epiphytic algal development raised concern regarding the sustainability of the water clarity and quality supporting the macrophyte community. This situation provided a clear need for using Ewens Ponds as case study for interacting ecosystem stressors in arid wetland systems.

A combination of monitoring, laboratory and field experiments, and modelling was used to estimate how changes in nutrients and flow would affect phytoplankton pelagic and epiphytic growth, reducing light availability for macrophyte development. First, the hydrology, hydrodynamics and nutrient budget of the system were characterized. Secondly, the most important factors controlling regime shift were

identified. Third, nutrient thresholds and management approaches were proposed to maintain ecosystem health.

The ponds were found to be characterized by low residence time. Phosphorous proved to be the limiting nutrient, with most inputs of allochthonous origin, coming from the groundwater inflow in the first Pond. The apparent age of water entering the aquifer was 26-37 years and based on historical nutrient use, a future increase of P was expected. The main factors controlling regime shift were nutrient availability and flow regimes, as well as the interaction between these factors. A phytoplankton growth model was used to predict changes in algal biomass at different conditions and the consequent light reduction for macrophytes. For example, a decrease of the maximum depth of colonization for macrophytes of about 1 m would be expected with drastic reduction in flow rate and if supported by a total phosphorus concentration of about 0.02 mg L-1 or greater.

Epiphytic algal growth represent and additional risk for the system and was also included in the study. The selected approach allowed the evaluation of the interaction between stressors controlling regime shift occurrence in Ewens Ponds, supporting specific management strategies. The methods used in this study can be easily applied to other clear water wetlands at risk of undergoing similar pressures.

A comparison of conventional and environmental DNA-based fish survey methods in a complex and ecologically-sensitive river system: the River Murray

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Presenter: Jennifer Shaw

Regular biological surveys are essential for appropriate management of freshwater ecosystems. However, current morphology-based biodiversity surveys can be invasive, time-consuming, and financially expensive. Molecular methods such as environmental DNA (eDNA) sequencing have been suggested as alternative non-invasive, time- and cost-effective biological survey tools. However, these molecular tools require careful experimental validation in natural ecosystems before confidence in their use can be assumed. In this study we compared data obtained via eDNA metabarcoding to that of conventional fyke netting for fish communities within drought-prone natural river systems. We compared the effectiveness of different eDNA sampling strategies and genetic markers in detecting rare and threatened fish species. We also compared whether water or sediment samples were the more effective eDNA medium, and evaluated the level of sampling depth required for effective surveys to take place. Our data highlighted a number of discrepancies between the conventional and eDNA surveys, on a per site basis, highlighting the benefits and limitations of both approaches. We discuss these discrepancies, and where possible, provide recommendations for eDNA metabarcoding fish surveys.

Prioritising pest and weed management to optimise success of a landscape-scale restoration project

Shepherd, B. and Meffin, R.

Department of Environment, Water and Natural Resources

Presenter: Ben Shepherd

The Coorong, Lower Lakes and Murray Mouth (CLLMM) Vegetation Program is a landscape-scale habitat restoration project, jointly funded by the Australian and South Australian governments under the CLLMM Recovery Project. Initiated in response to the Millennium Drought, one of its main aims is to build ecological resilience in the Coorong and Lower Lakes Ramsar-listed wetland and surrounds so that these systems can better withstand the impacts of future droughts.

Coordinating pest and weed control at the landscape-scale is a vital component of the program. The aim is to both protect existing remnant habitats and optimise the establishment success of newly restored sites. Planning and prioritisation are central to these efforts, ensuring resources are targeted to provide optimal outcomes. This talk will present the prioritisation framework applied to pest and weed control in the CLLMM region, the specific strategies adopted and highlight the achievements of the program. The prioritisation process used here is a valuable tool for optimising the cost efficiency and effectiveness of pest and weed programs and could be applied by NRM regions.

Simulation of flow and nutrient loadings in the Onkaparinga catchment by the eco-hydrological model SWAT

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[1] University of Adelaide

[2] South Australian Water Corporation

Presenter: Manoj Shrestha

Eco-hydrological models such as SWAT (Soil and Water Assessment Tool) are widely used for assessing the response of flow and nutrient loads to changes in climate, land use and vegetation cover in catchment. These models serve as tools for improved

understanding and management of catchment properties for safeguarding sustainable land use, water quantity and quality.

This study applied SWAT to simulate monthly stream flow and loadings of total suspended sediment (TSS), total nitrogen (TN) and total phosphorus (TP) for five monitoring stations within the Onkaparinga catchment, South Australia, and tested the model's performance based on data from 2000 to 2013.

Results showed that the model was able to satisfactorily simulate the stream flow for all of the five stations of the semi-arid Onkaparinga catchment as indicated by the Nash-Sutcliffe Efficiency (NSE) ranging from 0.64 to 0.84 for the calibration period (2000–2009) and from 0.69 to 0.87 during the validation period (2010–2013). It became evident that the simulation results for nutrient and sediment loads based on data only from the outlet monitoring station at the Houlgraves were improved after utilising data from multiple stations within the catchment. These results suggest a more realistic modelling of spatial heterogeneity of catchment characteristics requires data from multiple monitoring stations. A comparison between rural and urban sub-catchments of the Onkaparinga catchments revealed similar good simulation results for TN- and TP-loadings in contrast to results for TSS-loadings that appeared to be afflicted by high modelling uncertainty.

The resulting model is currently applied as tool for spatially explicit scenario analysis of impacts of prospective climate and land-use changes on the Onkaparinga catchment.

Botany 2016 — Past, present and future

Bioactive natural products and the South Australian flora: The arid zone awaits

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Presenter: Bradley Simpson

The undertaking of natural product chemistry research in Australia has historically focused on prospecting tropical habitats, in particular the state of Queensland. Given the high endemism and species richness of Qld, this location has unsurprising been a biodiscovery research hotspot. Two major, multi-year research projects including The Australian Phytochemical Survey spearheaded by the C.S.I.R (now C.S.I.R.O) during the mid 1900s and more recently a multi-million dollar collaborative project between AstraZeneca and Griffith University between 1993-2007 have scoured many thousands of square kilometers in search for novel compounds. This work has contributed significant scientific benefits including the discovery of new plant species, chemical and pharmacological properties of Queensland's biodiversity and repository of over 200,000 extracts held in what is now known as NatureBank.

The irony of these efforts however, is that it would appear extensive resources have been invested to explore such a small fraction of Australia's landmass, when considering 70% is classified as arid/semi-arid. Moreover, some arid regions have more recently been demonstrated to possess either high endemism/species richness or both, thanks to utilization of modern spatial mapping tools.

The case examples noted above utilised a "shot-gun" approach when determining what species of flora to collect, a strategy now considered by some in the field as redundant. Thus it is proposed herein, that Australia's arid regions present a fresh landscape with which to pursue biodiscovery focused research. But to do so requires a different level of thinking in terms of the collection strategies implemented and methods used for scaling up interesting bioactive materials given the set of challenges that arid zones present. With unique and diverse ecologies, arid zones have potential to yield bioactive compounds for medical and agricultural indications, for which tropical zones may not. One scenario being arid zone plant species must have developed heightened protective responses to the high relative ultraviolet radiation exposures that occur in such environments, which might be at least to some extent mediated by specialized secondary metabolites. Such compounds might therefore provide novel ingredients for use in developing commercial products related to skin health/protection in humans.

SA provides the perfect point of reference to study the bioactivities of arid zone plants. The land area of 983,482 km² is predominantly arid with a mean annual rainfall of approximately 100–300 mm, with very little of the flora having been chemically and biologically characterised to date. The future of botany lies in SA. It will consist of a co-ordinated, multi-disciplinary team of experts, passionate about nature, exploring a virtually untapped paradise of bioactive arid zone flora.

Lower Lakes and barrage release modelling

Sims, C., Fuller, J., Gibbs, M., Rumbelow, A. and Eaton, J.

Department of Environment, Water and Natural Resources

Presenter: Claire Sims

Changes to the natural flow regime of the River Murray System, principally due to river regulation and extraction, has resulted in reduced flow to South Australia and the need for ongoing adaptive management of the system. A series of five barrages regulate water levels within the Lower Lakes and control flow from Lake Alexandrina into the Coorong and Murray Mouth, which is a RAMSAR site of national and international importance. River operators must balance a number of competing objectives within the Coorong, Lower Lakes and Murray Mouth system. These objectives include: Lower Lakes' levels, Coorong water

level and salinity, connectivity between the Lower Lakes, the Coorong and the Southern Ocean, and the habitat of numerous species. Upstream channel capacity constraints further restrict delivery of environmental water to the system particularly during the summer months when irrigation demand is greatest. These factors present a number of challenges which must be continually addressed in the management of barrage releases.

The Science branch of DEWNR provides support to DEWNR River Murray Operations (RMO) in the form of Lower Lakes and barrage release modelling to inform management of the Lower Lakes, Coorong and Murray Mouth site. An eWater Source model of the River Murray in South Australia is used to assess the expected lake level profile and barrage releases under a series of (45 year) historic climatic and fixed diversion patterns, including SA Water and South Australian irrigation diversions. A multi-history approach is used for modelling which provides percentile outputs of flow and lake levels. The model is under continual review and development throughout the year and additional climate and diversion data has been applied to better represent the system.

The Murray-Darling Basin Authority (MDBA) provides a flow forecast to South Australia with volumes and timing of environmental water, SA entitlement flow, potential deferral of entitlement flow, and the corresponding Total Flow to SA. This is used to address two key questions:

1. What is the predicted lake level profile under a range of climate conditions, given the Flow to SA?
2. What maximum barrage release is possible to achieve a target lake level profile?

The model outputs assist RMO in negotiations with the Commonwealth Environmental Water Holder and the development of Watering Schedules which describe the delivery of environmental water, subject to agreed conditions and objectives. This presentation will outline the various conditions that have evolved over the 2015/16 year, including surcharging the Lower Lakes under dry conditions to provide operational flexibility and the ability to maintain barrage releases throughout the summer months, through to estimating additional barrage releases possible due to rainfall in early February, which improved lake levels and freed up channel capacity for the delivery of environmental water. The relatively dry conditions experienced during 2015-16 thus far has increased the reliance on modelled outputs as forecasts are frequently changed, and local conditions require continuous adaptive management. The eWater Source model is a vital component in understanding how environmental water can aid in the management of the Lower Lakes and provides support for South Australia's negotiations around environmental water delivery in terms of volume and timing.

Citizen Science on a shoestring: The Eyre Peninsula goannas project

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Presenter: Ben Smith

What do you get when you combine threatened goannas, a lack of data, a limited budget and the need to make sense of a rising number of anecdotal reports? An opportunity for innovative engagement.

Natural Resources Eyre Peninsula had their work cut out for them recently when they set out to spot, identify and report on an important local goanna species as part of the citizen science project 'EP (Eyre Peninsula) Goannas'.

Rosenberg's goanna (*Varanus rosenbergi*) were once common across southern Australia. However, their distribution is now limited to isolated populations in south west Western Australia, coastal regions of South Australia, Victoria, Canberra and the sandstone country of New South Wales.

Kangaroo Island is thought to be the species' last stronghold, although anecdotal evidence suggests that Eyre Peninsula may sustain a larger than expected mainland population, despite less than ten recorded in the Biological Database of South Australia prior to 2011 and their vulnerable classification.

With conservation methods such as 1080 fox baiting programs well established in the region for approximately two decades, the aim of this project was to gain a greater understanding of the distribution of these scavenger/predators, both inside and outside of National Parks.

The project team knew they wouldn't have the funding to launch the ultimate goanna monitoring project, but put their heads together to come up with innovative ideas to encourage community participation.

Four months later, their minor financial investment has paid off with over 500 (and counting) goanna sightings recorded through the website EPgoannas.com.au. Attached to these observations were over 250 photos and a handful of video clips.

To date, community engagement has been a key component to the success of this project. The next step will involve finding a PhD student(s) to undertake a more detailed studies of this species and hopefully determine the size Eyre Peninsula's *V. rosenbergi* population, understanding breeding areas and determine factors that affect trophic interplay.

Natural Resource Eyre Peninsula would like to everyone who has contributed observations to the EP Goannas data set.

Weir pool manipulation for environmental benefit in the river Murray

Smith, J.

Department of Environtment, Water and Natural Resources,

Presenter: Jaimi Smith

Before regulation, flows in the lower River Murray were highly variable. Major floods caused large-scale inundation of wetlands and floodplains. Conversely, during periods of low-flow, the river level dropped and the floodplains dried. The construction of weirs, dams and barrages after 1900 stabilised water levels in the River Murray, primarily to benefit navigation and irrigation. The stable pool levels have limited exchange of water, nutrients and biota between the river and floodplain, significantly impacting water quality and riverine ecology. Since 2000, numerous weir pools in the South Australia reach of the River Murray have been raised to reinstate some aspects of natural water level variability. Using existing weirs, environmental managers are able to slowly raise the water level to improve hydrological connectivity to anabranches and floodplains. From 2014–16, the Riverine Recovery Project raised weir pools 1, 2 and 5 to inundate wetlands and floodplains. These operations also allowed for testing of government process, community acceptance and ecological response models associated with weir pool raisings. Different duration, timing and frequency of raisings were trialled to elicit the requirements for optimal ecological outcomes and determine what was operationally practical. Monitoring of ecological and water quality responses has shown moderate, but positive, ecological outcomes, without realisation of potential risks. Additionally, a suite of modelling, assessment and planning tools, and processes associated with weir pool raising have been documented to facilitate weir pool manipulations becoming part of normal river operations.

S.A. koala health and disease research

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School of Animal and Veterinary Sciences, The University of Adelaide

Presenter: Natasha Speight

Since 2008 there have been a number of research projects undertaken on SA koala health and disease by staff and students at the School of Animal and Veterinary Sciences, University of Adelaide, located on the Roseworthy campus. These projects have included: description of the pathology of the kidney disease oxalate nephrosis in Mt Lofty koalas, including histological features and blood/ urine changes; the occurrence of Koala Retrovirus and *Chlamydia* infection in Mt Lofty koalas and associated pathology; causes of disease and death in Mt Lofty koalas; studies of the gastrointestinal bacteria that aid koalas in digestion of eucalypt leaves; and description of thyroid gland morphological changes.

Major findings from these studies include that oxalate nephrosis occurs at high prevalence in Mt Lofty koalas compared with Kangaroo Island and Queensland koalas, and causes chronic kidney dysfunction; that Koala retrovirus and *Chlamydia* have higher prevalence in Mt Lofty koalas than expected, but a lower incidence of clinical disease to that seen in the eastern states; that trauma due to motor vehicle accident is the major cause of death and injury in Mt Lofty koalas, oxalate nephrosis the most common disease and that a mange outbreak occurred in wild Mt Lofty koalas for the first time. Gastrointestinal bacteria that degrade the tannins in eucalypt leaves have been described and have some differences to those found in Queensland koalas; whilst the thyroid glands of Mt Lofty koalas have been found to have colloidal changes that progress with age, but are unlikely to have effects on health.

Current research is focussed on determining the role that dietary, genetic, environmental and metabolic factors play in oxalate nephrosis in koalas; and increasing the number of koalas tested for Koala retrovirus and *Chlamydia*, including the Kangaroo Island population, to understand how these infections affect South Australian koalas.

Thanks also to Honours students C. Graham, M. Birkett & D. Piro; DVM-1 students R. Penn, R. Faull, S. Bate, K. Johnson, P. Hicks, A. Matsui, E. Gray, E. Manthorpe, D. Mazzone & E. Wundersitz and interstate collaborators.

Hydraulic redistribution in Western myall: implications for mine site rehabilitation

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Presenter: Emma Steggles

Western Myall (*Acacia papyrocarpa*) tree roots were recently discovered 27 m below surface in a mine pit at Jacinth-Ambrosia (JA) in the far west of South Australia. This discovery highlights a discrepancy between the root-zone depth in undisturbed areas and the much shallower overburden soils (6–8 m) replaced over tailings in rehabilitated sites. It raises questions about how altered plant-soil-water relations in reconstructed soils may affect plant function and survival in the long-term. Our research examined the hydraulic redistribution of soil water by Western myall in an undisturbed area to determine the importance of this process for root development and tree survival.

Hydraulic redistribution is the transfer of soil water by plants via xylem pathways within root networks. Water movement occurs in response to changes in plant-soil water pressure gradients. In general, water is transferred to deeper soil layers during seasons of high rainfall or during large rainfall events, and is moved upwards via hydraulic lift to sustain surface roots during subsequent dry periods.

Western myall is a long-lived tree to 10 m high, often with multiple stems and a rounded canopy that spreads outwards with age. Individuals reach maturity after approximately 75 years and their lifespan exceeds 250 years. The species is restricted to semi-arid and arid regions in southern Australia where they form sparse open woodlands that extend across a narrow band fringing the Nullarbor Plain. The understorey plant community is dominated by perennial chenopod shrubs and a suite of annual forbs and grasses that emerge from the soil seed bank following suitable temperatures and rainfall. Other co-occurring tree species include Red mallee (*Eucalyptus oleosa*) and Bullock bush (*Alectryon oleifolius*).

Water is the main limiting factor for plant growth and survival in this ecosystem, with mean annual rainfall approximately 174 mm. An extended period of low rainfall in 2012 through to mid-2013 had left surface soils very dry at the study site. In May 2013, sap flow meters were installed in various positions on two Western myall trees: trunks (N, S, E & W aspects), several 1^0 and 2^0 lateral and vertical roots as well as taproots. Psychrometers measured canopy stem water potentials and soil sensors measured volumetric water content of surface soils adjacent to each canopy. An onsite weather station measured rainfall and temperature.

Subsequent rains in July 2013 (approximately 50 mm over a 13 day period) produced a rapid and prolonged hydraulic response in both trees. Taproots and several 1^0 and 2^0 verticals and laterals showed strong water movement downwards into the soil away from the trunk (negative flow), whilst some laterals transferred water towards the trunk (positive flow). Substantial flows were sustained throughout the day and night (i.e. in the absence of transpiration) for a two week period. Stem water potentials became less negative in response to increased water availability, indicating changes to plant-soil water pressure gradients. Similar responses to large rainfall events were observed over the next two year period during different seasons: autumn, winter and summer.

Our results show that Western myall trees redistribute surface water into deep soil layers via root systems, thus enabling trees to grow and support extensive root networks which make them resilient to drought. This process is likely employed by other deep-rooted species in the ecosystem, and has important implications for rehabilitation at the broader scale, as it influences landscape hydrology and potentially the spatial distribution of understory plants that rely on the transfer of water to surface soils during dry periods. Mine tailings beneath overburden soils differ from undisturbed soils in their chemical and physical properties. In particular, tailings have a much lower water holding capacity than undisturbed soils. This difference affects plant-soil-water dynamics and is likely to inhibit deep root growth which will compromise the sustainability of Western myall populations in rehabilitated sites. A long-term field experiment has been set up at JA which examines this issue by measuring Western myall growth response to different soil profile treatments over tailings.

Building knowledge to optimise the success of restoration outcomes

Stewart, H. and Meffin, R.

Department of Environment, Water and Natural Resources

Presenter: Hafiz Stewart

The Coorong, Lower Lakes and Murray Mouth (CLLMM) Vegetation Program is a landscape-scale habitat restoration project jointly funded by the Australian and South Australian Governments under the CLLMM Recovery Project. Initiated in response to the Millennium Drought, its main aims are to build resilience and restore the ecological character of the Coorong and Lower Lakes Ramsar-listed wetland and surrounds.

An important part of the program is optimising success by building knowledge to inform adaptive management decisions. This has resulted in a rich resource of knowledge and data. This talk will give an overview of what has been achieved, some key results, and highlight future opportunities. Projects to be discussed include baseline data for assessing changes in vegetation and bird communities, monitoring the survival of planted tube stock, assessing the effectiveness of different guard types on tube stock survival and growth rates, and undertaking trials in sandy sites to increase plant survival in non-wetting soils. The talk will also cover trialling the influence of topsoil removal compared to weed suppression with herbicides on native grass survival, understanding the importance of genetic provenance and how this varies among species, and increasing germination success of hard to propagate species.

Writing a WAP and winning over irate sections of the community

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Presenter: Simone Stewart

The Eyre Peninsula of South Australia is characterised by karstic limestone aquifers that are utilised as the priority aquifers from which to source groundwater in this region (including water for public water supply). Due to the heavy reliance on groundwater in this region, two Prescribed Wells Areas (PWAs) have been created: Musgrave PWA and Southern Basins PWA. In these areas, a Water Allocation Plan (WAP) provides the framework for sustainable management of the groundwater resources by considering the competing environmental, social and economic demands for groundwater.

A new WAP has been developed for the Eyre Peninsula PWAs and the NRM Act requires the NRM Board to consult with the community to ensure acceptance of the policies contained within the document. Because there was angst in some sections of the community about groundwater extraction and resource management in these PWAs prior to the development of the new WAP, a multifaceted approach to consultation was required in order to ensure effective consultation with all sections of the community.

In order to understand community concerns and viewpoints and engage fully with the community (which is essential for effective management planning outcomes), the NRM Board ran facilitated meetings managed by an independent facilitator, open house forums and one on one meetings with relevant stakeholders. The public were engaged early in the process and were presented with the science supporting the proposed policies options which were then discussed for inclusion in the WAP.

The key to successful consultation was to explain the science in simple terms, explain the risks or benefits of new management approaches, enter discussions open mindedly, and where possible, take into account anecdotal evidence. The community was encouraged to have as much input as possible, and policy compromises were made if the groundwater resource was not put at risk.

Facilitated workshops and written submissions to the draft WAP enabled the NRM Board to elicit from participants key concerns, values and the management policies they felt would be effective. This valuable information was used to finalise the WAP as one which is scientifically robust and meets the needs and concerns of the water resource managers, public water utilities, licenced users of the resource and the wider community.

Cross-border cooperation to streamline recovery actions for the endangered Murray hardyhead (*Craterocephalus fluviatilis*) in the southern Murray-Darling Basin

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Presenter: Lara Suitor

The Murray hardyhead *Craterocephalus fluviatilis*, a native fish species endemic to the Murray Darling Basin, is listed as 'endangered' under the Commonwealth EPBC Act. The species was historically common throughout South Australia, southern New South Wales and northern Victoria. Due to compounding threats (primarily habitat loss, changing flow regimes and pest species) the Murray hardyhead has suffered a severe decline in distribution. As few as 9 remnant Murray hardyhead populations persist, which are generally located within saline habitats. For example Disher Creek and Berri Evaporation Basin in the Riverland region of South Australia have historically been used for saline water disposal. In recent decades, Murray hardyhead surviving within these sites were confined to small drainage outfall habitats. In 2012 through federal and state partnerships, innovative projects were completed to increase available habitat at both sites through on ground works, drainage diversion and environmental water allocations (supplied by the Commonwealth Environmental Water Office) to manipulate seasonal water levels. A positive response to these interventions in terms of increased abundances was detected for both Disher Creek and Berri Evaporation Basin populations in February 2015. This encouraging result created an opportunity to increase the area of occupancy of the species (thus reducing the risk of extinction) by translocating fish from these currently robust populations to new habitats within their former range. A long standing cross-border collaboration between Victorian and South Australian departments ensured necessary permits were fast-tracked to facilitate the relocation of a sub-population of Murray hardyhead from the Riverland sites to Brickworks Billabong in Mildura, a wetland prepared and watered specifically to create a future recovery site for the species. Post translocation event researchers have witnessed some promising results.

Carbon turnover in Mallee – implications for carbon sequestration and NRM planning

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Presenter: Qiaoqi Sun

The store and exchange of organic carbon in terrestrial ecosystems is large and critically important in global carbon cycling and in providing invaluable ecosystem services. However, the understanding of plant and soil organic carbon turnover in extensive semiarid regions (including Australia) is inadequate. Long-term drought, occasional episodic rainfall and fires are all likely to constrain plant and soil biological activity and hence carbon dynamics. Measurements of above ground biomass, amounts of exchange of atmospheric CO_2 and soil respiration rates in a mallee ecosystem have enabled initial estimates of carbon turnover.

The field site on Calperum Station, north east of Renmark has been operating since August 2010. During this period the average rainfall was 310 mm/year with the range from 211 mm/year to 511 mm/year compared to the long term median of 251 mm/year. Measured evapotranspiration (ET) was 304 mm/year which indicates that stored soil water from the occasional wet year is very important for maintaining ET during the low rainfall years. Calculations of the total carbon accumulated derived from the half hourly measurements of net CO_2 exchange show that uptake of C varied from 2.6 t/ha in a dry year to 7.1 t/ha in a wet year. Balancing this

uptake is the net respiration which indicated a loss of C from the ecosystem ranging from 3.1 t/ha/year to 4.8 t/ha/year. This results in quite variable annual rates of net productivity for the ecosystem ranging from 1.9 t/ha in 2011 to -1 t/ha in 2014. In other words, it is only in the occasional wetter years that significant dry matter and therefore C accumulates, while in persistently dry years the ecosystem can have a net loss of C. Destructive measurement of standing biomass at the site was 10.3 t/ha, which indicates that this ecosystem accumulates C through living plants at less than 1 t/ha/year in the active growing phase. The estimates of C accumulation from CO_2 exchange and from limited destructive sampling are reasonably consistent. The advantage of the CO_2 flux measures are that they track the large season to season and hence year to year variation in net uptake. This then enables much better estimation of carbon turnover associated with the driving climate conditions.

Bridging the gap between farmers and NRM. Lessons learnt from working with the Agricultural Industry

Sweeney, S. and Herrmann, T.

Conservation and Land Management, Department of Environment, Water and Natural Resources, DEWNR

Presenter: Susan Sweeney

Bridging the gap etween farmers and the natural resource management system is a corporate priority for DEWNR (priority 3). The Sustainable Soils policy team within DEWNR's Conservation and Land Management Branch, is helping to address this priority. Since 2009 the team has developed and implemented over 80 partnership projects with regional NRM Boards and Agricultural Industry Groups. The sustainable farming projects aim to encourage the adoption of improved farming practices to protect soils from erosion and enhance soil health and productivity in the dryland cropping areas of SA, particularly in the face of climate change.

Projects are selected based on one or more of the following criteria:

- The project is based on sound science and best practice
- The project will enhance cooperation between NRM boards and farmers
- The project is innovative
- The project is able to add value to existing effective projects
- The project is able to provide proof of concept which could be progressed if initial results are promising.

Evidence indicates that the sustainable farming projects have helped bridge the gap between farmers and NRM by facilitating collaboration across a range of Agricultural industry, community and government NRM groups to increase adoption of sustainable farming practices. This is through developing partnerships between DEWNR, NRM Boards and agricultural industry groups to develop and deliver projects under the program. Many projects have since value added through leverage of additional funding from NRM Boards and Industry, as well as improving on existing projects. This encourages enhanced cooperation and sharing between NRM Boards, Industry and agencies on the integration of NRM with sustainable agriculture and fosters a considerable amount of good will. Examples and lessons learnt from individual case studies will be presented.

Historical changes in the distribution of hairy-nosed wombats (*Lasiorhinus* spp.)

Swinbourne, M., Taggart, D. and Ostendorf, B.

The University of Adelaide

Presenter: Michael Swinbourne

The first attempts to assess the overall distribution of the two hairy-nosed wombat species (*Lasiorhinus latifrons* – the southern hairy-nosed wombat; and *L. krefftii* – the northern hairy-nosed wombat) were not conducted until the 1970s. Prior to this, information on their distribution and abundance was largely piecemeal and confined to local knowledge and reports. As a consequence, determining the overall distribution of both species at the time of European settlement, and how and why it may have changed over time, was problematic. We conducted a search of the historical records for any mention of hairy-nosed wombats in order to establish their likely distribution at the time of European settlement.

The evidence suggests that there were two main groups of southern hairy-nosed wombats that were separated by Spencer Gulf in South Australia. The western group extended from the western shores of Spencer Gulf south of Whyalla to around Balladonia in Western Australia. The eastern group extended from the eastern side of Spencer Gulf south of the Flinders Ranges, along the western and northern banks of the Murray River to Euston in New South Wales (NSW).

The Queensland population of northern hairy-nosed wombats was probably geographically large but highly patchy, occupying territory along the lower western slopes of the Great Dividing Range from the NSW border near St George to their current location near Clermont. There was also an abundant population in the NSW Riverina. Populations of both hairy-nosed wombat species underwent a significant decline between 1870–1920, with the main influences hypothesised to be competition from rabbits and actions taken by landholders to control both rabbits and wombats.

Our findings suggest that rabbit control measures undertaken since the mid-twentieth century have probably allowed wombat numbers to recover, and they are now reoccupying their lost territory. Our findings also suggest that suggest that the ongoing control of rabbits via methods that do not harm wombats is critical for wombat conservation today. Hairy-nosed wombats may also be sensitive to the influences of climate change, and recommend additional research in this area.

The use of Next Generation Sequencing to examine the diet of native and introduced herbivores in grassy ecosystems of the Murraylands

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Presenter: David Taggart

Declining grassy ecosystems in the Murraylands are of concern for natural resource management resulting in a reduction in feed availability, loss of soil stability, reduced biodiversity and erosion. These are all significant issues for both the conservation and agricultural sectors. Grazing can have both positive and negative effects on grass fitness; at the appropriate levels it can stimulate and encourage growth and diversity, whilst overgrazing, or grazing at inappropriate times, can result in reduced species' density and/or diversity. Understanding overall grazing pressure is vital in managing land for conservation and primary production. In the Murraylands, dominant grazing species currently include the native - western-grey kangaroo (*Macropus fuliginosis*), euro (*Macropus robustus*), red kangaroo (*Macropus rufus*), and southern hairy-nosed wombat (*Lasiorhinus latifrons*), and the introduced - sheep (*Ovis* spp.), European rabbit (*Oryctolagus cuniculus*) and Mediterranean snails (*Cochlicella* spp.). Together these species contribute to grazing pressure in the region. A variety of native perennial grasses, forbes and shrubs form the major component of the diet of these species, however, knowledge of the diet and dietary overlap of these species, their collective grazing pressure on native vegetation, and how this varies in the presence of exotic weed species, or with season, remains to be determined.

The aim of this study was to use Next Generation Sequencing to determine the diet and dietary overlap of significant grazing species (native and exotic) impacting native grasslands in the Murraylands of South Australia, and to determine the nutritional value of the plants consumed and how this varies with season using general biochemistry and protein electrophoresis.

A proposed project investigating correlates of *Toxoplasma gondii* and macroscopic species of *Sarcocystis* to explain their higher prevalence on Kangaroo Island

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Presenter: Patrick Taggart

Sarcocystis gigantean, *Sarcocystis medusiformis medusiformis*, and *Toxoplasma gondii* are coccidian parasites of felids (definitive host) which life cycle uses warm blooded intermediate hosts. When sheep are infected with *S. gigantean* and *S. medusiformis* oocysts, macrocysts will develop in their musculature which often result in carcass trimming or condemnation at slaughter. This results in major economic losses within the sheep industry. Similarly, toxoplasmosis, the disease caused by *T. gondii*, can induce foetus resorption, abortion, still-birth and neonatal mortality in sheep. In wildlife, toxoplasmosis can cause a range of symptoms including respiratory, neurological and gastrointestinal problems as well as behavioural changes. Australian marsupials are particularly susceptible to infection, with fatalities observed in many species in both captive and free-ranging populations. On Kangaroo Island (KI) preliminary research has shown the prevalence of *Sarcocystis* spp. and *T. gondii* infections in sheep to be substantially higher than that on mainland South Australia (SA). This project aims to estimate the prevalence of *Sarcocystis* spp. and *T. gondii* in sheep and wildlife, quantify their economic impact on the SA sheep industry, and investigate why these diseases are predominant on KI when compared to mainland SA. Hypothetical explanations for the high prevalence of these diseases on KI include different environmental conditions, densities of cats, and/or the abundance of infected intermediate hosts.

Botany 2016 — Past, present and future

What's hot in biosystematics and taxonomy in Australasia, and why you need to know about it

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Presenter: Kevin Thiele

Biosystematics and taxonomy are utterly fundamental sciences. Very little of the work presented at this Science Conference would have been possible without the often painstaking work of generations of biosystematists and taxonomists, who have discovered, delimited, named and characterised every species and other taxon being discussed here. Biosystematists and taxonomists ask and answer Question Zero of biodiversity studies — "what's

what?" Try to imagine a world where we have no idea what species are out there or how they differ from one another, and you can understand the fundamental nature of the discipline. This talk will focus on what's hot in biosystematics and taxonomy, highlighting new and emerging methods, concepts and opportunities. From the collections of vouchered research specimens that underpin biosystematics and taxonomy (and that comprise one of the few tools in science that gets sharper with repeated use) to the novel information systems used to communicate biodiversity knowledge to a wide audience, Australian and New Zealand biosystematists and taxonomists have done, and continue to do, ground-breaking and world-leading work. So, if you see a biosystematist or taxonomist during the coffee break — give them a hug.

A top-down approach to habitat restoration using key structural species

Thiessen, J., Eichler, E. and Meffin, R.

Department of Environment, Water and Natural Resources

Presenter: James Thiessen

The Coorong, Lower Lakes and Murray Mouth (CLLMM) Vegetation Program is a landscape-scale habitat restoration project jointly funded by the Australian and South Australian governments under the CLLMM Recovery Project. Initiated in response to the Millennium Drought, one of its main aims is to restore the ecological character of the Coorong and Lower Lakes Ramsar-listed wetland and surrounds. A major component of this is restoring lake edge communities which have been drastically reduced in extent and diversity as a result of the drought and grazing.

Traditional restoration techniques focus on reconstructing entire communities based on assessments of what may previously have occurred at a site or other management goals. Here we present an alternative paradigm in which a key structural species is introduced which can facilitate recruitment of other species and eventually establishment of an entire community. This has the dual advantages of being more cost efficient and ensuring that final community composition is appropriate for the restoration site.

An example of such a key structural species is the aquatic sedge *Schoenoplectus validus*. Lake edge plantings reduce wave energy inshore, thus decreasing erosion, allowing sediment to settle, improving water quality, and facilitating the re-establishment of diverse aquatic plant and animal communities. Plantings rapidly expand in width and density, and resemble the community structure and composition of remnants after around a decade. Approximately 30 km of the Lower Lakes' shoreline will have been planted with this sedge species by the end of the program, making a significant contribution to restoring the ecological character of the wetland.

Are we underestimating climate change risk in South Australia?

Tibby, J.

Department of Geography, Environment and Population and Sprigg Geobiology Centre, University of Adelaide

Presenter: John Tibby

The South Australian State Government's Climate Change Strategy is based on the principle that: "*Policy responses that are founded on the best scientific knowledge*".

However, current South Australian climate change projections and adaptation strategies underestimate the full range of climate change risks at a range of scales.

At the ultimate level, reliance on a select range of climate models (for good scientific reasons) fails to encompass the full range of future climate possibilities. At regional scale, climate change projections used in adaptation strategies have relied on "mid-range" estimates of climate futures.

A range of downscaled climate projections have been developed for South Australia regions (Charles and Fu, 2015) and are the basis of "agreed" climate change projections for the state's regions. They are based on some of the best available science and provide environmental managers with a useful tool to plan for climate change impacts. However, only a subset of the best available climate models (the CMIP family of models) were used in the exercise – as excluded models lacked outputs needed for downscaling. In the assessment of risk, this outcome, while not intentional, is undesirable. The models not used in the downscaling exercise derive "worse" climate projections (in terms of higher temperatures) on average than those used in the agreed projections. The excluded models project higher equilibrium warming with a doubling of CO_2 (termed "climate sensitivity") than those included in South Australia's downscaled assessment. As a result, any strategy based on these "agreed" models cannot make a full assessment of climate change risk.

A recent review of South Australia adaptation strategies implemented in various regions has shown that there is a diversity of approaches applied (Moretti et al. 2015). A number of regional scale climate change adaptation strategies have adopted "middle line" scenarios (e.g. Morreti et al. 2015, p. 22) as the basis for planning. In doing so, adaptation planning is not taking account of the full range of possibilities. As an example why such an approach may be flawed, there is substantial debate in the climate change literature about the extent of possible sea level rise by 2100. It has been argued that projections summarised in past and current IPCC reports underestimate the upper range of possible sea level rise (Rahmstorf, 2007; Horton et al. 2014). As a result, risk assessments should take into account the possibility that global sea level may rise by up to 1.2 m by 2100 (Horton et al. 2014), with a similar acknowledgement of the full range of possibilities needed for other elements of the climate system.

Lastly, while it has been argued that adaptation plans should not go into too much "technical detail" (as non-specialists involved in the planning process "switch off"), it is nevertheless critical that such plans encompass the full range of future possibilities.

In conclusion, without a change in practice there will be a continued multiple-level narrowing of risk perceptions in South Australia. "Narrowed" climate projections will be utilised in adaptation strategies which further narrow the perceived risk by using the middle of the range of (already narrowed) climate change projections. This situation will likely contribute to maladaption to climate change in the state.

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Long-term study of skeleton pathology shows differences between Indo-Pacific Bottlenose Dolphins in Gulf St Vincent and Spencer Gulf, South Australia

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Presenter: Ikuko Tomo

The SA Museum has been collecting marine mammal carcasses for scientific purposes for many years. In order to find the primary and contributory cause of death of the dolphins, full pathology examinations have been conducted since 2009 with the support of AMLR–NRM. Pathology examinations include post mortem, bacterial, viral and parasitological examinations. Post mortem examinations are normally conducted on soft tissues not on prepared skeletons. The primary causes of death of these dolphins have been identified mainly as traumatic injury, infection, circulation disorder and some cases still remained as unknown based on post mortem examinations. Many studies have reported results of marine mammal necropsies but few have included follow-up investigation of skeleton pathology yet this can provide additional evidence as to a dolphin's death. As bones respond to the body's mineral homeostasis and metabolism, their pathology may reflect their living circumstances especially water and/or prey quality.

During 1988–2013, 162 Indo-Pacific Bottlenose Dolphins were collected from Gulf St Vincent (GSV, n = 83) and Spencer Gulf (SG, n = 79). Pathology data from skeletons were categorised into four groups: 1) lytic lesions (relate to infection), 2) degenerative lesions (age-related), 3) trauma/fractures and 4) malformation/dysplasia (congenital). Statistical comparisons were made using data on skeleton pathology, relative age (mature vs immature), sex, collection date (1988–2000, 2001–2013), anthropogenic/non-anthropogenic circumstance and location. Combining the gulfs, 126 dolphins (78%) had skeleton pathology. Among these, trauma 104 (83%) and lytic lesions 92 (73%) had the highest prevalence. Age appeared to be an important variable for several types of pathologies. In Spencer Gulf, many dolphins that died from anthropogenic circumstances had skeleton pathology. Dolphins in Gulf St Vincent had more skeleton pathology (especially lytic lesions) than those in Spencer Gulf. We are continuing to evaluate bone microstructure and heavy metals in dolphins from Spencer Gulf. The purpose of this study was to investigate the health of dolphins using the rarely-employed technique of skeleton pathology. The results will assist agencies charged with managing Indo-Pacific Bottlenose Dolphins in SA.

Climate change adaptation on the SA coast – the policies and the science behind them

Townsend, M., Guy, J. and Huppatz, T.

Department of Environment, Water and Natural Resources

Presenter: Murray Townsend

In 1991 South Australia became the first Australian jurisdiction to adopt a policy framework which included climate change adaptation with the Coast Protection Board's *Policy on coast protection and new coastal development*. It was another "first" when the key elements of this policy were incorporated into the state's planning system in 1994, and South Australia's coastal development has been guided by this policy ever since.

A key component of this policy is the allowances the Coast Protection Board adopted for sea level rise (SLR) over the 21st Century. These inform the management of risk from coastal hazards in the planning system and in the development of protection and adaptation strategies for coastal environments, settlements, development and infrastructure. The SLR allowances were based on the Intergovernmental Panel on Climate Change's First Assessment from 1991.

The science behind this policy, how this has developed and the current state of play will be presented and discussed. This will include comparisons between projected changes in sea level and what the regional and global measurements are telling us. There are also lessons gained from 25 years of application of this policy, and its evolution, weaknesses and potential improvements will be addressed.

Remote sensing of groundwater dependent ecosystems in the western Lake Eyre Basin

Turner, D., Clarke, K. and Lewis, M.

School of Biological Sciences, The University of Adelaide

Presenter: Dorothy Turner

The overall aim of this research was to characterise the geographic distribution and temporal response of vegetation growth in terrestrial and aquatic ecosystems in the western Lake Eyre Basin, where vegetation production is thought to be one of the main drivers of ecosystem function.

We used specialist remote sensing expertise to develop an index of shallow groundwater dependent ecosystems (GDEs) for the western Lake Eyre Basin. This work is part of a larger investigation by the Department for Environment, Water and Natural Resources (DEWNR) "Ecosystems Dependent on Shallow Groundwater Systems in the Western Rivers (Lake Eyre Basin)" (the 'shallow groundwater project').

The GDE index identifies and maps, on a pixel basis, areas that remain green into prolonged dry periods and are most likely to be associated with groundwater availability. The index calculates how often NDVI (derived from MODIS 2000 - present, at 16 day intervals) exceeds a threshold (indicative of actively growing vegetation) during dry periods (derived from the AWAP gridded daily rainfall data), with periods likely to be influenced by significant rainfall events excluded.

The GDE Index Tool (developed in Python) allows the user to define the parameters used in calculating the GDE Index, i.e. the NDVI threshold; the length of the dry period in days; and significant rainfall events (defined by the cumulative rainfall total to be reached in a defined number of days). We present the results of a number of scenarios for the western Lake Eyre Basin.

The results of this analysis could be used to better understand the water balance of the western Great Artesian Basin (GAB). Repeating the analysis periodically can also assist in monitoring the health of the western GAB. The GDE Index Tool can be used in any area with raster rainfall and NDVI data.

Assessing the influence of operation of an environmental flow regulator on ecosystem productivity within an anabranch creek

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[2] CSIRO Land and Water, Urrbrae

Presenter: Sanjina Upadhyay

The importance of floods in mobilising and transporting terrestrial carbon and nutrients and driving riverine productivity has been well documented in a range of conceptual models. However, there is a distinct lack of empirical data showing ecosystem responses to episodic inputs of terrestrial derived natural organic matter. This constrains our ability to predict ecosystem responses to environmental flows. Understanding how to deliver environmental flows in a way that produces a useful pulse in primary productivity that supports higher order organisms is a critical area of research. We compared whole ecosystem metabolism in a floodplain anabranch creek between a period (i) with; and (ii) without lateral connectivity between the creek and the adjacent floodplain to examine how productivity changed in association with changes in water level. We hypothesised that we would observe significantly elevated Dissolved Organic Carbon (DOC) concentrations and changes in Gross Primary Production (GPP), Community Respiration (CR) and Net Ecosystem Production (NEP) during the period of lateral connectivity. Although we observed elevated GPP, we detected no difference in DOC concentration, CR and NEP during the period of increased connectivity. The results demonstrate the heterogeneity of responses to inundation across the floodplain and the need for a better understanding of the importance of hydrology and lateral connectivity between the mosaic of floodplains habitats and creeks/rivers, to improve our ability to plan delivery of environmental flows in a way that supports ecosystem productivity and energy transfer to higher trophic levels.

Botany 2016 — Past, present and future

Population genetic analysis and conservation implications for *Eucalyptus paludicola* using genome wide markers

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Presenter: Korjent van Dijk

In partnership with the NRM regions AMLR and MDB, University of Adelaide and DEWNR researchers have been testing a novel approach to assessing and refining the conservation status of threatened species. *Eucalyptus paludicola* D.Nicolle, commonly known as Mount Compass swamp gum, marsh gum or Fleurieu swamp gum, is listed as an endangered species under the *Commonwealth Environmental Protection and Biodiversity*

Conservation (EPBC) Act (1999). Populations of *E. paludicola*, and closely related species, *E. ovata* and *E. cosmophylla* were analysed using novel genetic markers developed using Next Generation Sequencing (NGS) methods. NGS has facilitated the discovery of affordable management-informative markers that can be subsequently screened in populations of conservation concern. A total of 365 samples were screened for 167 single nucleotide polymorphisms across 48 amplified DNA regions.

Eucalyptus paludicola, and possibly some groups of *E. ovata* samples show evidence of clonality, 111 samples showing signs of sharing one of 60 multilocus genotypes. No evidence to support the divergence of Kangaroo Island populations of *E. paludicola* from mainland populations was found.

Eucalyptus paludicola has a genetic signature that contains elements of both *E. ovata* and *E. cosmophylla* suggesting a recent hybrid origin. Hybrid analysis suggests they are usually first generation hybrids (F1) and rare back crosses to parents. This suggests that the generation of this taxon is the result of contact between the two parental species and subsequent recruitment of hybrids.

This finding opens a debate as to the conservation strategies that might be applied to *E. paludicola*, including its status as endangered.

Regional ecosystem monitoring to improve understanding of oyster productivity

van Ruth, P.

SARDI Aquatic Sciences,

Presenter: Paul van Ruth

There is very little information available on the relationship between changing environmental conditions and food web dynamics, and what this means for oyster performance, in South Australian oyster growing areas. A new project, part funded by an adapt NRM grant from Eyre Peninsula Natural Resources Management Board will begin to address this knowledge gap by investigating the influence of temporal variations in water quality and food web dynamics on oyster performance (growth, conditioning, mortality) in the Coffin Bay growing areas. Continuous monitoring of water quality parameters will be achieved via the deployment of Pentair environmental probes (fitted with data loggers and telemetry packs) in Coffin and Kellidie Bays, which will record temperature, conductivity, pH, dissolved oxygen and chlorophyll a concentrations at regular intervals. This information will be ground-truthed and augmented by seasonal sampling and analysis of additional indicators of ecosystem health by researchers from SARDI Aquatic Sciences. Samples will be collected in the vicinity of the environmental probes and variations in macro-nutrient concentrations, pigment concentrations, microbial and planktonic biomass and abundance and particulate organic and inorganic matter will be assessed. Analysis of this data together with information from related projects (FRDC Oyster feeding project, South Australian Integrated Marine Observing System (SAIMOS)) will provide a local and regional context for the project and offer insights into the broader climatic drivers of any observed variation in food web dynamics. The baseline understanding of environmental variation derived from this project will underpin more detailed future studies of ecosystem structure and function, which will provide oyster growers with valuable information on the drivers and timing of shifts in food web dynamics in growing areas to help maximise productivity.

Over-abundant macropods – Managing the risks

van Weenen, J.

Natural Resources Adelaide & Mt Lofty Ranges, Department of Environment, Water and Natural Resources

Presenter: Jason van Weenen

The management of macropods is a common practice for many primary producers across SA who try and protect crops, orchards and/or pasture from various impacts. Similarly, in recent decades, kangaroo management has also been expanded onto conservation estates to deal with the impacts that overabundant macropods can have on other biodiversity. Managing our native wildlife on public reserves comes with expectations that it's clearly justified and that the managed species will be not become threatened in the process. In SA this means that there is currently a requirement for quantitative information on kangaroo impacts and kangaroo abundance to ensure sound (defendable) wildlife management decisions are being made. Such a requirement for quantitative information has constrained the implementation of timely management programs in parts of the state and a revised "risk management" approach for guiding the future management of macropods is discussed.

Managed aquifer recharge to support economic development in South Australia

Vanderzalm, J., Page, D., Dillon, P., Barry, K., Gonzalez, D. and Torkzaban, S.

Land and Water, CSIRO

Presenter: Joanne Vanderzalm

Water is a limiting resource to support increased agricultural productivity in South Australia; of particular interest is the Northern Adelaide Plains where the growing global demand for food presents an opportunity for economic growth in the region at a time when employment opportunities are declining. At the same time, both urban stormwater and wastewater need to be managed for protection of the built and natural environments. Water recycling via an aquifer is the most economic option to store water for summer peak use and also reduce the discharge of nitrogen to the Gulf St Vincent. In addition,

the potential to harvest urban stormwater provides a source of fresh water that can be blended with recycled wastewater to reduce the salinity of the recycled water available for irrigation.

The Australian Managed Aquifer Recharge (MAR) Guidelines provide guidance to ensure all MAR schemes are developed and operated in a manner that ensures protection of both public health and the environment. Specifically, the MAR Guidelines address twelve hazard categories that address water quality (e.g., pathogens, inorganic chemicals) and the environment which is generally the receiving aquifer (e.g., pressures and flow rates). Two decades of research led by South Australian researchers provides the knowledge to address the risk assessment and management necessary to support a large-scale aquifer storage and recovery operation that could support economic development on the Northern Adelaide Plains. Research outcomes from laboratory studies and MAR demonstration projects with treated wastewater and stormwater at Bolivar, Andrews Farm and the City of Salisbury will be presented to illustrate the fate of pathogens, nutrients and trace organic chemicals in aquifers, variability in salinity of recovered water, mobilisation of iron and arsenic, quantitative microbial risk assessment, risk management, community consultation and economics.

Management of environmental water to stimulate productivity in order to achieve ecological outcomes in the lower River Murray

Wallace, T.A.

Water Research Center, School of Biological Sciences, The University of Adelaide,

Presenter: Todd Wallace

Over the last decade, the majority of the focus of large river restoration activities in the Murray-Darling Basin has been on achieving outcomes for large charismatic biota such as floodplain trees, water birds and native fish. This is partially because changes in condition of trees or abundance of birds and fish are relatively easy to detect, and the community relates these biota, via their own value systems, to river health. It is somewhat intuitive that achieving outcomes for fish and birds requires provision of both sufficient habitat and food resources. Consequently, delivery of environmental water to maintain habitat is a recurring theme in many watering plans. However, the delivery of environmental water specifically to achieve increases in primary productivity that supports higher order consumers has received comparatively little attention. In many cases, any focus on the capacity of environmental flows to mobilise carbon has been on risk mitigation and reducing the likelihood of triggering hypoxic blackwater events and/or problematic algal blooms rather than the positive outcomes resulting from provisioning of carbon and nutrients to fuel the food web. This paper explores the potential for environmental watering actions such as weir pool manipulations and managed inundations of floodplains using environmental regulators to influence riverine productivity as one of the many pieces of the complicated puzzle in achieving a sustainable river ecosystem.

Constraining worst-case climate projections for realistic adaptation planning

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[2] Institute for Sustainable Futures, University of Technology Sydney

Presenter: James Ward

Carbon emissions from fossil fuel dominate greenhouse gas (GHG) projections and resultant projections of global warming. In the absence of global emissions reduction efforts, the GHG emissions – and thus global warming – are arguably limited by recoverable fossil fuel resources. Substantial progress has been made in fossil fuel production modelling, and recent efforts (e.g. Mohr et al., 2015) have constrained GHG emissions projections to a narrower range than the RCP scenarios (van Vuuren et al., 2011). Ongoing uncertainty in estimates of ultimately recoverable resources (URR), however, results in a persistent spread between upper and lower emissions scenarios.

Formal risk management processes require an estimation of the probability of a given hazard occurring (Aust. Standards, 1998). However, despite the wide range of emissions projections, there has been no formal guidance offered to policymakers, natural resource managers, or planners of long-term infrastructure in terms of the relative probability of high versus low warming scenarios. Planning based on a worst-case (severe warming) or a best-case (benign warming) scenario without considering each scenario's likelihood is an inappropriate approach to managing the risks of climate change.

We present a stochastic modelling approach to account for uncertainty in URR of fossil fuels. The URR for each fuel type and country was varied between bounds based on best estimates from published geological data and 10,000 fossil fuel projections were generated using the GeRs-DeMo model (Mohr, 2010). Non-fossil fuel GHG emissions were taken from the RCP6.0 scenario (Masui et al., 2011), which approximately tracks the upper range of GHG emissions in the stochastic runs. The scenarios were then parsed through the MAGICC 6.0 climate model (Meinhausen et al., 2011) with default C4MIP average parameters, to produce 10,000 global temperature projections (Figure 29).

The projections assumed a mid-range equilibrium climate sensitivity (ECS) of 3K per CO_2 doubling, based on the range of 1.5 to 4.5 K given in IPCC's Fifth Assessment Report (Stocker et al., 2014). Using this assumed ECS, by 2100 global warming exceeds 2K relative to pre-industrial in all runs (Figure 29), with 30% exceeding 3K by this time. Temperatures stabilise by about 2200 in all runs, with 55% stabilising above 3K and 20% above 4K warming.

Temperature projections are critically dependent on ECS, and a key goal within climate science is to narrow the range of

estimates for this parameter. Unfortunately the goal is proving elusive; model-based estimates have historically tended to support higher estimates of ECS but the most recent observation-based studies (e.g. Lewis, 2015; Lewis & Curry, 2015) support lower estimates. To investigate the impact of a possible downward revision of ECS, further runs were conducted using a lower ECS of 2K. Under the lower ECS scenario, both the median and spread of projected warming are reduced (Figure 29). The chance of global warming exceeding 2K by 2100 reduces to 46%, and median warming stabilises at 2.1K in around 2150, with 90% of runs stabilising between 1.5 and 3K.

This modelling approach and its results should be of interest to all agencies planning for climate change adaptation, as it assigns likelihood values to global warming thresholds while accounting for the uncertainty of recoverable fossil fuel resources and consequent GHG emissions. The results highlight the need for the climate science community to further constrain the range of ECS in order to improve the reliability and usefulness of global temperature forecasting.

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What to do about blue-green algae in the River Torrens

Ward, K.

Natural Resources Adelaide & Mt Lofty Ranges, Department of Environment, Water and Natural Resources

Through collaboration the South Australian government, local governments and the Goyder Institute for Water Research have taken significant strides toward effective management of cyanobacteria in the River Torrens.

Since the late 1990s Torrens Lake has suffered regular blooms of cyanobacteria, or as it is more commonly referred to, blue-green algae. And as a result the lake has been closed to recreational use on numerous occasions to safeguard public health.

While blue-green algae is predominantly an issue for Torrens Lake, it can grow at numerous locations throughout the lower River Torrens during summer.

In two separate trials over the last five years the efficacy of dilution flows and hydrogen peroxide to reduce blue-green algae has been tested. Dilution flows are a type of environmental flow delivered during summer for amenity and river health improvement.

Early work concluded that for a typical blue-green algae growth rate of 0.4 /day a 10% dilution would be required to have a noticeable impact on the blue-green algae population (Brookes et al., 2015). The volume of Torrens Lake is approximately 400 ML.

Dilution flows were first trialled in 2011–12 and repeated in 2012–13, using a flow rate of 40 ML/d released from Hope Valley reservoir. A major difference between these two trials was that in 2011–12 the blue-green algae population in Torrens Lake was dominated by *Anabaena circinalis*, but in 2012–13 it was dominated by *Microcystis aeruginosa*. These trials concluded that a dilution flow of 40 ML/d was ineffective at reducing the blue-green algae during the peak growth period. Torrens Lake was closed to recreational use in both January 2012 and January 2013. Even so, these trials did conclude that the dilution flows achieve environmental benefits along the river other than blue-green algae dilution.

Dilution flows were subsequently trialled in 2013–14, 2014–15 and 2015–16, using a flow rate of 150 ML/d released from Kangaroo Creek reservoir. Similarly to previous trials it was interesting to note that different blue-green algae dominate at different times. In 2013–14 *Mircocystis flos-aquae* and *Anabaena circinalis* were the dominant species in Torrens Lake with *Microcystis aeruginosa* and *Planktothrix* sp. also present. In 2014–15 the dominant species was *Mircocystis flos-aquae*. In December 2015 the dominant species was *Microcystis aeruginosa*, but as the 2015–16 summer progressed the dominant species became *Mircocystis flos-aquae*. In both 2013–14 and 2014–15 three dilution flows were released, totalling 2046 ML and 1801 ML of water respectively. At the time of writing this paper four dilution flows had been released in 2015–16. Dilution flows have been successfully used since summer 2013–14, and have kept Torrens Lake open for recreational use.

From the later trials it has been concluded that dilution flows could be effective, particularly if flow is released from upstream reservoirs in response to warm weather and heightened risk of algae growth as a preventative measure. But there are limitations.

The delivery of dilution flows at around 150 ML/d is the only successful short-term option trialled to date, however this short-term strategy must sit within a longer-term management plan (Brookes et al., 2015). It has therefore been necessary to work toward developing a multi-pronged approach with both proactive and reactive, and short-term and long-term strategies.

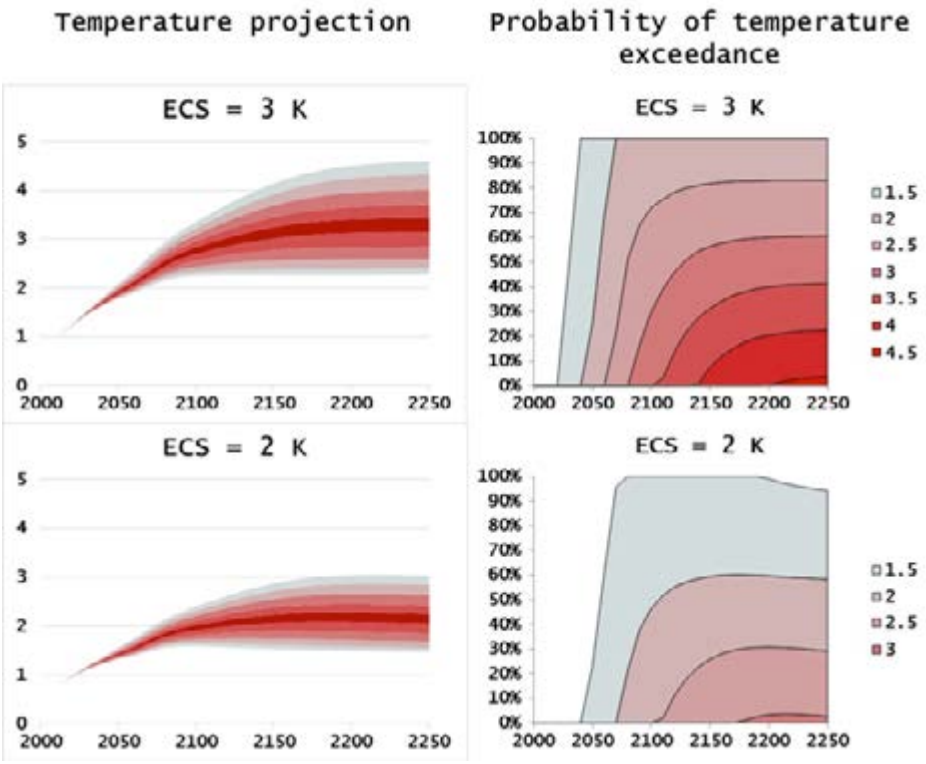

Figure 29. Projections of global temperature change relative to pre-industrial levels based on fossil fuel GHG emissions considering uncertainty in URR (10,000 stochastic scenarios) for two values of ECS.

In low concentrations hydrogen peroxide can be used as an algicide to reduce the abundance of blue-green algae without deleterious effect on other algae or aquatic life. In an Australian first, this trial tested the efficacy and suitability of using hydrogen peroxide in a recreational lake. The trial was staged, commencing with laboratory tests, then a small scale offline test and most recently a small scale application in Torrens Lake.

The trial tested the use of sodium carbonate peroxyhydrate (which contains hydrogen peroxide as the active ingredient).

An ecotoxicology assessment in the laboratory was initially undertaken to evaluate if sodium carbonate peroxyhydrate is acutely toxic to freshwater biota that are relevant to Torrens Lake. Six species were included in the laboratory tests: waterflea (*Ceriodaphnia dubia*); midge larva in 2nd instrar stage (*Chironomus tepperi*); freshwater snail (*Physa acuta*); adult freshwater shrimp (*Paratya australienis*); embryo-larval stage of Murray cod (*Maccullochella peelii*); and juvenile Murray rainbowfish (*Melanotaenia fluviatilis*). The results showed that the majority of species would be minimally impacted for hydrogen peroxide concentrations up to 10 mg/L.

Subsequently nine 6.5 kL pools were used to test the effect of sodium carbonate peroxyhydrate in reducing the abundance of blue-green algae, on green algae or diatoms, on water chemistry and on freshwater biota. Of the nine pools, three were used as a control, three were applied with enough sodium carbonate peroxyhydrate to achieve 2 mg/L hydrogen peroxide, and three were applied with enough sodium carbonate peroxyhydrate to achieve 10 mg/L. All pools contained water pumped from Torrens Lake with blue green algae present, and five different species of aquatic biota (same as used in the laboratory tests). The results showed a significant reduction in blue-green algae abundance over 48 hours at both 2 mg/L and 10 mg/L hydrogen peroxide. At 2 mg/L hydrogen peroxide there were no detectable impacts to green algae, water chemistry or aquatic biota. However at 10 mg/L hydrogen peroxide the sodium carbonate peroxyhydrate did cause a detectable increase in water pH and salinity. At this concentration there were also significant and dramatic adverse effects on shrimp and snails. From this stage it was recommended to proceed to in-lake trials, but to limit the application of sodium carbonate peroxyhydrate so as to achieve hydrogen peroxide concentrations less than 2 mg/L.

At the time of writing this paper the in-lake trial was in progress with only preliminary results available.

The author would like to acknowledge the following organisations and people for their immense contributions to the project over the past five years: Andrew Smith, Adelaide City Council; City of Charles Sturt; Tracey Corbin, Peter Goonan and Clive Jenkins, South Australian Environment Protection Authority; The Goyder Institute for Water Research; David Cunliffe, SA Health; Rob Daly, Peter Hobson, Jessica Iacopetta, and Steve Kotz, SA Water; and Justin Brookes, University of Adelaide.

Reference:

Brookes, J.D., Ward, K. and Daly, R. (2015) *River Torrens Water Quality Improvement Trial – Summer 2014/15*. Report to the Adelaide and Mount Lofty Ranges Natural Resources Management Board

The koala on Kangaroo Island: Breeding dynamics of an overabundant, out of range herbivore subject to fertility control management

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Presenter: Freyja Watters

On Kangaroo Island (KI), the koala (*Phascolarctos cinereus*) occurs as an overabundant and out of range of population. High koala densities have caused defoliation of their preferred food trees, threatening their own habitat. Over the past two decades, Natural Resources KI (DEWNR) has been actively managing the population through an ongoing sterilization program. As part of my honours project, I aimed to quantitatively examine the outcomes of fertility control on koala breeding dynamics at the population-level using data gathered during the course of management. This talk investigates the affect of surgical sterilization on population density and breeding rates through time in the Cygnet River sub-population, where island management has been primarily focused.

Evidence of a steadily declining trend in koala density over time in Cygnet River was observed, with densities not substantially exceeding the programs target density of 0.75 koalas/ha since 2006.

Declines in breeding rates per head of population over time were a strong indicator that a large proportion of females in the Cygnet sub-population are currently sterilized, providing support for the success of the sterilization program in achieving its goal of reducing koala densities. Temporal trends indicating an increase in the breeding rates of fertile females suggested a compensatory breeding mechanism may be occurring in response to decreasing densities. This compensation however, was insufficient to overcome the effects of fertility management. The presented results illustrate the importance of maintaining annual projected sterilization targets to ensure the program remains an effective management tool into the future.

Botany 2016 — Past, present and future

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The idea that the *past* and the *present* inform our *future* is certainly not new. In fact, the basis for advancement of scientific knowledge is built upon learning from work done in the past, using it to develop testable ideas today and using the answers gained to find new ideas to develop hypotheses in the future. This Symposium will bring together more than 20 speakers who will present different aspects of the past, present and future as it relates to the discipline of botany in South Australia.

The idea for this symposium came from the celebration by the State Herbarium of South Australia of its 60th Anniversary during 2014-2015. A short history of the herbarium is found below (Figure 30) as there will not be time during the Symposium and we hope that these sessions provide a range of topics for you to enjoy the botanical history, the diversity and evolution of disciplines and to also find something for our future work in botany.

A State Herbarium for South Australia

In November 2014, the State Herbarium of South Australia recognized its past through celebrating its formation as an independent entity for 60 years. The genesis of the formation of the Herbarium was with the appointment of Noel Lothian as Botanic Gardens Director in 1948. Although herbarium collections had been a part of the work of previous staff at the Botanic Gardens, Lothian recognized the need to establish a State Herbarium with associated taxonomic works conducted under its auspices.

In 1954, the State Herbarium of South Australia was formed under the acting leadership of Edward Stirling Booth out of collections formerly held by the Museum of South Australia (which included Botanic Gardens collections) and the Botany Department at The University of Adelaide. In addition, an active collecting program was undertaken by early staff led by the first Keeper, Hansjoerg Eichler.

Since its formation, virtually all significant plant, algal and fungal collections in the State have been amalgamated into the State Herbarium of South Australia. Significant additions made at a later date were the large collection formerly held by the Waite Institute (c. 57,000, transferred in 1985), and the marine algae from the Botany Department (c. 70,000 in 1990). Other significant material has included much of Cleland's fungal collection (also from the Waite Institute), a large private collection of Australian and foreign mosses and lichens from D.G. Catcheside, a *Eucalyptus* collection from the Woods and Forests Department, and collections formerly held by the University of South Australia and the Animal and Plant Control Commission. Today the collections have grown into the 4th largest herbarium collection

in Australia, with over 1 million specimens of plants, algae and fungi. Among the treasures of the collections are specimens from early scientific expeditions to the interior regions of northern and western Australia and major initiatives in surveying biodiversity:

- Elder Exploring Expedition (1891-2) [principal collector Richard Helms]
- Horn Expedition (1894) [principal collector Ralph Tate]
- Calvert Expedition (1896-7) [collector George Keartland]
- Simpson Desert Expedition (1939) [Madigan Expedition]
- Arnhem Land Expedition (1948) [principal collector Ray Specht]
- South Australian Biological Survey Program 1983-2010
- Weeds collections initiative [2009-ongoing].

The last three decades have seen significant taxonomic works undertaken by staff of the State Herbarium, and some significant works are still underway by former and current staff whose commitment to their work is extreme. Like many other collections-based institutions around the world, the State Herbarium recognizes the valuable contributions that our volunteer and honorary research associates provide to the herbarium operations.

The future for the State Herbarium of South Australia will continue to be strongly linked to its role as a caretaker, provider and generator of core, foundational botanical knowledge in SA for the betterment of the community as a whole.

Important functions of the herbarium will continue to be:

- A provider of core environmental knowledge — our specimen records are available and used, locally, nationally and globally
- To provide the up to date "Flora of South Australia" for accurate identification of plants
- A source of reference material to compare botanical biodiversity in the past, present and future
- A repository of specimens representing the physical presence of plants in a particular place and a particular time
- An important partner in botanical biodiversity and biodiscovery research
- A provider of taxonomic advice, education and decision making for the State of South Australia, including the identification of new weeds
- The authoritative sources of evidence for plants, algae and fungi found in South Australia (Census), including the identification of new weeds, and the regions they occur in
- A provider of taxonomic, systematic and botanical research for South Australia.

Gerard Floodplain Watering Trial: a partnership between Aboriginal Lands Trust, Gerard Community Council, Gerard Aboriginal Learning on Country Team and Natural Resources SA Murray-Darling Basin Wetland and Floodplain Team

Wegener, I.

Natural Resources South Australian Murray-Darling Basin, Department of Environment, Water and Natural Resources

Presenter: Irene Wegener

The ecological impacts of river regulation, in particular upon wetlands and floodplains of the Murray-Darling Basin of Australia, are well documented. Modification of the hydrological regime (through locks, weirs and extraction) has resulted in widespread decline of floodplain vegetation, particularly of long-lived vegetation such as river red gum (*Eucalyptus camaldulensis* var. *camaldulensis*), black box (*E. largiflorens*) and lignum (*Duma florulenta*). Additionally, lack of regeneration and recruitment of vegetation has implications of the continual survival of these species and species that depend upon them.

The Gerard Floodplain is an extremely important site for the Riverland Aboriginal community. The area is a prominent cultural site among the Riverland Aboriginal Community and many of the community have strong memories or associations of living or utilising the area. The degradation of the area over several decades is a major concern to the Riverland Aboriginal community and the restoration of its environmental and cultural values is considered a high priority. Improving the understanding of the water

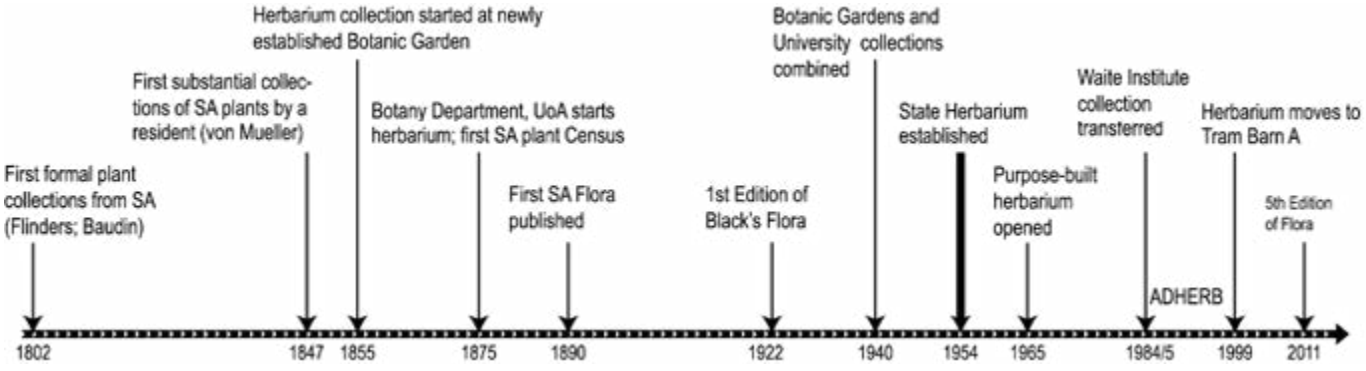

Figure 30. Timeline relating significant collections and institutional dates, including the formation of the State Herbarium of South Australia.

requirements of black box is important as a gap in knowledge exists concerning this. In spring 2013, a trial investigating the effects of watering via gravity fed infrastructure on the condition of black box trees on the Gerard Floodplain was established. A total of 90 trees have been monitored at the site seasonally, with five trees comprising each individual plot. Thirty trees acts as control trees, while 60 trees are split between two treatments. The Treatment 1 group receives 3000 L water/plot on a monthly basis while Treatment 2 group receive 3000 L water/plot on a bi-monthly basis. Monitoring of trees is undertaken on a quarterly/seasonal basis.

As anticipated, trees in the control group have continued to decline in condition within the monitoring period. Trees in the Treatment 1 group have shown the greatest improvement in condition while the condition of trees in the Treatment 2 group has been largely maintained within the monitoring period.

The project was undertaken in partnership with the Aboriginal Lands Trust and the Gerard Community Council. Much of the trials design, establishment and monitoring has been undertaken by the Gerard Aboriginal Learning on Country Team.

Distribution of and observations on gut content of the oriental weatherloach (*Misgurnus anguillicaudatus*) in the South Australian Murray-Darling Basin region: From specimens captured by Natural Resources SA Murray-Darling Basin

Wegener, I. and Suitor, L.

Natural Resources South Australian Murray-Darling Basin, Department of Environment, Water and Natural Resources

Presenter: Irene Wegener

The oriental weatherloach (*Misgurnus anguillicaudatus*), is a fish species native to Asia. In Australia, the first specimen was collected from the wild in 1980, with the first breeding population detected in the Yarra River (Victoria) in 1984. Its importation to Australia was subsequently banned in 1986. The species displays several characteristics of a successful invader: it is long-lived, matures early, is highly fecund and has broad environmental tolerances. As such the potential invasion risk of the oriental weatherloach is considered to be high to very high in Australia. The species is considered exotic in South Australia under the Fisheries Management Act 2007 and importation is banned under the Environmental Protection and Biodiversity Conservation (EPBC) Act 1999. Little is known about the species impact in Australia, much of this is speculative at present.

The Natural Resources SA Murray-Darling Basin Wetland and Floodplain Team undertake seasonal fish monitoring across the South Australian Murray-Darling Basin region. At the height of the 2010/11 flood event that the oriental weatherloach was captured for the first time in the South Australian Murray-Darling Basin. In February 2011 a single individual was captured on the Chowilla Floodplain signalling an increase in the species range downstream.

Since the species initial capture, a total of 222 individuals have been captured at 25 locations along the River Murray. Sampling undertaken between 2011 and 2015 has shown that a range expansion has occurred downstream within this period. Both male and female specimens have also been identified from specimens captured. Fish captured between 2011 and 2015 have ranged in size from 56 to 183 mm, indicating the presence of both juvenile and sexually mature fish comprising the population within this time. A total of 10 native fish and 4 non-native fish species, as well as a range of aquatic invertebrates and other aquatic fauna (e.g. frogs and tadpoles) have been captured with oriental weatherloach. Additionally, oriental weatherloach have been captured in a range of physical habitats and in varying surface water qualities.

Recent gut content observations have revealed that the diet of the species has been varied with food items ranging from vegetative matter, to detritus, and aquatic invertebrates. These food items may overlap with native species including species of conservation significance. Observations on the diet of the species in South Australia will assist in further determining the species impact in its invaded habitat.

Does biodiversity supress infectious disease emergence?

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Presenter: Philip Weinstein

Healthy ecosystems provide a variety of ecosystem services to humans, most obviously provisioning services (food, water, fuel, and shelter), but also regulating services (climate control, disease suppression) and cultural services (recreation and wellbeing). Biodiversity is fundamental to maintaining ecosystem functionality and resilience, and when biodiversity is adversely affected by human activities such as urbanisation, agriculture, and CO_2 emission, ecosystem services can fail. Directly or indirectly, the maintenance of biodiversity can prevent a variety of public health problems, including the triggering of emerging infectious disease epidemics.

One of the earliest documented and best examples of biodiversity supressing emerging infectious disease is that of lyme disease in North America: In biodiverse old-growth forest, predators and competitors reduce the number of reservoir animals and ticks harbouring the lyme disease bacteria (*Borrelia* sp.), thereby decreasing the probability of human infection compared to regrowth forest where biodiversity is lower (Ostfeld and Keesing 2000). A similar situation exists for Ross River Virus (RRV) in Australia, where healthy biodiverse freshwater ecosystems

contain predators and competitors that keep mosquito numbers low. When this biodiversity is lost through for example dryland salinisation, mosquito populations can boom and increase the risk of RRV outbreaks (Carver et al. 2010).

The cutting edge in this field now lies in the area of microbiome research, with increasing evidence that exposure to a broad range of microbes 'primes' the immune system to respond appropriately to both allergens and pathogens (Rook 2013). Floral and faunal macro-biodiversity correlates well with environmental microbial diversity, and exposure to a diverse microbiome may reduce the rate of allergic, autoimmune, and infectious disease. Exposure to urban green space may therefore have immune-mediated health benefits, and a major Adelaide-based study is currently investigating this possibility. In the first instance, geographical correlations will be sought between biodiversity exposure and disease outcomes in a broad multinational study, followed by individual-level work using immunological markers. If confirmed, such a relationship would support the inclusion of exposure to biodiverse green space in urban planning and recreation.

Controlling mechanisms for freshwater lenses beside gaining reaches of the River Murray

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Presenter: Adrian Werner

Saline groundwater adjacent to the River Murray in South Australia gives rise to freshwater lenses, which are considered important features in ecosystem functioning within the adjoining floodplains. In the gaining reaches of the River Murray, where adjacent aquifers are saline, water density forces and groundwater flow act towards the river to inhibit freshwater discharge from the river into the aquifer. That is, both the hydraulic and density-driven forces within the aquifer appear to preclude the formation of freshwater lenses, at least based on the subsurface processes. Therefore, the processes that are thought to form freshwater lens near gaining rivers are: (1) floodplain inundation recharge during flooding events, (2) temporary losing river conditions causing event-based freshwater discharge from the river to the aquifer, and (3) groundwater flows that short-circuit the river course due to meanders. These are commonly attributed to the bodies of lower salinity found in the floodplains next to gaining-river reaches of the River Murray, because the subsurface conditions otherwise appear to exclude the long-term occurrence of stable freshwater lenses.

In this study, an analysis has been undertaken that demonstrates that if buoyancy forces are taken into consideration, freshwater lenses may penetrate adjacent floodplain aquifers despite gaining river conditions. A new analytical solution is presented that describes terrestrial freshwater lenses in gaining river settings where the adjacent aquifer is saline. The method requires a number of simplifying assumptions, including aquifer homogeneity, steady-state conditions, and a sharp-interface between immobile freshwater and hydrostatic saltwater. Application of the method identifies the parameter combinations that allow for the occurrence of freshwater lenses despite gaining river conditions. The outcomes of this study provide custodians of Murray River floodplains with a simple-to-use and physically justifiable method to calculate the extent of freshwater lenses in gaining reaches, at least as a precursor to adopting more complicated and time-consuming methodologies to explore the floodplains conditions in these regions. The implications of these findings are that the occurrences of freshwater in otherwise saline aquifers adjacent to the River Murray do not necessarily indicate losing river conditions, nor does it infer that bank storage effects or land surface inundation has emplaced freshwater into the adjoining floodplain. Instead, in a rather counterintuitive manner, freshwater lenses in River Murray floodplains may be driven by buoyancy forces that are sufficient to overcome the other forces acting on the system, which appear prima facie to oppose freshwater lens development.

Biodiversity adaptation to climate change in the Mount Lofty Ranges: evidence, scenarios, synthesis, and management implications

Andrew West

Natural Resources Adelaide and Mt Lofty Ranges, Department of Environment, Water and Natural Resources

Presenter: Andrew West

Over the last 25 years, there has been an explosion of scientific work focussed on the potential impact of climate change on biodiversity. However, the synthesis and translation of this growing body of knowledge into management has been very limited due to: competing research paradigms; variable scales of application and coverage across the different levels of biological organisation; conflicting results; limited considering existing impacts on biodiversity; and the majority of studies focussing on potential climate implications, with comparably little focus on potential adaptation responses.

To help guide adaptation in the Adelaide and Mount Lofty Ranges Region, a synthesis was produced from the current scientific work by evaluating it using an uncertainty cascades framework, and then incorporating it with scenario analysis and goal-based conservation planning. This enabled a comprehensive and spatially explicit identification of climate change implications for biodiversity under different future scenarios, and the identification of associated adaptation strategies and actions.

Applying an intervention ecology framework to the 30 Year Plan for Greater Adelaide: improving the recognition of complementary environmental and socio-economic outcomes

Andrew West

Natural Resources Adelaide and Mt Lofty Ranges, Department of Environment, Water and Natural Resources

Presenter: Andrew West

The modern foundations of biodiversity conservation emerged from island-biogeography theory in the 1960's. This work and its assumptions have supported the development of important conservation policy and regulatory reform, such as the targeted establishment of protected areas, vegetation clearance controls and components of the Planning Strategy.

However, island-biogeography has also resulted into two unfortunate misconceptions that have been formalised through current policy:

(1) The misconception that biodiversity values are restricted to 'islands' of native vegetation / habitat embedded in a 'sea' of hostile / developed land

(2) The misconception that the biodiversity value of an area can be determined by the similarity of its current vegetation composition to what was presumed to be present prior to European settlement.

These misconceptions give the appearance that conservation and production are competing land uses. However, there are many examples where production landscapes are now the strong-hold for significant components of biodiversity. Unfortunately, this is poorly recognised, resulting perverse policy and regulatory implications that can undermine both economic and conservation goals.

To support policy improvement for those landscapes in which biodiversity and production outcomes are complimentary, a new spatially-explicit analysis was completed and incorporated into the 30 Year Plan for Greater Adelaide (which is the component of the Planning Strategy that covers the Adelaide and Mount Lofty Ranges region).

Rather than adopting the traditional island-biogeography paradigm, the analysis applied a modern intervention-ecology framework. This emphasized the recognition and maintenance of existing conservation values, regardless of whether these occur in areas primarily managed for other purposes (such as primary production). In doing so, this work also helped to reform the associated policy frameworks and support the achievement of both conservation and economic outcomes.

Keeping Culture: community data storage and access, a project within the Diamantina River Catchment project (Lake Eyre Basin)

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[3] Wangkangurru Yarluyandi Native Title Group

4 South Australian Native Title Services

Presenters: Mel White and Jean Barr-Crombie

The protection and preservation of Aboriginal sites, objects or remains in South Australia is managed by the Aboriginal Affairs and Reconciliation agency who administer this information through a central archive. Over the last decade there have been increasing desire by Aboriginal groups to have information systems that can independently manage cultural information in an accessible way to store and use knowledge. This has especially been evident in the area of land management where Indigenous rangers can upload and store cultural information.

The Wangkangurru Yarluyandi Native Title Group are part of a four-year project focussing on the natural features and human influences of key refuge waterholes and wetlands along the Diamantina River, Warburton and Kallakoopah Creeks in the Marree-Innamincka district of the SA Arid Lands region. A vital component of the project is working with Wangkangurru Yarluyandi people to improve the understanding of the cultural significance and protection priorities of important cultural sites. For the final two years of the project there is a desire to have a database to store historic and contemporary cultural information and make linkages between Indigenous Biocultural Knowledge and the science that is being collected as part of the project. With data support by DEWNR, a *Keeping Places* database will be developed as an important tool for recording, teaching, maintaining language for future generations that is privacy protected and is solely for Wangkangurru Yarluyandi use.

Keeping Places is an online data portal where culture is categorised into photos, documents, movies, sounds and objects and is then grouped into People, Places, Collections, Fauna, Flora, Events, Activities, Spirituality, Historical Stories, Organisations and Technology. Records from these categories and groups are linked together to form a web of interrelated knowledge. This structure, together with the ability to expand existing groups and create new ones, makes *Keeping Culture* a flexible platform for recording and preserving every aspect of a rich and diverse culture.

Oh no not you again? Exploring drought preparedness to manage SA Murray-Darling-Basin threatened fishes during another diminishing river flow period

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Presenter: Nick Whiterod

Threatened fishes of the SA Murray-Darling Basin were placed under unprecedented risk of extinction during the recent Millenium Drought. All regions of the SA Murray-Darling Basin, including the Coorong and Lower Lakes, tributary streams of the Eastern Mt Lofty Ranges, and the lower River Murray main channel and associated floodplain wetlands, experienced reductions in water availability and associated habitat loss, reduced water quality and desiccation. Fish communities were severely impacted with several observed instances of reductions in species richness and abundance, shifts in assemblage structure toward dominance by generalist salt-tolerant species and species expiration, particularly during the period of critical water shortage (2007 to 2010). Urgent conservation actions were improvised to mitigate the impacts on a suite of small-bodied threatened fish species, but presented numerous challenges. The impact and response to the millenium drought emphasised the critical need for forethought and preparedness to conserve freshwater fish in drought-prone regions of the world. As a strong El Niño pattern persists presently, it is timely to consider the preparedness of freshwater fish (and managers) as we potentially enter another extended period of diminished river flow. We discuss lessons learnt during the Millenium Drought, assess the present status of key species and functional groups, and offer guidance to aide the sustained conservation of freshwater fishes. Without the necessary preparation and willingness, future periods of drought may signal permanent changes to the fish community of the SA Murray-Darling Basin.

Varying responses of two lakes with different trophic status to effects of warming and nutrient loading

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Presenter: Chaturangi Wickramaratne

Climate change and eutrophication remain global problems that continue to threat water quality. A 1-dimensional hydrodynamic model (General Lake Model) coupled with a biogeochemical model (Framework for Aquatic Biogeochemical Model) was used to study the impacts of increasing temperatures and modified nutrient loads on water quality, especially in relation to nuisance phytoplankton blooms. Eutrophic Mt Bold reservoir from South Australia and oligotrophic Lake Tarawera from New Zealand were used as study sites to determine the variation in responses to climate change and modified nutrient regimes as influenced by the trophic status. A matrix of scenarios under different nutrient status as controlled by both increasing and decreasing nutrient loads under rising temperatures (1–4°C) was tested to determine the nutrient loading schemes that can offset the predicted negative impacts of climate change. Increase in nutrients had the most severe impact on the oligotrophic lake, resulting in a three-fold increase in phytoplankton biomass while the eutrophic reservoir observed a two-fold increase under both increased nutrients and temperature rise. The results showed a high sensitivity of oligotrophic lakes to nutrients and high sensitivity of eutrophic lakes to both high temperatures and nutrients. Nutrient or trophic status of lakes was found to play a key role in determining the detrimental effects of climate change and oligotrophic lakes are more resilient to the impacts of rising temperatures. Results highlighted the great challenge climate change poses for lake managers if nutrient inputs are not reduced substantially from present day values, with the possibility of traditional lake restoration techniques having to be enforced at higher intensity, and more frequently, in order to be successful under a future climate with higher air temperatures.

Planning NRM conservation projects in coastal and terrestrial ecosystems

Wiebkin, A., Brad Page, B., Jane McKenzie, J. and Meakin, C.

Department of Environment, Water and Natural Resources

Presenter: Annelise Wiebkin

There are many forms of NRM investment and ways to monitor the impacts of them, but it can be challenging to identify methods that provide the best value for time, money and information. This talk discusses decision-making processes to plan NRM investments at either local, regional or statewide scales, and to develop monitoring programs to track the impacts of those investments on ecological, economic and social systems.

This talk uses local and regional-scale NRM projects, undertaken in partnership with staff from NRM regions and DEWNRs Science, Monitoring and Knowledge branch, as case studies to show how planning processes can be used to identify investment priorities and to develop clear, focused objectives and strategies

to achieve them. Strategies are based on budget forecasts and the capacity to manage natural resources. They are also based on predictions about how the condition of the natural resource will change in response to management within a given timeframe. Tools used in the planning phase of these programs include value-matrices, program logic and conceptual models.

Monitoring programs and indicators must relate to clear objectives detailed in the management planning process. They must also be implemented within a set budget, a timeframe, be analysed appropriately and provide sufficient information at the appropriate spatial scale to determine whether objectives have been met. Monitoring indicators must also have realistic targets and management triggers, which provide the basis for evaluating the success of the project, and adaptive management.

Practical examples will be discussed, along with how results can be communicated to broad audiences.

Reviewing Groundwater Target Management Levels in the South East of South Australia: Kingston Confined Aquifer Study

Wood, C., Bond, T., Pierce, D., Schilling, J. and Peterson, J.

Department of Environment, Water and Natural Resources

Presenter: Cameron Wood

The South East Natural Resources Management Board (SENRMB) administers allocation of groundwater from the unconfined and confined aquifers in the Lower South East of South Australia through the Lower Limestone Coast Water Allocation Plan (LLCWAP). Historically, permissible annual volumes (PAVs) of groundwater extraction from the confined aquifer in the South East of South Australia were determined with the assistance of a groundwater flow model. Furthermore, groundwater allocations were determined based on the area of crop irrigated and estimates of crop water use. With the adoption of the current LLCWAP in 2013, new volumetric allocations were determined and new target management levels (TMLs) were set for groundwater management areas.

In the Kingston area, where the confined aquifer is artesian, the calculated volumetric allocations in the 2013 LLCWAP is 40 GL/y. This is well above the historical PAV of 25 GL/y and measured groundwater extraction (from metered data only available since 2007) of 9–14 GL/y. Thus it was stipulated in the LLCWAP (2013) that an appropriate TML for the Kingston area should be determined through the use of the groundwater flow model, within two years of adoption of the LLCWAP.

In this project, the groundwater model for the confined aquifer was updated and re-run to assess the potential impact of different TMLs. In doing so, new metrics for describing groundwater resource condition and potential impacts in the area were developed. These new resource condition limits (RCLs) relate primarily to the extent of artesian pressure in the aquifer, which influences the extent of irrigation extraction can occur without the added costs of pumping. The outcomes of this work help fulfil the requirements stipulated in the LLCWAP. They also inform an ongoing discussion with groundwater users in the Kingston Confined Aquifer Management Area around scientifically robust management of groundwater resources. This will assist future groundwater management implementation and review in the South East.

Understanding SA River Murray floodplains: hydrology and hydrogeology

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[3] Australian Water Environments

[4] CSIRO Land and Water

Presenter: Juliette Woods

The River Murray is highly unusual as it is a major river system that flows through an extensive landscape with highly saline groundwater. The river is naturally prone to salinity, and this propensity has increased over the past century due to the construction of river locks and the introduction of large-scale land clearance and irrigation. River flow volumes and river level variability have been reduced, while the watertable has risen. The overall impact has been to degrade riverine ecosystems and increase river and floodplain salinity.

Management actions that cause significant long-term changes in river salinity must be assessed according to Schedule B to the Murray-Darling Agreement, and short-term salinity is addressed in the Basin Plan. To manage the river effectively, SA must understand the long-term and short-term movement of water and salt within the floodplain landscape, under present conditions and under various management options.

A study funded by the Goyder Institute for Water Research aimed to improve understanding of floodplain processes for the SA River Murray. The project identified key hydrological and hydrogeological processes. A review of existing salinity risk analyses was conducted, to provide an approach for gauging risk to the salinity of both the river and the floodplain aquifer. A newly-available satellite dataset for Actual Evapotranspiration (AET) was examined, as evapotranspiration is understood to be a critical part of the floodplain water balance. Detailed modelling studies of surface water and groundwater flow were conducted to improve the simulation of salt movement within the floodplain at fine spatial and temporal scales. Many of the study's findings and recommendations are being implemented to improve the management of River Murray salinity and to investigate management options for improving floodplain ecological health, such as environmental watering and groundwater pumping.

Rainfall-Based flash flood forecasting systems for Adelaide

Wright, C.

Centre for Water Management and Reuse,
University of South Australia

Aim of Research

The research project aims to develop comprehensive flood forecasting and warning processes for the rapid response river catchments which threaten the urban community around Adelaide. The particular difficulty in the Adelaide situation is that most of the creeks and watercourses respond very rapidly to rainfall, this allows very little time to detect a potential flood and issue a warning. Conventional flood forecasting models need time to collect, analyse and identify a flood situation. This is partly due to the complexity of catchment behaviour, and partly to the time taken to process large amounts of data required by the models. The research is aimed at minimising the process time by pre-calculating a full range of rainfall, storm duration, and catchment conditions, compiled into a single data base, so that on the day of the flood the incoming rainfall information can be compared using a rapid "lookup" process to select the condition which mirrors the current situation, and forecasts flood magnitude. It is feasible to do this quickly, and to adjust the forecast as conditions change, allowing maximum time for Emergency Response agencies to react and protect the community.

Good quality flood risk mapping using current hydrological and hydraulic modelling techniques has been developed for most of the high flood risk areas of Adelaide. The models were calibrated against real events, wherever possible. By arrangement with the engineering hydrologists who developed these models, the models are run to analyse a wide range of rainfalls and storm durations to populate the data base mentioned above.

To enable rapid calculation, the rainfall in each time-step for calculation will be the catchment average, rather than distributed rainfall. Because the catchments are mostly small and urbanised, this is believed to be a reasonable approach. It will be tested against real storm events, so that any error bounds on the accuracy of forecast can be understood. Furthermore, a partial area method will be tested for short duration storms which takes calculates the lag between rainfall and peak flow at a point, and that the net area of catchment contributing can be much smaller than the total catchment area.

The Adelaide climate is relatively dry, which means that a significant portion of the rain that falls is held up in infiltration, minor storages and in wetting up the ground surface. This loss of water can be significant and must be taken into account in flood analysis. Much work has been done on loss analysis for rural catchments, but there is a scarcity of published work on urban catchments relevant to Adelaide. Recent work by UniSA, using the Frederick St gauging station, on runoff from Drain 18 catchment, near Glenelg is a potentially valuable source of data for developing a loss model suitable for real time flood forecasting. Drain 18 data (also the data from the Paddocks catchment, in the northern suburbs of Adelaide) will be used to inform the rainfall loss estimation process, as a part of this research study.

Objectives of Research

The objectives of this research are as follows:

- To consider the need for an effective flash flood warning service for Adelaide, and to understand the opportunities for its development and potential constraints on its effectiveness.
- Given the Emergency Response arrangements in Adelaide, how could an effective flash flood warning service be developed to minimise risk to life and damage to property and infrastructure, taking advantage of the experience and advances in other flood prone areas in Australia and overseas;
- To maximise the lead-time available for flash flood forecasting using available technology;
- To assess the potential advantage of a Rainfall-based flash flood forecasting system, and develop a method for early warning at critical locations;
- To consider any limitations on successful implementation of a flash flood warning service for urban creeks and stormwater overflows, in particular to consider how to estimate net flood rainfall allowing for losses;
- To develop a comprehensive method for the development of a fully effective quick response flood warning system for Greater Metropolitan Adelaide.
- To facilitate implementation of the system and to test its effectiveness.

Research Questions

The study will seek to answer the following questions:

- Given the infrequency of life-threatening floods in and around Adelaide, can the effort and cost in developing flood warning arrangements be justified?
- What are the opportunities for a Rainfall-based flood warning system to avoid potential loss of life and damage minimisation in a flash flood situation?
- How might a Rainfall-based flood warning system be developed for Adelaide?
- What newly available technologies can be used to advantage for real time flood risk assessment (e.g. radar-based rainfall assessment)? What are the limitations, and how might they be overcome?
- Is the system suitable for adoption by the Emergency Response agencies and how would it be implemented?
- How could measures developed for Adelaide could be implemented in other flash flood risk locations?

Ecological response to Commonwealth environmental water delivered to the Lower Murray River

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Presenter: Qifeng Ye

River regulation and flow modification impact riverine ecosystems throughout the world. Environmental flows may be used to re-establish key components of the natural flow regime in order to restore ecological processes and rehabilitate ecosystems. In recent years, significant volumes of Commonwealth environmental water have been delivered to the Lower Murray River (LMR). A five-year Long-term Intervention Monitoring (LTIM) program was implemented in 2014/15, to monitor and evaluate ecological outcomes and support adaptive management of Commonwealth environmental water. A number of indicators were selected for targeted investigation in the LMR: hydrology, stream metabolism, fish, matter transport and microinvertebrates.

During 2014/15, ~581 GL of Commonwealth environmental water was delivered to the LMR in conjunction with other environmental water (e.g. The Living Murray). This assisted in maintaining flow in the LMR at 9,000–10,000 ML day^{-1} during spring–summer. This led to an increase in hydraulic diversity (velocity and water levels) in the river channel; intermittent increases in the supply of carbon; increased transport of nutrients and phytoplankton; increased microinvertebrate diversity and abundance; reduced salinity concentrations in the Murray Mouth; and increased export of salt from the River Murray and Lower Lakes and reduced import of salt to the Coorong. There was, however, negligible spawning and recruitment of 'flow-cued' spawning fish such as golden perch (to age 0+), as was expected in association with the flow regime delivered to the LMR in 2014/15. Based on the monitoring outcomes, recommendations were provided for the future management of environmental water in the LMR.

Artificial floodplain inundation promotes common carp

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Presenter: Brenton Zampatti

In Australia's Murray-Darling Basin (MDB), river regulation is considered a primary cause of declines in native fish populations whilst concurrently facilitating the proliferation of non-native common carp. River regulation has also caused declines in floodplain overstorey vegetation; nevertheless, in an attempt to improve vegetation health in the southern MDB, further regulation in the form of weirs, levees and pumping is being trailed in an unprecedented ecological experiment. This approach may decouple floodplain inundation from the riverine hydrograph and create large areas of lentic habitat, which presents risks for native fish whilst potentially facilitating carp recruitment.

During spring 2014, a 3 m high, 79 m wide regulator on Chowilla Creek in the lower River Murray was used to inundate ~3,000 hectares of floodplain during relatively low river flows (max. 10,000 ML/d). We compare fish assemblages in ephemeral floodplain habitats between engineered floodplain inundation and a natural overbank flood (discharge = 90,000 ML/d). During the natural flood, eight native and five invasive species were sampled, small-bodied native fishes (e.g. carp gudgeon) and bony herring were numerically abundant, and carp represented 1% of the catch. During engineered floodplain inundation, 4 native and 4 invasive species were sampled, native fishes were rare and young-of-the-year carp comprised 97% of the catch. Our results support the notion that engineered floodplain inundation may benefit carp at the expense of native fishes. In light of multiple floodplain regulators proposed for the southern MDB, the implications of enhanced carp recruitment on floodplain ecosystem processes and regional carp population dynamics require further consideration.

Preferred habitat of southern Australian bottlenose dolphins (*Tursiops* c.f *australis*) in Adelaide's coastal waters

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Presenter: Nikki Zanardo

The identification of preferred habitats is key for the conservation and management of coastal dolphin species. Information on the preferred habitats of southern Australian bottlenose dolphins (*Tursiops* sp.) is currently lacking and inhibits the implementation of priority areas for their conservation. This is particularly important for a species which is under threat from a range of anthropogenic activities. Here we use boat-based surveys and species distribution models to describe the preferred habitat and distribution of southern Australian bottlenose dolphins along the metropolitan coast of Adelaide, South Australia. We investigate the importance of specific ecogeographical variables and use ensemble modelling to identify areas of high probability of dolphin occurrence. Results indicate that water depth and benthic habitat were the environmental factors influencing preferred habitat along the metropolitan coast. Dolphins along the Adelaide metropolitan coast appear to favour shallower, near shore areas in both summer and autumn, and prefer deeper areas further offshore in winter. To investigate the importance and ecological function of these preferred areas, we used kernel density estimation methods to identify core and representative areas according to behaviour. Generally, a larger percentage of core feeding areas overlapped with areas of high dolphin probability. Thus, we suggest that prey movements influence the seasonal variation in dolphin distribution along the metropolitan coast. Management authorities should consider this heterogeneity in preferred habitat and prioritise conservation efforts on a seasonal basis. We further recommend continued monitoring to assess potential changes in preferred habitat under increasing anthropogenic pressures and climatic changes.

Posters

Leafy Seadragon population monitoring in the AMLR NRM region – Pilot study at Rapid Bay

Baker, J.

South Australian Conservation Research Divers (SACReD)

Other project participants: P. Macdonald, L. Baade, R. Rath, D. Aston, C. Charter, J. Beacon, K. Hart, L. McLean, C. Rapson, B. Battersby, M. Sutcliffe, D. Bishop, D. Fernie, D. Kinasz, M. Savelberg, A. Malkowska , T. Brown, L. Nazimi, G. Andrew, J. Manna and S. O'Callaghan-Ross

The legislatively protected leafy seadragon *Phycodurus eques* is South Australia's marine emblem, and a very popular subject for dive recreation and tourism, and marine conservation advocacy. This poster discusses the results of a community-based pilot monitoring project which was undertaken during 2013 and 2014 at Rapid Bay jetty. The project was partly supported by a grant from Natural Resources - Adelaide and Mt Lofty Ranges. As part of the study, pairs and small groups of divers from various clubs and associations undertook 120 dives over 12 months, to find and photograph leafy seadragons around the original Rapid Bay jetty, which is breaking down over time. More than 20 SCUBA divers were involved with the project. Photographs and specific location data in relation to tagged piles were analysed by citizen science group South Australian Conservation Research Divers (SACReD). A number of photographs ranging from 2011 to 2016 were also accessed for comparison with data from the 2013-14 pilot period. This poster illustrates the results, including usefulness of specific marks on the head and body to identify seadragons over several years; long term site residency (e.g. more than 4 years verifiable by the current image set); local movements over space and time; breeding period and duration; and behavioural observations. Based on the results of this pilot study, supported by additional data and discussions with regular divers, probable reasons are discussed for the observed decline in numbers of leafy seadragons at Rapid Bay jetty structure habitat in recent years.

Spatial movements of Grey-headed flying-foxes *Pteropus poliocephalus* in Adelaide and their proximity to horses.

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Objective

To collect and analyse flight data from Grey-headed flying foxes, *Pteropus poliocephalus*, at an Adelaide camp including distance, duration and direction. To identify food sources accessed by this population in spring and flying fox proximity to horses.

Methods

This observational descriptive study used data from male Grey-headed flying foxes fitted with CSIRO Camazotz satellite telemetry devices. Flight data collected from 1 September to 2 October 2015 was downloaded to a base station at the camp and interpreted via a combination of GPS Visualiser, Google Maps, Google earth and Daft Logic mapping software and Microsoft Excel spreadsheets. Flight data included spatial, temporal and acceleration measurements of flying fox activity. Flight maps were generated, potential feeding sites were investigated, food species were recorded and classified, and proximity to mapped horse locations was assessed.

Conclusion

Too few individuals were tracked to be of statistical significance in this population, however the data illustrates flying fox spatial movement in Adelaide, their forage locations and the reliance on introduced food species. The apparent overlap of flying foxes with horses is minimal however this description of new activity has indicated the need for tracking a larger, statistically significant sample size over longer time periods as part of the ongoing study.

Identifying parasites and their impact(s) in little penguins (*Eudyptula minor*)

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There is growing evidence for the roles of parasites on population declines. In penguins, parasites have been shown to decrease individual fitness and increase mortality risk. In this study, we identified parasites in little penguins (*Eudyptula minor*) in the Gulf St Vincent and examined their potential impact(s) on fitness to explain patterns of population declines. Using molecular techniques, we identified blood parasites in 90% of the individuals sampled. Parasites presence did not vary between years and sexes but more parasites were found in adults than in chicks. We then correlated morphological measurements, haemoglobin concentration and haematocrit data with parasite presence and prevalence to test for an impact on fitness. Preliminary analyses suggest an impact of parasite presence on bill size.

Water Model Warehouse: Practical data management and services

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The South Australian Department of Environment, Water and Natural Resources (DEWNR) initiated the Model Warehouse in 2010 to store numerical groundwater models. DEWNR is currently expanding the warehouse to include hydrological and ecological models as well as models developed by the Goyder Institute for Water Research.

Computer modelling is a critical tool for national and state-wide natural resource management and policy development. It is vitally important that models, once developed, be archived, managed and discoverable, with continual enhancement of guidelines, archive and services.

The Model Warehouse aims to improve management of modelling projects and maintain the technical integrity of the DEWNR's own models and third party model developments that affect the Department's decisions or business activities. The MW involves a systematic approach to the archiving and naming of models, related files and folders, as well as development of operational rules, data management, protocols for model development, rules for using the Department's models and specifications for modelling projects. The MW provides a proactive and integrated approach to model reviewing services.

Information on existing and the most up to date models for all of the state's groundwater, surface water and ecology in all areas of importance is made available on the Department's WaterConnect website for public access.

The Model Warehouse project has successfully managed the DEWNR's groundwater modelling projects and is expanding to include other types of models. Some outcomes from the Model Warehouse project have been adopted by other organisations and in the Australian Groundwater Modelling Guidelines 2012. The Model Warehouse will ensure DEWNR has the most up-to-date models to underpin the management of South Australia's natural resources.

Occurrence of the Koala retrovirus (KoRV) and *Chlamydia pecorum* in the Mount Lofty Ranges koala population

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Poster presenter: Jessica Fabijan

Two key infectious pathogens of koalas (*Phascolarctos cinereus*) are the koala retrovirus (KoRV) and *Chlamydia pecorum*. High circulating KoRV in the bloodstream is associated with cancers such as leukaemia and lymphoma, which may immunocompromise koalas leading to secondary infections with opportunistic pathogens such as *Chlamydia*, which causes ocular, respiratory and urogenital tract disease.

Both pathogens are highly prevalent in eastern Australian koala populations, however the prevalence in the Mt Lofty Ranges koala population was unknown and thought to be low. This study aimed to determine the occurrence of KoRV and *C. pecorum* in the Mt Lofty Ranges.

Blood samples were collected from 36 rescued wild koalas euthanised in 2014–15 on welfare grounds to determine KoRV status by PCR and assess white blood cells. Dry swabs of the conjunctiva and urogenital sinus were collected for chlamydial detection using Clearview Chlamydia MF test and q-PCR.

Preliminary results suggest the occurrence of KoRV is 61% (22/36) with 8.3% of affected koalas having lymphoma. *Chlamydia pecorum* was identified at 52% (12/23) with 66.6% of these koalas showing disease (8/12) and the remainder subclinical carriage (4/12). Urogenital tract disease was the most common presentation of chlamydial disease, but was usually mild and not often detectable by external examination.

These preliminary findings of the occurrence of KoRV and chlamydial infection in rescued koalas indicates these pathogens may be significant in the Mt Lofty Ranges koala population, requiring further investigations to sample a larger number of koalas and to determine the true prevalence in the wild population.

Acknowledgments

This project was funded by a grant awarded from the Queensland Government Koala Research Programme to Dr Gregory Simmons.

The Seeds of South Australia website

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The Seeds of South Australia website is an online resource that provides information and images from field work and laboratory studies conducted by the South Australian Seed Centre since 2003. The content includes photographic images of plant species in several life stages, with detailed pictures of flowers and fruits and microscopic images of seeds. The site provides descriptions of plant and seed anatomy and information about flowering times, seed ripening, seed collection, processing, viability, dormancy mechanisms and germination protocols. A tool for seed identification and comparison of plant or seed images has been built in. Each species page has a link to the entry in the State Herbarium Census of South Australian Plants. Recent upgrades include IBRA subregional distribution and status and work is in progress to search for plant species lists within subregions. The initial focus of the website is on threatened plant species and will fill a knowledge gap in the identification and utilisation of native seeds from the state.

Shelter site use of western quolls (*Dasyurus geoffroii*) reintroduced to a semi-arid environment

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Unsuitable habitat is one of the leading reasons for failed reintroductions. Despite being a highly adaptable species, western quolls (*Dasyurus geoffroii*) require up to five shelter sites per hectare. We investigated the shelter site availability and use of a population of western quolls recently reintroduced to the Ikara-Flinders Ranges National Park in South Australia. All quolls were radio-tracked for six months following release to determine shelter site choice and how these changed over time, particularly over the breeding season. Results from this study may assist future quoll reintroduction programs.

A spatially explicit assessment of cumulative human impacts on marine habitats in Spencer Gulf

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Spencer Gulf supports a variety of commercial and recreational activities including thriving fisheries, a strong tourism and recreation sector, and multiple ports and shipping activities associated with the mining industry. Each human activity operating in the Gulf has potential to impact the Gulf's marine habitats and the species they support. We collated all available data to generate a habitat map of the entire Spencer Gulf, classified into eight broad-scale marine habitats (subtidal algal forest and rocky reef; intertidal, un-vegetated soft substrates; intertidal rocky substrates; mangroves; saltmarshes; intertidal and subtidal seagrasses; subtidal soft-bottomed habitats; pelagic habitats). We also mapped the spatial footprint and intensity of human activities occurring in the Gulf, including fishing and aquaculture, shipping and boat traffic, marine habitat modification, nutrient discharge and marine invasive species. The relative threat of each human activity to each habitat was subsequently assessed using an expert opinion survey. By combining data on the location of each habitat and human activity, with the relative threat scores from the expert survey, we generated a spatially explicit assessment of cumulative stress on the Gulf's marine habitats. This enables the identification of areas, or habitats, that are most under pressure from human impacts. Securing a sustainable future for Spencer Gulf will involve effective management of the concurrent pressures on marine habitats from all human activities. Our map can be used as an integrated spatial management tool, which accounts for the potential cumulative impacts on the Gulf's marine habitats from multiple human activities. As such, it may be viewed as a baseline assessment of the current threats to the Gulf's habitats, as well as a tool for assessing the risks and merits of any proposed new activities, or increases in the intensity of existing human activities within the Gulf.

Seeing the Big Pitcher – Coevolution of the Albany Pitcher Plant and its associated wingless fly

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Cephalotus is a monotypic genus of carnivorous plant confined to permanent, peaty, sphagnum bogs and wetlands around south-western Western Australia. The single species, *C. follicularis* Labill. (The Albany Pitcher Plant) (Figure 31) has specialised habitat requirements, with the wild populations being naturally fragmented and isolated. The fluid inside the pitchers functions as habitat for larvae of a wingless ant-mimic fly (*Badisis ambulans*: Micropezidae) (Figure 31, top left), where these air-breathing aquatic larvae live in the pitchers and feed on captured prey. Because *Cephalotus* (and even more so *Badisis*) have potentially unique gene flow problems related to their specialised ecology, life histories and habitat fragmentation, a study of their ecology, life-history and conservation status will be performed.

This relatively little studied system also provides the opportunity to assess the level of coevolution between the two species, using next-generation sequencing techniques to determine population genetic structures and gene flow between metapopulations. When applying this method to *Cephalotus*, it has been found that there is strong structuring with multiple distinct genetic groups having formed, most likely attributed to geographic barriers for dispersal and genetic drift within the isolated populations.

Figure 31. Cephalotus follicularis. Top left: Wingless ant-mimic fly (Badisis ambulans).

The results of this study have informed a larger-scale population genetic study for both the plant and fly. This, along with an increased understanding of their collective ecology, has led to an increased effort to conserve these already threatened species, and also an insight into how habitat fragmentation affects genetic diversity and coevolution in a mutualistic system.

Engaging the Mallee through the Mallee Challenge

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Natural Resources South Australian Murray-Darling Basin are currently supporting the continuation of the Mallee Challenge Project, now in its the eighth year. The Mallee Challenge provides farmers with support to conduct paddock scale demonstrations fitting to their farm enterprise to address local issues. Through paddock scale trials the Mallee Challenge provides dryland producers with meaningful results that relate directly to their business and wider region.

Through farmer consultation the Mallee Challenge Project team identifies on-farm trial sites to address local farming issues, providing technical support to farmers to ensure objective measurements are taken throughout the establishment, monitoring and testing phases.

The main outcome of the Mallee Challenge Project is information collected from locally based projects can be applied on farm to improve productivity and increase the farmers understanding of NRM issues.

The results from each Mallee Challenge site is reported back to the local farming community, providing information to over 200 local farmers annually. The dissemination of results through locally based newsletters ensures a wide number of farmers are provided with the information. Importantly, this post-trial extension and farmer discussion drives the development of the proceeding Mallee Challenge themes. By working collaboratively from the discussion phase through to results phase the Mallee challenge has evolved into a sincere and applicable project.

The farmer scale trials actively contribute to the understanding and value management options available to Mallee farmers as they tackle the many challenges involved with implementing sustainable farming systems.

Characterising ephemeral river recharge in arid Australia

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In 2012, the Australian Government established an Independent Expert Scientific Committee (IESC) on Coal Seam Gas (CSG) and Large Coal Mining Developments to provide independent expert scientific advice concerning the impacts such developments may have on water resources. As part of this initiative, the Australian Government funded DEWNR to address a critical knowledge gap concerning recharge mechanisms to the Pedirka Basin under present-day arid conditions.

Geochemical, hydraulic and geophysical techniques have been used to improve the hydrogeological understanding of the connection to the Finke River and characterise the geological controls on ephemeral river recharge mechanisms.

The results from the study were unexpected and the conceptual model of surficial recharge to the Pedirka Basin requires revision. The investigation did not identify modern recharge to the Pedirka Basin sediments via ephemeral river recharge, owing to low permeability of the sediments (K 0.001–0.09 m/d), low driving hydraulic gradient (0.0007–0.003 m) and minor storage capacity (< 5 m). Carbon-14 derived recharge estimates ranged from 0.1–3 mm/y.

From a management perspective, the results indicate that modern recharge to the Pedirka Basin is negligible. This will have implications for development of the groundwater resource as extraction will deplete storage. There are however significant knowledge gaps on the hydraulic connection with the overlying Great Artesian Basin, which is highly transmissive and is regularly recharged by the Finke River.

References:

Hancock M, Fulton S and Wohling D, 2015, Pedirka Basin–Finke River recharge study, DEWNR Technical report 2015/06, Government of South Australia, through Department of Environment, Water and Natural Resources, Adelaide.

Environmental data flows - From my data to open data

Miles, M.

Department of Environmnent, Water and Natural Resources

Data for purposes known to me = My Data.

Data shared for purposes unknown to me = Open Data.

Best practice NRM accepts that data generated for science, research, monitoring or management must inform a question or hypothesis that is considered and documented. With ever increasing multi-disciplinary, long-term or large scale investigations being done by scientists other than those who collected the data, it is recognised that some if not all of the data we generate should be available for as yet unknown questions and hypotheses.

We clearly value information as evidence for our questions and decision making. The *sharing* of information for others to use however is also highly valued. Across the globe researchers are searching for new applications or information from others' data and Governments at all levels are making data open and accessible as much as possible. Some new tools have been developed to support this Open Data world. E.g. data sensitivity filters allow data to be restricted where openness is not appropriate and creative commons licencing protects the Intellectual Property rights of data owners.

DEWNR manages many of South Australia's authoritative environmental databases. Biodiversity data, groundwater and surface water data, soils and herbarium collection databases are all decades old and robustly maintain the stores of data required to manage environmental legislation, water management and NRM in SA. Even as technology has progressed with new software to manage these databases, the data itself has persisted and continues to be managed and added to. With the notion of open data now firmly understood as an obligation of government, a vehicle for transparency, and an enabler of innovation, DEWNR continues to develop mechanisms for sharing environmental data.

This poster illustrates the main channels by which environmental data is available for government (or official) use and for public (or open) access on the web. DEWNR's core role in describing standards, maintaining access and co-operating with other states to create national environmental datasets enables consistent handling of data sensitivities and licencing. Government policy, researchers and communities expect on-line, on-demand access to public information bases. DEWNR is fulfilling this responsibility to make environmental data available as widely as possible by developing and maintaining regular data flows into a variety of on-line systems and applications for access, integration and use.

Die Back in River Red Gum (*Eucalyptus camaldulensis*) communities in the Northern & Yorke Region 2008–2015

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Severe die-back was noted in river red gum communities in the Northern & Yorke region in 2005. From 2008–2015, over 60 sites have been monitored annually in the four target catchments of Broughton, Mambray Coast, Wakefield and Willochra. The overall cause of die-back and decline was found to be reduced water availability, due to decline in regional rainfall and increased extraction rates from catchments.

Parameters measured generate scores to indicate the risk of decline and the chance of recovery for each site. At 34 special monitoring sites, the stage and crop volume of the phenological cycle were noted (buds, flowers, fruits, leaves), to determine the timing of seed shed.

From the stressed condition of 2008, red gum communities partially recovered in 2010 and 2011, following good rainfall. Site condition deteriorated again in 2012–13, coupled with heavy insect attack on recovering epicormic growth. Levels of insect attack in 2014 and 2015 were insignificant, and canopy condition improved as epicormic growth converted to normal tip growth. Recovery continued in mature trees in 2015, and all catchments have trees with dual crops, indicating healthy phenological cycles, and healthy seed volumes available.

Broughton is the catchment in best condition, with low risk of decline and medium chance of recovery. Mambray Coast has improved its risk of decline scores, but has a low chance of recovery. Wakefield has a low risk of decline but only a low-medium chance of recovery. Willochra has a low-medium risk of decline and a medium chance of recovery.

A key concern is the fact that no regeneration of red gum seedlings has been found at any monitoring sites on any surveys since 2008. The primary factors preventing regeneration appear to be competition from dense spring weeds in riparian zones and from early annual growth of reedbeds in watercourses due to declining flows.

Active intervention will be required to sustain red gum communities in the long term. Otherwise, there is an increasing risk that aging and water-stressed river red gum communities will not be replaced and will gradually disappear from regional landscapes. A proposal presented to the NRM Board recommends a target of 20% multi-layered native vegetation in regional landscapes, using roadsides, riparian zones along watercourses, fencelines, ridgetops, reserves and easements.

The event is presented by the Natural Resources Management Research and Innovation Network, a partnership between the Department of Environment, Water and Natural Resources, the SA Natural Resources Management Boards, The Conservation Council of South Australia, the Department of Primary Industries and Regions SA, SA Water, the University of Adelaide, Flinders University and the University of South Australia.

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