



**A Conference on Restoring Ecological Processes,  
Ecosystems and Landscapes in a Changing World**

**5-9 February 2017, Armidale NSW Australia**

## **CONFERENCE ABSTRACTS**



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## Plenary

### Using ecological site information to evaluate the probabilities and effects of restoration

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Ecological Sites (ES), conceptual groupings of climate, soil and landform properties, and their component State and Transition Models (STM) are useful tools for predicting the possibilities and effects of restoration efforts on a variety of ecosystem services. To improve the utility of site specific information, there must be protocols for both refining to finer scales to account for spatiotemporal variability within a mapped site and expanding to include interactions with other sites in the landscape in a hierarchical context. Accounting for multiple levels in the hierarchy is necessary to account for integrative disturbances and ecosystem services such as wildlife habitat, hydrology, fire, insect outbreak and invasive species. Finer-scale interpretations are required to identify key ecological processes and mechanisms during restoration and to design monitoring systems and management responses. Coarser-scale interpretations are necessary to develop models of key ecosystem services that integrate processes across landscapes such as water quality and wildlife habitat. Thus, ES are an important level in the land hierarchy to organize and interpret information. This presentation will explore the development and application of ES information that can support and facilitate interpretations in a restoration context.

### The last four decades of land repair in Australia: what have we learnt?

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This presentation will reflect on the landcare and revegetation movements in Australia over the last forty years, from both policy and practice perspectives.

Australia has deployed a rich and diverse menu of policy instruments to encourage land repair (particularly revegetation of over-cleared farmlands) over recent decades, to varying effect. Attitudes to land degradation and revegetation among farmers have definitely changed over that period, undoubtedly influenced by the landcare movement and associated incentives. Some landscapes are definitely in markedly better shape than they were forty years ago and some notable restoration efforts are rightly celebrated.

Regrettably, in 2016 it is still difficult to get a definitive continental picture of the extent and health of native vegetation in Australia. In aggregate, the area of land cleared each year probably far exceeds that revegetated, whether through natural regeneration or replanting. Invasive plants and animals continue to out-compete and threaten native species in many ecosystems. Landcare groups are moribund in many areas. The dominant framing of land conservation activities posits trade-offs between conservation and production at farm, district and regional scales.

This presentation will trace the evolution of policy and practice over the last forty years, teasing out potential lessons that could hopefully inform community, industry and government leaders as we grapple with the challenges of this century under rapidly changing climates. It will highlight Australian innovations in natural resource management (NRM), arguing that we have already developed in various parts of the continent at various times, most of the ingredients for the world's best NRM system. Our challenge now is to get sufficiently organised to combine and deploy these innovations strategically, synergistically and patiently. We have most of the pixels we need for a great picture.

### Restoring the island continent

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With an estimated 80% of the global terrestrial land surface now impacted by humans and increases in the ingress into the last remaining wild areas the need to recover, rehabilitate and ultimately restore native



ecosystems has moved from the 'backyard' to the national and transnational scale. Of all continents, Australia with two global biodiversity hotspots and 48% of the continent disturbed by humans is probably the continent in most need of recovery of natural ecosystems. This is evident from the west coast where a rapidly drying eastern Wheatbelt poses significant issues for what to do with retiring failed agricultural land to eastern Australia where great strides are being made yet contemporary issues such as the closure of the Hazelwood brown coal mine and power station with an estimated restoration bill of \$1B faces the prospect of limited technological capability to deliver safe, stable and resilient restoration. A key component missing in efforts to repatriate damaged and degraded ecosystems has been an understanding of what standards need to be applied - whether it is a local coastcare group restoring square meters of coastal vegetation or mine sites charged with a legal requirement to restore square kilometres. With the launch in 2016 by the Society for Ecological Restoration Australasia of the National Standards for the Practice of Ecological Restoration, Australia was the first country to adopt a national approach to define what is ecological restoration, and importantly what is not. This document has now led to the development and launch in December 2016 of the first International Standards. Both documents provide the first framework for defining the 'recovery continuum'. Both documents emphasise that restoration as a science and practice is new, emerging and almost is continually innovating. This means that a problem today may have a solution tomorrow. Both documents encourage the robust application of 'adaptive management' "(learning through doing) while providing a measure of progress along the recovery continuum.

### **Restoring species rich and functionally complex grassy communities – feasible or fiction?**

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Whether it is feasible or not to restore species rich and functionally complex native temperate grasslands or grassy woodlands has been debated by this sector over the past decade. During this time there has been growing evidence from a number of small scale projects across several states that this is indeed possible. However, despite these promising developments (and the critical need to increase the extent of these threatened plant communities), there has been relatively little uptake or support of these approaches. Explanations for this situation are varied but prime among them is the likelihood that these new approaches challenge strongly held views held by some in the sector concerning the degree to which restoration (with strong agronomic-underpinnings) can or should be involved in conserving complex ecological communities. More pragmatic issues that limit the uptake of these approaches include limitations on seed resources (quantity and species diversity), lack of infrastructure and equipment, unresolved debates concerning the issue of provenance ranges, and a lack of credible markets to support large-scale or long term projects. At the same time there is evidence of much greater success restoring native grassy communities in the United States (from both the literature and from first-hand observations) where well developed markets for restoration have created large scale and financially viable seed production and restoration sectors. This presentation will detail what has been learnt to-date about restoring Australian grasslands and grassy woodlands (highlighting ecological, technical and social barriers to success). It will also contrast the US experience showing how large, stable and varied markets have supported outcomes that are far beyond what have been achieved in this country. In summary it will present a case for a much greater acceptance in Australia of the role restoration in helping to halt and even reverse the loss of biodiverse grassy ecosystems and argue for structured long term market support of the sector so that these goals can be achieved by a willing and innovative sector.

### **Pollination services in restoration – comparing intact and degraded communities provides assembly rules for restoring cleared landscapes**

Author: **Caroline L. Gross**

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Pollination is a key ecosystem function that directly and indirectly provides food for all organisms – regardless of the trophic level. Installing plant and habitat resources for pollinators starts with an understanding of the temporal and spatial habitat needs of pollinators, and the *augmentations*, the co-factors and conditions required for pollinator populations. These co-factors, not immediately recognized as linked to the provision of pollination services, are critical for complexity and include a diverse array of resources such as food plants for larvae, shelter and temporal legacies of earlier flowering species. Using

an endangered ecological community, the Warkworth Sands Woodlands, I evaluate the task of reassembling pollination networks into restoration landscapes. Using network tools, we have revealed facilitator species, specialisations, generalisations, and extinction scenarios and a hierarchy of plant species to inform re-assembly rules. We found that connectivity in intact landscapes was higher than that found in degraded and cleared landscapes and this is strongly linked to the facilitation effects of staggered flowering resources. Networking tools also allow the irreplaceability and dependence of non-native pollinators in the community to be evaluated and we found that the local extinction of the feral European honeybees is likely to leave several plant species in degraded habitats without pollination services. Practical steps for restoration include the installation of an array of plant species that provide a staggered supply of flowers and this can be refined to include specific floral types that are the mega supermarkets for nectar and pollen resources.

### **Where to from here? Challenges for restoration and revegetation in a fast-changing world**

Author: **Richard Hobbs**

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Ecological restoration provides hope and the opportunity for positive action in the face of ongoing rapid environmental change. Restoration techniques and approaches are improving, and restoration is seen as an important element of conservation management and policy from local to global scales. Motivations for undertaking restoration are numerous, and resources available for this enterprise vary greatly from case to case. Restoration encompasses everything from multinational companies restoring minesites or offsets to comply with environmental regulations to local bushcare groups doing voluntary work in their local patch of bush. The financial and human resources available largely determine the extent and type of restoration activities that are possible. An important task is increasing the resources available for these activities, but it is also important to recognize that resources will continue to fall well short of what is actually required into the foreseeable future. In addition, the need for restoration will only increase with ongoing development and changing environments. In this scenario, how then, should decisions be made about what types of restoration activities are appropriate and possible? How do we ensure that the good intentions behind restoration management and policy translate into good outcomes? Challenges for restoration include not only improving the techniques and approaches but also tackling hard questions about what restoration goals are appropriate and engaging in open discussion of hidden assumptions and values behind decisions.

### **Ecosystem restoration: recent advances in theory and practice**

Author: **Thomas A. Jones**

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Restoration of damaged ecosystems is receiving increasing attention worldwide as awareness increases that humanity must sustain ecosystem structure, function, and diversity for its own well-being. Restoration will become increasingly important because our planet will sustain an increasingly heavy human footprint as human populations continue to be very large. Restoration efforts can improve desirable ecological functioning, even when restoration to a historic standard is not feasible with current practice. Debate as to whether restoration is feasible is coupled to long-standing disputes regarding the definition of restoration, whether the more damaged lands are worthy of restoration efforts given limited financial resources, and whether the novel ecosystem concept is a help or a hindrance to the restoration cause. A willingness to consider restoration options that have promise, yet would have previously been regarded as “taboo” based on the precautionary principle, is increasing. Functional restoration is becoming more prominent in the scientific literature, as evidenced by an increased emphasis on functional traits, as opposed to a simple inventory of vascular plant species. Regarding plant provenance, the presumption that “local is best” is increasingly being called into question in favor of more biological approaches that involve empirical measurement. Increased appreciation for soil health, plant-soil feedbacks, water quality, and the restoration of soil biocrusts is evident. In the United States, restoration projects are becoming increasingly motivated by or tied to remediation of major environmental problems or recovery of fauna that are either charismatic or deliver key ecosystem services, e.g., hymenopteran and lepidopteran pollinators. Biodiversity continues to be regarded as important, but its goals are becoming less stringent, with an increasing array of options being considered for provenance.

## National standards for the practice of ecological restoration in Australia

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The mission of the Society for Ecological Restoration (SER) is 'to promote ecological restoration as a means of sustaining the diversity of life on Earth and re-establishing an ecologically healthy relationship between nature and culture'. In 2012, the newly formed Australasian chapter, SER Australasia, initiated a collaborative project (with 13 other non-profit restoration practice organisations from around Australia) to develop a set of National Restoration Standards. Launched in 2016, these Standards draw from the successes and failures of thousands of real life projects carried out over the last 30+ years to convey best practice principles, approaches and procedures in a way that can lead us forward to higher quality and larger scale works. Nearly 10 months after their launch, the Standards are being increasingly adopted by community, agency and industry sectors involved in managing, implementing and funding projects - and have been adapted for international release by the parent body of SER. This talk will convey the need for standards and will show - through liberal use of 'restoration' and 'restorative' examples from the Standards and SERA's 2016 Awards for Restoration Excellence - how the Standards can encourage managers to aspire to the highest level of recovery feasible - whether the 5-star 'gold' standard (even if it takes many decades) or some lower level of recovery that may nonetheless be highly valuable to the larger challenge of improving ecosystem recovery at cumulatively larger scales.

### Upscaling the restoration effort – a New Zealand perspective

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There is increasing interest in substantially upscaling ecological restoration efforts internationally and within New Zealand in order to address a range of environmental issues including carbon emissions and biodiversity loss. While tree planting to meet carbon sequestration goals is relatively straightforward, a number of issues need to be considered in order for such projects to also provide meaningful biodiversity outcomes. In this presentation, we consider some of these issues from a New Zealand perspective. We believe four areas need to be considered in order to successfully upscale restoration efforts, focusing in particular on private land where most current and likely future restoration efforts will be:

Existing remnants need to be protected and managed because they are the direct link to the original biota and act as critical refuges for many species and provide the source propagules for future colonisation of restoration sites. Restoration plantings will have little value for biodiversity conservation without adequate remnant protection, including mechanisms to ensure their in-perpetuity protection.

Careful consideration needs to be given to the sourcing of restoration material, both in terms of the provenance of the material and the species involved (including successional stage), taking into account current and future environmental conditions, and the need to allow for long-term ecosystem development. This will become increasingly challenging as nurseries upscale to provide substantially larger number of plants and there is a need to ensure that they can guarantee ecologically appropriate plant material.

The landscape-scale spatial arrangement of restoration is particularly important in terms of their long-term viability and the goals that the plantings aim to meet (e.g. enhancing connectivity for fauna or buffering existing remnant areas). In addition, simple but informative measures for assessing the success of restoration plantings, including the establishment of later-successional conditions, need to be developed in order to improve the restoration process and provide feedback to stakeholders and funders.

Finally, remnants and restoration plantings need to be managed together, and this needs to be undertaken within the context that the land on which they are located is largely private and is used for other purposes (e.g. for farming or plantation forestry). Landowners and local communities need to be actively engaged in the restoration process, while at the same time appropriate regulatory frameworks and funding need to be in place to support these endeavours. Managing native biodiversity on private land (remnant management and restoration) must, however, complement what is happening on the public estate, rather than be an alternative - the sum of both is likely to be greater than the value of each individually. While we focus on these issues from a New Zealand perspective, similar issues are likely to be encountered elsewhere as restoration efforts are upscaled.

## **A changing climate, considerations for future ecological management and restoration**

Authors: Suzanne M. Prober, **Kristen J. Williams**, Veronica Doerr, Linda Broadhurst

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The likelihood of dramatic climate change impacts on biodiversity and ecosystems is now well-recognized. Accordingly, there is a burgeoning scientific literature on projecting/predicting such impacts, and potential adjustments in policy and management to facilitate adaptation. While recommendations for action are proliferating, there is surprisingly little discussion of where such actions might lead us. What are we aiming for, now that the usual course towards historical ecosystem structure and composition needs to accommodate future climate change? Here we raise ideas for guiding ecological restoration and management in a changing climate, with the aim to stimulate greater debate. The most commonly promoted goal to date is to move the focus from historical ecosystem structure and composition, towards optimising ecological processes and services, including capacity to adapt. This is a broad concept, and needs further development towards operationalisation. And what about less 'utilitarian' values? We suggest there is a need to consider factors other than function, in the context of what we value in our native ecosystems. These could include maintaining the evolutionary character of the biota both nationally and regionally, a sense of place, and minimizing species loss nationally. Ultimately, managing biodiversity under climate change will largely be about facilitating nature's response, but to steer change toward more rather than less desirable futures for Australia's biodiversity, we need to think more about what a desirable future might be. We present these ideas from an Australian perspective but emphasise they can be equally applied elsewhere.

### **Keynote**

#### **Restoration genetics – how far have we come and where are we going?**

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The restoration of degraded Australian landscapes have had more than 30 years of significant investment from governments, communities and land holders. Despite this, we know little of the how this investment is tracking over time and whether it is likely to meet our expectations of long term population persistence. Of major importance in renewing our degraded vegetation systems is ensuring that there is sufficient adaptive capacity to cope with future environmental challenges. However, small plant populations that often characterise highly degraded landscapes are often inbred which impacts on both the quality and quantity of seed available for restoration. Past reliance on these small populations as seed sources may not have necessarily restored sufficient evolutionary adaptive capacity to cope with predicted future change. The limitations of seed supply for restoration from natural populations were first recognised more than 15 years ago but we have made limited progress towards addressing this problem. This is now compounded by predicted declines in seed produced by natural populations associated with increasing temperatures and reduced water availability. This paper will examine some of the major genetic issues underpinning selecting seed for restoration, review our track record in restoring genetic diversity and discuss the role and importance of genetics in improving restoration practices.

#### **Turquoise is the new green: riparian restoration and revegetation in the Anthropocene**

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Riparian zones are one of the most important components of any landscape but especially those which are heavily modified and in which riparian vegetation typically represents amongst the only remnant vegetation present. In such cases, riparian vegetation supports a disproportionately high number of critical ecological functions and ecosystem services, many of which are likely to grow in significance as the climate changes, e.g. water regulation, climate control, disturbance mitigation and habitat provision. Degraded riparian vegetation is widely associated with major catchment management concerns including declining water quality and riverbank erosion. Consequently, riparian revegetation has become a major global industry in recent decades. Approaches to riparian restoration range from actions intended to promote passive revegetation (e.g. fencing) to highly interventional strategies encompassing both 'hard'

(e.g. armouring) and ‘soft’ (i.e. ecological) engineering. In all cases, however, riparian restoration is faced with considerable challenges, many of which can be attributed to the high degree of spatial and temporal heterogeneity that characterise riparian ecosystems as well as the strongly contested management of the freshwater ecosystems which they comprise. Here, I discuss the growing recognition that conventional approaches to riparian restoration are unlikely to be effective or appropriate in human-dominated landscapes. Further, I outline alternative approaches to setting objectives, planning, implementing and evaluating riparian restoration and revegetation actions and present recommendations for the context of 21<sup>st</sup> century Australia.

### **Fauna: passengers and drivers in vegetation restoration**

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Practical efforts to restore terrestrial ecological communities frequently depend on plant-focused actions developed either from forestry (tree planting) or weed control (suppression of non-native plants). They also typically assume that plants can be effective ecological surrogates for everything else. Fauna are often neglected during both design and monitoring, even though they comprise the majority of species. Furthermore, the scientific literature about flora and fauna in vegetation restoration operates largely as two independent fields of enquiry. Two major assumptions that are typically made about fauna will be discussed, making selective use of Australian examples. First, in terms of outcomes, faith in the “field of dreams” paradigm (assuming fauna will follow if vegetation is floristically reconstructed) has led to insufficient consideration and testing of habitat features (e.g., food and nesting resources) or the role of spatial context (e.g., patch size, surrounding vegetation), and inadequate longer term biodiversity monitoring. Second, in terms of restoration actions, fauna are viewed as passengers not drivers, so actions target plants not animals. But plant reproduction and regeneration are frequently governed by trophic or mutualistic interactions with animals. Trophic relationships within multispecies food chains (granivores, small and large herbivores, carnivores) determine survival of both seeds and seedlings. Animal-mediated seed transport determines dispersal and colonisation. Animal-mediated pollination determines seed set and genetic out-crossing. These interactions are crucial to longer-term regeneration and the developmental trajectories of floristic diversity and composition. Accordingly, intervening to alter abundances of functionally important fauna species deserves more attention as technique for restoring biodiverse vegetation communities.

### **Landscape connectivity: do we have the right science to make a difference?**

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Improving landscape connectivity began as an attractive concept and was initially undertaken in an intuitive way – planting areas that looked to human eyes like they would provide for movement of native species. A wealth of research then emerged to help inform these approaches, including theoretical studies and conceptual models in landscape ecology and metapopulation biology, empirical studies of actual or potential movements, models based on movement costs or landscape resistance or graph network theory, scenario analysis and prioritisation, and models suggesting movement pathways under climate change. Yet despite this massive investment in research, the practice of improving landscape connectivity has arguably changed very little in the past two-and-a-half decades. We argue that one reason is that research has largely focused on the wrong questions to actually inform on-ground practice. To rectify this problem and ensure our wealth of knowledge can make a difference, we need to refocus research efforts to answer the specific questions and challenges faced by practitioners. These include questions about thresholds (how much connectivity is enough?), how to recognise and manage existing connections to maintain their value, the mechanics of restoring stepping stones, and most importantly the social and economic mechanisms for achieving specific spatial arrangements on private land at large scales. These gaps won’t be filled quickly, so practitioners also need to be creative about finding opportunities to experiment and do things differently to take better advantage of the research we already have.

## **Grazing management for biodiversity conservation**

Authors: **Josh Dorrough**<sup>1</sup>, Sue McIntyre<sup>2</sup>

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There is no doubt that large herbivore grazing, in particular livestock, has modified the composition and structure of native vegetation and impacted on soils and landscape processes. However, the long-term effects of livestock grazing are not consistent and the direction and magnitude of responses vary among regions and vegetation types. In particular Mediterranean regions seem to have been most susceptible while others (e.g. summer rainfall areas) have been more resilient. Much of our understanding of the effects of livestock are also drawn from land use comparisons that confound nutrient enrichment and other historical processes. Despite long-held beliefs that livestock are generally bad for biodiversity, removal of livestock from conservation areas is no longer a fait accompli, and arguments in support of retaining and managing livestock are being promoted. Conclusions from herbivore exclosures often suggest some positive effects of livestock, even in areas where long-term comparative studies have shown livestock to have negative impacts on biodiversity. Recent historical narratives emphasize the imperative to restore and maintain grass dominated forests and woodlands, the maintenance of which will depend in part on the management of large herbivores. In addition grazing management approaches that claim to benefit biodiversity (e.g. Holistic Management) are being adopted by many livestock producers. This shift towards managing rather than excluding livestock has required a simultaneous shift in research emphasis. However, there is still little evidence to suggest that any particular grazing regimes are better for restoring biodiversity. Responses to alternative grazing regimes are highly variable and depend in part on focal taxa, past land use, climate and rainfall. The varying conclusions presented in this symposium highlight this. Despite the shift in research emphasis from interpreting long-term impacts to better management of livestock in the contemporary landscape, we often lack generalizable information to guide decisions about when livestock exclusion is appropriate or what grazing regime to apply if livestock are retained.

## **Invasive species and their impacts on agri-ecosystems: issues and solutions for ecosystem regeneration and restoration**

Authors: **Peter J.S. Fleming**<sup>1,2</sup>, Guy Ballard<sup>2,3</sup>, Nick C.H. Reid<sup>2</sup>, John P.Tracey<sup>1</sup>

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Humans are the most invasive of vertebrates and they have taken many plants and animals with them to colonise new environments. This has been particularly so in Australasia, where Pangean and domesticated taxa have collided with ancient and isolated Gondwanan ecosystems. Many plants and animals that humans introduced benefited from their pre-adaptation to their new environments and some become invasive, damaging the biodiversity and agricultural value of the invaded ecosystem. The invasion of non-native organisms is accelerating with human population growth and globalisation. Expansion of trade has seen increases in purposeful and accidental introductions and their negative impacts are regarded as second only to activities associated with human population growth. Here, the theoretical processes, economic and environmental costs of invasive alien species (i.e. weeds and vertebrate pests) are outlined and the symposium theme introduced. However, defining the problem is only one side of the coin. We propose general science-based solutions, including the imposition of essential human behavioural changes, applied at appropriate temporal and spatial scales to restore, regenerate and revegetate invaded Australian ecosystems.

## **Broad-acre revegetation strategies and challenges**

Author: **David Freudenberger**

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The restoration activities to date have generally been mere cautious fiddling in the face of Australian wide habitat loss, fragmentation and degradation. A fundamental principle of conservation is to address threats at the scale of the threatening processes. This is still not happening for two reasons: we don't

know how to restore at scale, and if we did, there is no demand because it doesn't pay. The first problem of developing the technologies needed for large scale revegetation will largely be solved if we collectively demand reveg at scale. Just have a chat with Paul Gibson-Roy about the remarkable commercial innovations he saw in the USA in regards to the native seed and sowing businesses that have been developed to meet a Billion dollar US Government demand for restoration of grasslands and woodlands. Such a scale of demand by Australian governments (taxpayers) is only likely if a 10% GST is placed on all food to fund a permanent Natural Heritage Trust. That will take a while. A price on carbon would help. Existing carbon funded large-scale restoration projects show it's possible. The other big opportunity is from latent demand from the commercial farmer. Greening Australia's Whole of Paddock Rehabilitation (WOPR) and a similar approach in WA with forage shrubs, to date has been funded by government, but the cost of such agriculturally productive reveg, including native pasture sowing needs to come down in price and be marketed on a fully commercial basis. This requires sustained R&D supported by novel partnerships with the massive Australian agricultural industry. Native vegetation must move from the margins to the mainstream.

### **The critical importance of monitoring in restoration**

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Millions of ha of land are being targeted for restoration efforts globally. Yet very few restoration projects will be monitored and even fewer will be monitored well so that it is possible to definitely determine whether restoration interventions have been ecologically effective and cost-effective. Researchers at ANU have worked closely with farmers, staff from regional bodies (such as those from Local Land Services) and practitioners from Landcare and other groups for the past two decades to quantify the response of a range of groups of biota to a range of restoration programs in temperate Grassy Box-gum woodlands from north-eastern Victoria to south-eastern Queensland. The monitoring partnerships have helped identify characteristics of effective restoration programs, including inter-related factors at the individual site, farm and landscape scales. Most importantly, the monitoring data gathered to date has indicated that restoration programs can make a significant positive contribution to bird persistence and increased site occupancy in many regions. Restored areas support markedly different vertebrate faunal assemblages relative to regrowth and old growth woodlands suggesting that replanting need to be considered as separate but complementary habitat types to other kinds of vegetation assets on a farm and in a landscape. Few time series datasets exist on changes in biodiversity within restored areas but those that do will be critical for further informing future decision making about vegetation assets in agricultural landscapes.

### **Policy drivers for restoration: does it matter why we're doing it?**

Author: **Martine Maron**

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Biodiversity offsetting has introduced a new policy imperative for revegetation, restoration and private land conservation around the world, and Australia is one of the earliest and most enthusiastic adopters. The approach involves requiring those responsible for biodiversity impacts to generate, or purchase, equivalent biodiversity gains, thus achieving 'no net loss' of biodiversity. Since 2001, offsetting has grown to become a near-standard condition of approval for development that significantly impacts biodiversity. In this presentation, I highlight why biodiversity offsetting differs fundamentally as a policy driver for restoration from superficially similar market-based schemes such as land stewardship. First, the objective of offset-driven restoration is to replace the particular biota that was lost—a very precise goal that restoration ecologists would suggest is infeasible for most ecosystems. Second, the stakes are raised: each unit of environmental improvement achieved (or intended to be achieved) by offset-driven restoration is, by definition, undone elsewhere by an equivalent environmental loss. Third, growing awareness of the potential to sell their restoration work as offset credits can disincentivise purely voluntary conservation work by private landowners. Offset-led restoration has a valid role in dealing with unavoidable impacts on biodiversity, but potentially damaging 'mission creep' is occurring. Confining restoration offsets to impacts on those biota for which there is good evidence we can restore, avoiding celebrating offset-led restoration works as conservation 'wins', and ensuring adequate support for voluntary conservation works

not funded by offsets, are all important steps in ensuring offsets lead to better, not worse, environmental outcomes.

### **Effectiveness of natural resource governance: the human and institutional dimension**

Author: **Paul Martin**

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There is ample evidence that despite many laws and policies, a great deal of excellent science, and committed efforts by government employees and private citizens, the environmental attributes of rural landscapes continue to decline. There is no strong reason to believe that this trajectory will suddenly improve under current rural governance approaches. Solutions that are popularly advocated include more precise measurement, more research, increased public funding or more rigorous stewardship requirements on farmers. This paper, which is based on natural resource governance research projects conducted or led by the Australian Centre for Agriculture and Law, suggests that because of fundamental systemic causes, more sophisticated solutions are needed. In particular significant institutional innovations is the pre-requisite for improvement.

Alternative solutions will be canvassed, but none are easy. Most require new management and engagement skills and innovative institutional arrangements. The paper reflects the idea, popularly attributed to Einstein, that only a fool believes that faced with poor outcomes they will get significantly better results by continuing what they have done to date.

Even those who are deeply committed to positive rural social and environmental outcomes (who accept that conventional approaches to solutions are unlikely to meet their goals) will find it difficult to make the necessary changes. This is particularly because many stakeholders have learned to complain about unfavourable institutions rather than attempt to change them. The paper thus proposes that a central challenge is to alter group mindsets and strengthen the ability of the 'good guys' to lead radical changes to rural natural resource governance, if better outcomes are to be realised.

### **Cost effective revegetation and restoration**

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Many hundreds of millions of dollars of public and private funds have been invested in revegetation and landscape restoration over the past 20 years across Australia. This talk is an overview of the period from 1998 (when I was a freshly appointed Bushcare Facilitator at the North Central CMA in Victoria) to the present.

Has this investment been worthwhile? ... "If we had our time over again would we do things differently?"

The big challenges in tackling this question are to understand **exactly how much** has been spent and what has been the impact.

Questions to ask in terms of impact:

Why - what was the objective? Was it linked to a SMART public good outcome?

How - what was the method or technique? Was it appropriate in relation to the objective and landscape attributes?

Where - in the landscape did it occur and to what extent did it augment other investments?

What and when - was the result and what benefits were generated over time.

Questions to ask in terms of costs?

What was the direct cost of implementation and who bore those costs?

What have been the ongoing maintenance costs?

What are the private costs? - one of the reasons for failure or lack of stewardship of native vegetation projects on private land is the unforeseen costs (opportunity and maintenance).

What have been the transaction costs?

The planning of future investment in landscape restoration will benefit by taking a structured approach to assessing cost effectiveness – this will entail thinking hard about estimating benefits and time lags, risks of failure, potential negative spin-offs and most importantly a transparent assessment of costs.

### **Sustainable revegetation in the Mt Lofty region of South Australia: a long way to go**

Authors: **David C Paton**, Joel R Allan, John Bulter, Kimberly P McCallum, Hayley J Merigot, Fiona L Paton, James Trezise

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South Australia's Mt Lofty region (MLR) is a biodiversity hotspot but with just 10% of original woodland remaining, ongoing species loss is predicted, particularly for already-declining woodland birds. Substantial re-establishment of woodlands to around 30% cover is required to prevent species loss. Despite regional management plans promoting this, woodland cover has barely increased and remnant vegetation condition continues to decline. Without substantial investment in new revegetation, long-term sustainability of MLR's biota is unachievable. Furthermore, investment needs to switch from short- to long-term to support on-going management and monitoring as the plantings grow and change through time.

To maximize regional benefits, plantings need to consider functional aspects (e.g., flowering), not just species of plants, and be self-sustaining and resilient. Survival, growth, and recruitment in the 40-year old Monarto woodlands show that locally endemic plant species do not perform any better than non-endemics (largely eucalypts from WA), suggesting a wider array of plants could be used. Large distances between conspecifics reduce regular cross-pollination, leading to reduced seed production and recruitment. This is despite rapid establishment of pollinator networks and indicates plant arrangements need consideration during revegetation. Additionally, further work on seed bank development and response to disturbances (e.g., fire) is needed to assess resilience.

The Monarto woodlands support many declining woodland birds, with individual birds present over extended periods (up to 10 years). So valuable are these new habitats that some have been gazetted as Conservation Parks. More plantings like these are now needed to curb species loss at a regional scale.

### **The ecosystem service of biological pest control: Valuing native vegetation**

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Globally the economic value of natural pest control is estimated at \$400 billion per year worldwide. The ecosystem service of natural pest control in agricultural crops is a critical component of sustainable production. Nancy will focus on the value of native remnants and perennial habitat for beneficial arthropods. Using examples from experiments and observation, Nancy will show that beneficial arthropods that provide pest control live and reproduce on native plants and perennial habitat in the cotton-grain landscape; they move from these habitats into newly emerging crops; and suppress pests. However, the high demands for agricultural products and lack of arable land will allow for relatively small management interventions for ecosystem services on farms dominated by production. To overcome this challenge Nancy will suggest targeted revegetation measures to secure the continuity of resources throughout the life cycle of service-providing organisms. Such measures are likely to increase the stock, flow and stability of pest control, while balancing the needs of production.

### **Managing invasive plants on sub-Antarctic Macquarie Island**

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The Antarctic is one of the last and most inhospitable frontiers on earth for weed invasion. On Australia's world heritage sub-Antarctic Macquarie Island, there are currently only three species of invasive weeds that are well established (*Poa annua*, *Stellaria media* and *Cerastium fontanum*), though isolated occurrences of other species have been found. Initial introduction of these species is believed to have been from human activities, a threat which is likely to increase. All three weeds are palatable and were suppressed to some extent by pest herbivore (rabbit) grazing. Given the high conservation value of Macquarie Is and threats to ecosystem structure and function from weed proliferation following rabbit eradication, well targeted control measures for invasive plants are vital. We hypothesize that a successful restoration program should incorporate concurrent control of non-native plants as well as non-native herbivores. Of the non-native plants, *S. media* may most easily be managed, if not eradicated, because of its more limited distribution, but little is known about the soil seed bank or population dynamics of *S. media* post pest eradication, or the effect of herbicides and non-chemical control methods in cold conditions. A current research project helps fill those knowledge gaps and focuses on a non-grass species to complement and build on data collected in an earlier project on the ecology and control of the more widespread invasive grass *P. annua*. With an interest in off-target herbicide impacts, our work also includes a study of the movement and fate of herbicides in Macquarie Is soils at low temperatures. Research in such a remote, cold, wet and windy place is fraught with logistical difficulties. Nevertheless, results are being used to help develop effective, low-impact control or eradication options for sub-Antarctic weeds.

### **Working with nature to improve both the environment and farm profitability**

Author: **Andrew Watson**

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To improve the 'Environment' is a very broad challenge, especially in farming where every farm decision is connected to the environment. Andrew and Heike Watson are focused on working with different aspects of nature, whilst still maintaining and improving farm profitability. They encourage and support research projects on their farm at Boggabri, and continuously trial research outcomes at a field and farm scale to prove the business case for working with nature rather than against it. They view one of the larger challenges facing efforts to improve our connection with nature as persuading farmers to try using 'environmental services', however, demonstration sites and farm trials are proving to be one of the most convincing methods.

### **Indigenous Natural Resource Management in Northern NSW: a regional overview and case study of the award-winning 'Murries on Barwon'**

Author: **Harry White**

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There are many, varied natural resource management projects being undertaken by Aboriginal people across our region. I would like to share with you some of the history of the area, our culture and some examples of successful Aboriginal NRM. For example, I coordinate an Aboriginal Reference Advisory Group which advises the Northern Tablelands Local Land Services, the peak NRM organisation for the region, on culturally appropriate NRM and provides guidance on the direction that our organisation should take in this regard. Across our region, we are supporting Aboriginal groups to manage Indigenous Protected Areas, Land Council lands and privately owned property. We are supporting the documentation of cultural heritage in order to keep it for future generations. We are also trying out projects that are relatively new to the area such as Aboriginal fire management and cross-cultural research.

My presentation is also a journey to a remote Aboriginal community in the far northwest of New South Wales where Aboriginal People from low socio-economic backgrounds achieve enrichment in their lives through training and later gain employment as a direct result of their involvement in a natural resource management project called 'Murries on Barwon'. The Murries on Barwon project employed several Aboriginal men and women in a structured 12 month traineeship working side-by-side on a large property owned by the local Aboriginal people at Mungindi. Their story is both inspirational and spiritual. I look forward to sharing with you our experiences and the joy of success.

## **Cost effective revegetation and biodiversity restoration**

Author: **Gordon Williams**

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Farmers and land managers are under increasing pressure from society in general to improve land stewardship and in particular biodiversity outcomes. This in itself is a good thing, but there is often a poor understanding from the wider community as to how and if this can be achieved, who should pay for it, and the financial constraints that farmers operate under.

Farming is a high cost, high risk and low return (less than 2%) to capital business, which means to prioritise surplus cash for investment in environmental endeavours that generally have a longer term financial return, can be very problematic.

However much can be achieved if a long term plan is acted upon, but this requires good planning, having environmental initiatives integrated in the whole farm business model, fine tuning throughout the process and a lot of hard work and commitment.

Continuing long term research into the roles and benefits of biodiversity is essential and high quality and sensitive extension of this information is paramount.

Every farm and farmer is different, as well as differences within farms, and any "one size fits all approach" is a recipe for failure. There are no "silver bullets", other than the broad concept of management of groundcover.

We all need to be in this together to achieve realistic and sustainable outcomes.

## **General**

### **Comparison of two methods to sample pest and beneficial invertebrates in crops and native vegetation**

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Two methods for sampling pest and beneficial invertebrates (aphids, parasitoid wasps, thrips, beetles, spiders, leafhoppers, lacewing, weevils, ants and lepidopteran larvae), the beat box and D-vacuum, were compared in different crop (wheat) and native vegetation types (river red gum woodland, poplar box woodland and native grassland). We sampled each vegetation type using the two methods with different sampling intensities on three farms near Boggabri (latitude 30°42'13.92"S, longitude 150°2'39.98"E), New South Wales, Australia, in October 2015. Larger numbers of each invertebrate taxon (except parasitoids) were counted using the beat box method than the D-vacuum. Although the minimum number of beat-box beats required to capture the total richness of each invertebrate taxon varied with vegetation type, six beats were sufficient to capture most morph species per taxon regardless of habitat.

### **FOFI5M: taking threatened species recovery to the next level**

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Multiple native fauna are threatened by predation and competition. These ecological processes limit their reestablishment and recovery outside of the few high-security conservation reserves they presently occupy. Rangeland sheep and goat production is likewise limited by these same processes, and their population trends reflect those of 'threatened species' in some places. Decline of sheep in particular, has led to a resurgence of investment in pest-proof netting fencing on a scale not seen in Australia since European settlers first erected such fences. Now, for the first time in 100 years, widespread erection of pest-proof fencing on livestock properties has made eradication of large vertebrate pests (e.g. wild dogs, feral pigs, foxes, feral goats, overabundant kangaroos etc.) possible across vast areas, offering simultaneous and substantial benefits to both agriculture and the environment. These infrastructure developments, driven by agriculture, also mean that fauna and flora conservation aspirations embodied in

the nation's first Threatened Species Strategy – namely, the widespread reestablishment and recovery of multiple threatened species outside of reserves – are now within reach on pest-fenced livestock properties. In this context, the FOFISM RD&E program seeks to assist livestock producers with complete eradication of five target pests ('five out'), restore populations of at least five threatened fauna ('five in'), and increase livestock production by five million sheep or their equivalents ('five million'). Convergence of agricultural and environmental investment around a shared problem in this way has the potential to permanently transform the status of threatened fauna, flora and livestock alike.

### **Landscape scale conservation: incentives for cross property action**

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Production landscapes are critical for biodiversity conservation. Individual landholders can contribute but the real challenge is coordinated cross-property action at a landscape scale. This paper describes 2 projects through which we have attempted to better understand that challenge. The 'Communities in Landscapes' project (Caring for Our Country 2009-2012) provided coordinated advice and training to develop cross-property biodiversity plans and \$70k for each of 7 landholder groups for the initial phase of the implementation. The project generated collaboration on landscape scale biodiversity conservation but without ongoing support the benefits could be lost.

The 'Increasing landholder collaboration for landscape scale conservation' project (NSW Environmental Trust 2016-2017) is exploring the nature and extent of collaboration and the opportunities provided by collaboration for public and private benefit. The vision is for landholders to develop 'Landscape Corporations' which are the vehicle for integrating production and conservation for landholders sharing the same landscape.

### **Kangaroos and conservation: can people be better predators?**

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Populations of the large kangaroo species that can be harvested commercially fluctuate dramatically and at times cause damage to conservation and production areas. The commercial industry is not achieving sufficient localized control for reasons which include the nature of the harvest, low demand for kangaroo products and the interaction between the industry, the regulators and landholders. The reintroduction of wolves into Yellowstone National Park has refocused attention on the impact of natural predators on herbivores and the cascade of ecological benefits that they can generate. In the absence of significant non-human predators of kangaroos in production landscapes, there is a clear role for people to learn to be predators. The current system of commercial harvest and damage mitigation permits is too haphazard and episodic, allowing kangaroo populations to settle and increase. In this paper, the shortcomings of the status quo are described and a new direction is proposed which involves people mimicking aspects of predator behavior to improve kangaroo management for production and conservation.

### **Grazing eco-innovators: are they regenerative?**

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Ten paddocks managed by 10 different innovators were compared across a fence-line with paddocks subject to continuous stocking by a neighbour. Full paddock histories and farming system descriptions were obtained from all innovators and neighbours. Perennial plant and litter cover, landscape function and vegetation diversity were measured on all sites, and soil chemical, physical and microbiological analysis were conducted on 4 sites. The innovators' paddocks had greater native plant diversity, much higher perennial plant and litter cover. Landscape function indices of nutrient cycling, water infiltration, soil stability were all higher, as were levels of soil P, N, C and pH. The innovators were highly enthusiastic about the impact of their management and were motivated to continue to adapt their practices. Whilst

detailed financial analyses were not undertaken, innovators reported maintained or increased profitability and optimism about future viability and long term sustainability. The study concluded that widespread adoption of the adaptive grazing management used by the innovators would improve the extent and condition of grasslands and the sustainability of the grazing system.

### **Policy Drivers for Restoration session): Seeing the wood for the trees... what's going on around our restoration work**

Author: **Francesca Andreoni**

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Native vegetation is critical for our biodiversity, the climate, productive farmlands and healthy waterways. Effective policy drivers are essential not only for native vegetation restoration efforts but also to ensure the retention of native vegetation in the first instance (particularly remnant and high conservation value vegetation). The current policy and legislative settings for native vegetation management across Australia mean that there is still a significant net loss of native vegetation extent and quality – thus undermining current restoration and regeneration efforts. Rates of native vegetation loss, which have increased again significantly in recent years, mean we all must play a role in changing the way native vegetation is valued and managed. This presentation will explore ways this policy disconnect can be addressed – from Government, Not for Profit sector, Industry and Community perspectives.

### **Allies and partners. Breaking down the “greenies vs farmers” divide**

Author: **Francesca Andreoni**

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Agriculture has a critical role to play in the management of native vegetation, and therefore the health of our biodiversity, waterways, farmland and climate. Farmers and other land managers have a central role to play in advocating for and implementing policy and legislation that protects native vegetation and sustainable farm production. The community supports farming and farming communities – they are at the core of our Australian identity. Where farmers and environmentalists are working together – the best outcomes can be achieved with high levels of support from the community at large. This session will explore how farmers and conservation NGOs can work together, and how the diversity and sophistication of contemporary sustainable Australian farming can be reflected in the public debate. These will be considered in light of the current context, and latest research into community views on the issue.

### **Restoration of native grassland infested by African lovegrass**

Authors: **Matthew W. Appleby**<sup>1</sup>, Nicki Taws<sup>2</sup>, Peter Saunders<sup>1</sup>, Phil Palmer<sup>1</sup>, Brett Peden<sup>1</sup>

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Scottsdale reserve in south-east NSW is a former grazing and cropping property with remnant patches of the critically endangered Natural Temperate Grassland of the South Eastern Highlands. African lovegrass was sown in the paddocks as a perennial pasture. Over several decades, lovegrass spread to adjacent remnant vegetation where it displaces most native grassland species. The cover of lovegrass can reach 100 % as it is relatively unpalatable and dense once it becomes rank. Where lovegrass has invaded remnant patches, Bush Heritage can successfully control the weed using the selective herbicide fluproponate at low rates/concentrations. Similar native species (C4 grasses) such as Kangaroo grass are unaffected if the herbicide is applied at low rates and when the native grasses are dormant. Following this treatment the areas typically go through a phase of strong natural regeneration by native grassland species. In areas where native species are largely absent because of ploughing and cropping, lovegrass (and other exotic species) is being removed by scalping the soil surface (<1 ha patches) to remove plants and the seedbank. The soil surface is then sown with native forbs and grasses to create seed production areas within the lovegrass. Over time, the area surrounding these revegetated sites will be treated in the same way as the remnant areas to allow native species to recolonise and, ultimately, to reconnect isolated patches of native grassland.

## **Unlocking the self-sustaining restoration potential of drained wetlands**

Author: **Mark Bachmann**

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The great opportunity presented by tackling water management as a restoration method at strategically selected former (drained) wetland sites is the ability to trigger and unlock a self-sustaining spontaneous process of habitat recovery.

The goal of this approach is to unlock the natural regeneration potential of wetland species of both flora and fauna, already adapted to respond to dynamic hydrological conditions. This is the “X Factor” that sets wetland restoration apart from terrestrial restoration, when considering response time, maintenance costs and the feasibility of tackling degraded sites. Inundation can provide excellent natural weed control and reduce competition, while simultaneously promoting an aquatic vegetation response – making rapid improvements in ecosystem condition possible.

This highly visual presentation will provide practical examples of where this approach has been successfully employed by Nature Glenelg Trust in South Australia and Victoria and the broad range of benefits (which extend far beyond ecology) that have resulted from the projects undertaken so far.

Fortunately, on-ground action often has less to do with what people know (although this is still crucial), but more importantly how they feel. That means building trust.

This presentation will explore how trust is built, by looking at the way scientific ideas are shared and communicated, and how people – both within agencies and the wider public – can become part of a restoration journey. Practical examples of wetland restoration projects, including the type of data they generate and how it has been communicated, will be used to illustrate how a social licence can be earned to undertake spectacular, successful restoration projects on both public and private land - in some cases, overcoming positions that had been entrenched for decades.

## **Rethinking the relationship between small mammals and predation to restore ecosystem function within large reserves of south-eastern Australia**

Author: **Mark Bachmann**

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A small mammal monitoring program has been conducted over the past 15 years in Lower Glenelg River Conservation Park. Of note, this South Australian reserve has been under the proximal influence of Glenelg Ark over the past decade, a comprehensive fox baiting program operating in Lower Glenelg National Park, the adjacent reserve in western Victoria. Not only do the cliffs of the Glenelg River form a significant geographic barrier capable of slowing fox re-invasion to this site, enhancing the effectiveness of the baiting program, but this is also the only location under the direct influence of Glenelg Ark where a long-term baseline dataset exists prior to the baiting program commencing.

The results plainly show that the highly diverse small mammal community originally observed at the site has been gradually replaced by a simplified community, at least in part under the growing, now omnipresent, influence of an unregulated Brushtail Possum population that has emerged in the absence of foxes. This is a cautionary tale about our current approach to feral predator management and, when interpreted in a wider south-eastern Australian context, highlights an urgent need to rethink the role of predation (and what cascading effects unfold in its absence) in our temperate ecosystems.

Clearly, the devil is in the detail.

## **From illegal clearance to restoration reserve – the story of Eaglehawk Waterhole**

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Eaglehawk Waterhole is a 1700 acre private nature reserve owned and managed by Nature Glenelg Trust, situated near the western end of the Little Desert National Park, on the border between SA and Victoria.



The property has a chequered history, including a successful state government prosecution of a previous owner for illegal clearance, which left a legacy of a complex legal and management framework over the site.

This presentation will explore how the policy drivers and systems that govern native vegetation clearance in South Australia, played a role in making the future protection of the property a more feasible proposition several years after the illegal clearance issue was resolved. Having policy mechanisms in place, capable of creating a positive legacy from otherwise negative circumstances, has a critical role to play in environmental management and restoration.

But a word of caution - policy alone is never the answer for achieving lasting or strategic on-ground results - and when the property was placed on the open market, its future management appeared uncertain. At that point, a new partnership between Nature Glenelg Trust, the Native Vegetation Council and Nature Foundation SA Inc. resulted in the site being secured for conservation and restoration, and the 510 hectares of the 684 hectare property that were still being farmed are now either regenerating or being restored - meaning this story has a happy ending.

### **Earning a social licence to undertake restoration projects on public and private land**

**Author: Mark Bachmann**

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The science of environmental restoration in many respects is extremely well advanced, but how do we turn the science into practice? How do we work with a wide range of people from different backgrounds to deliver on-ground action?

When confronted with doubt and opposition, scientists often retreat to what they know and come back later with more data and evidence to prove that they are 'right', only to meet the same resistance. There are also times when information gaps exist that prevent us from ever being able to have all the answers we need before we begin, meaning restoration options may need to be trialled first.

### **Returning the tide - restoring estuarine habitat to an artificially created freshwater wetland at Hexham Swamp**

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Hexham Swamp is an internationally recognised wetland, and part of the Hunter River estuary Ramsar site near Newcastle, NSW. The Hexham Swamp Rehabilitation Project aims to restore an estuarine wetland within an artificially created freshwater wetland. Floodgates installed across Ironbark Creek in the early 1970s reduced flooding impacts on the surrounding area, and maximised use of land for agriculture. Tidal flow was eliminated from what was an ecologically significant mosaic estuarine and freshwater wetland. Estuarine habitat soon deteriorated. This impacted migratory wader and shore birds, and nursery habitat of commercially valuable fish and prawns. By 2002, mangroves reduced from 180 to 22 ha; saltmarsh reduced from 900 to 6 ha; and the common reed (*Phragmites australis*) increased from 170 to 1,005 ha.

After 12 years of planning, research and stakeholder consultation, the Hexham Swamp Rehabilitation Project was approved by the Department of Planning in 2006. The project aims to achieve a 600 ha transition from dominant freshwater vegetation, to estuarine wetlands through progressive floodgate opening. The first of eight floodgates was opened in 2008, with all eight floodgates opened by 2013.

Rigorous monitoring since project approval provides encouraging results. The project has substantially rehabilitated Hexham Swamp into a healthy, functioning, estuarine wetland system again. A total of 443 ha of estuarine habitat has transitioned to date. Mangroves have increased by 60 ha; salt marsh has increased by 52 ha; over 40 new bird species have been counted; eastern king prawns and school prawns have increased by 1,500 percent; 15 new estuarine / marine fish and prawn species have been counted; juvenile bream have increased by 62 times; and juvenile mullet have increased by 10 times. The total cost of the project is \$10 million, including land acquisition, construction, ecological surveys, approvals, management and monitoring, with a present annual monitoring obligation of \$200,000.

## **Is local best? Testing forest tree provenancing strategies using field trials embedded in restoration plantings in Tasmania**

Authors: **Tanya Bailey**<sup>1,2</sup>, Peter Harrison<sup>1</sup>, Archana Gauli<sup>1</sup>, Jordan Whitmore<sup>1</sup>, René Vaillancourt<sup>1</sup>, Neil Davidson<sup>1,2</sup>, Brad Potts<sup>1</sup>

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Climate change is expected to significantly impact the long term success of ecological restoration plantings, especially those planted in highly modified landscapes. With local environments changing due to direct and indirect effects of climate change, local seed sources may not be the best choice as local adaptations become decoupled. Therefore, the choice of species and where to collect seed within a species range will be critical decisions in building climate resilience into long-term environmental plantings. A number of seed sourcing (provenancing) strategies have recently been proposed that capitalize on inherent genetic diversity and adaptive capacity within native species, however, evidence backing these strategies is limited. To understand how the choice of seed may impact restoration plantings we have established pedigreed eucalypt provenance trials embedded within multiple large scale restoration plantings across the Midlands of Tasmania. The trials consist of large provenance collections of five eucalypt species to test the local vs. non-local superiority in fitness (i.e. survival, growth, reproduction), in combination with glasshouse studies investigating provenance differentiation in functional traits. Glasshouse results are providing evidence for adaptive syndromes in key functional traits, which are correlated with increasing home-site aridity and/or maximum temperature. Further, early field trial results suggest that local adaptation may be context dependent and related to population structure and test site location within the species range, suggesting that local can be best but not always. These early findings are refining the assumptions of our species and provenance choice strategies and helping to guide future restoration projects.

### **Delivering landscape rehabilitation in national parks**

Author: **Andrew Baker** and Sophia Meehan

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In addition to conservation goals, revegetation can deliver program objectives linked to emission reduction and carbon offsetting. Achieving these at a meaningful scale in the current context can require a non-traditional view of delivery and success. Together with an increasing focus on climate change initiatives, broad scale revegetation activities are becoming more feasible.

This presentation outlines how the NSW Office of Environment and Heritage is undertaking landscape scale revegetation and rehabilitation projects working with private industry and non-government organisations under the Federal 20 Million Trees Programme and the Emission Reduction Fund. These projects seek to revegetate sites that have been cleared in the past but are now managed by the NSW National Parks and Wildlife Service.

Sites under the programs are scattered across NSW in a range of habitats and vegetation communities. The first cohort of sites aims to revegetate more than 3800 ha of land across 17 parks and will involve planting more than 1.5 million endemic trees and shrubs. Revegetation success is linked to the goals of the respective funding programs, program partners, as well as achieving conservation goals of the agency.

Resourcing remains a challenge for many organisations. This initiative explores an alternative approach to securing ongoing resources and achieving conservation outcomes through landscape scale rehabilitation projects.

## Seed banks of riparian zones in the semi-arid floodplains of the northern Murray Darling Basin

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Seed banks play a vital role in maintaining plant diversity, especially in highly unpredictable environments such as arid and semi-arid floodplains. In such systems floods and droughts tend to be extreme and periods between floods tend toward severe aridity. A significant ecological filter that will determine the overall vegetation structure in these hydrologically unpredictable floodplain plant communities would include the “regeneration niche” which would include the various life history strategies that plants will have to enable them to recruit periodically when conditions are favourable such as significant and persistent seed banks. In semi-arid floodplain systems these seed banks are often within the soil profile but can also be held in above-ground litter, including animal (e.g. kangaroo) scats. In order to examine the germinable seed abundance, and thus the potential seed banks across different hydrological settings we collected soil, litter and animal scat samples from 28 riparian floodplain sites across the semi-arid northern Murray Darling Basin. Samples were subsequently re-wet and kept moist, with germination recorded over 12 months. All three potential seed-banks supported a diverse array of plants including, grasses, sedges, forbs, herbs and woody plants, including *Eucalyptus coolabah*, *Acacia stenophylla* and *Acacia pendula*. In terms of species richness, litter tended to have a higher numbers of species, with similar numbers for soil and scats. These results are discussed in context of the regeneration potential of these banks compared to the extant vegetation and highlight some differences among plants with contrasting reproductive traits.

## Reset, Rebuild, Restore: enterprise, ecosystem and community restoration in north east NSW

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Invasive animals are an unsustainable burden on production and conservation areas (=agri-ecosystems) of north eastern New South Wales. They impose real and substantial costs on industry, biodiversity and local communities. Middle-sized invasive predators (wild dogs, red foxes) kill and maim thousands of calves, sheep and goats annually. Invasive herbivores (e.g. rabbits, horses, deer, macropods) and omnivores (feral pigs) compete with livestock for pasture and browse, and cause habitat degradation to largely unquantified extents. Free-roaming dogs, foxes and feral cats impact upon the internationally significant conservation areas of northern NSW through Key Threatening Processes of predation and competition. Endemic species such spotted-tailed quolls, brush-tailed rock wallabies, koalas, parma wallabies, long-nosed potoroos and rufous bettongs are surviving in northern NSW but most are declining except where intense and sustained invasive animal management complements suitable habitat retention and rehabilitation.

Economic and psychological stresses caused by invasive species, particularly predators, are evident at the individual, locality and community level. Effective management of invasive species results in less stress and increased job satisfaction / confidence for livestock producers and public land managers, and increased opportunities for economic growth and social stability in rural communities.

Here we outline monitoring tools and management strategies for key invasive animals that we have assessed. For example, wild dog and red fox populations can be suppressed by >90% at large geographic scales and feral cat control is promising. We also outline our invasive animal management program for resetting, rebuilding and restoring the socio-ecological landscape in north east NSW.

## Landscape-level revegetation reverses the decline of woodland birds in agricultural environments

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Replanting and restoration of vegetation is being undertaken in many regions where excessive loss of natural habitats has occurred. It generally is assumed that this will reverse faunal decline and reinstate the original biota. We examined the species richness and composition of woodland-dependent birds in 43 landscapes, each 8 km<sup>2</sup> in size, across an agricultural region in south-western Victoria, Australia. These were selected as sets of landscapes in which wooded cover was either: a) primarily remnant natural vegetation; b) a mixture of remnant and replanted vegetation; or c) primarily replanted vegetation. In each set, wooded vegetation cover ranged from <2% to ~19% of the landscape, the remainder being farmland with some areas of scattered trees. There were two key results. 1) Progressive loss of *remnant* woodland led to a decline in species richness of woodland birds and a simplified composition; but as landscapes increased in cover of *revegetation* this trajectory was reversed, species richness increased, and species composition was enhanced. 2) The trajectory of recovery is not simply a reversal of the trajectory of decline. For a given cover of wooded vegetation, species richness was lower in revegetated landscapes and the avifaunal composition differed in predictable ways. Restoration through revegetation offers conservation benefits at the landscape scale, but does not necessarily provide suitable habitat for entire assemblages, at least in the short-term.

## Comprehensive, reliable habitat classification and mapping is vital for restoration ecology

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Developing comprehensive hierarchical ecological **classifications** that capture the range of ecological diversity and underpinning processes, at local and regional scales, underpins biodiversity assessment and restoration activities. Accurate **mapping** (>80%) of finely classified units, combined with landscape scale planning to address habitat fragmentation, provides spatial context. 17 years ago the Guyra vegetation classification and map (New England Bioregion NSW) was published. It set a standard for accurately mapping numerically-derived woody plant communities to small (one hectare)-sized remnants. Its polygons are coded for vegetation type, vegetation structure, degree of canopy disturbance and naturalness of ground cover - attributes useful for benchmarking: the project aimed to assist restoration ecology. The Guyra risk codes evolved into the NSW Vegetation Classification and Assessment risk criteria that, in turn, informed the IUCN Red List of Ecosystems international risk criteria. The NSWVCA used a hybrid quantitative/qualitative approach to define 590 plant communities across 78% of NSW and is used in NSW regulations. Recent acquisition of high resolution airborne, digital imagery across NSW, able to be interpreted in 3-D space, has revolutionized the capacity to deliver Guyra-like vegetation map accuracies along with maps of condition attributes, fulfilling key requirements for environmental planning and restoration ecology. Given large expenditures on auto-generated modelling methods that have delivered unreliable maps with 30-50% accuracy to type, there is a cost-benefit in pursuing quality over expediency pitched at satisfying political imperatives.

## Rehabilitation design to encourage fauna recolonisation

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Historically the goal of rehabilitation, particularly in the mining industry, has been to make what was once a barren landscape as a result of mining operations green. Little consideration was given to designing a fully functioning ecosystem with a vegetation community that reflected what was once there. Often rehabilitation programs did not re-introduce the correct structural layers, species composition or species diversity let alone design with the consideration of factors that may encourage sustainable fauna recolonisation.



Rehabilitation has most definitely improved over the past ten years, however, are we designing rehabilitation with fauna recolonisation in mind? Are we looking to improve the old rehabilitation that already exists, that has been so poorly designed fauna recolonisation will be extremely slow?

In this presentation, Kleinfelder will look at different factors that can help improve fauna recolonisation of rehabilitation. The work that has been undertaken looked at the effects of different levels of woody debris, in tons per hectare, and nest box installation to fauna recolonisation of existing rehabilitation in the lower Hunter Valley. As one would presumably assume, no single factor alone can strongly influence fauna recolonisation. The success of fauna recolonisation will most definitely depend upon our ability to design, implement and manage the rehabilitation in a holistic manner, ensuring all structural layers of the vegetation community, along with habitat features such as woody debris and nest boxes, are combined to create a fully functioning ecosystem.

### **Payments for ecosystem services: what difference do they make and who puts their hand up**

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Ongoing decline in the extent and condition of natural vegetation in agricultural landscapes poses a significant risk to the supply of provisioning, regulating and cultural ecosystem services. Given that a large proportion of remaining natural vegetation in these landscapes occurs on private land, ecological restoration to address these declines must involve private landholders. Paying private landholders to adopt sustainable management practices represents one approach to ecological restoration. While this approach is used in many places across the world, relatively little is known about the effectiveness of these types of incentive programs, particularly in Australia. In this study we characterise the participants in voluntary incentive programs and investigate the impact of incentives on participants and native vegetation condition. To do this we use empirical data from programs in South Australia, where land managers received payments for remnant vegetation management over a 5 to 10 year period.

### **High efficiency woody weed control in Western Sydney**

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Woody weeds pose a significant problem for bushland rehabilitation and condition improvement. Woody weeds can rapidly achieve a stable, dominant monoculture that smothers natives. Removal of the woody weed monoculture is relatively straightforward. However, once removed herbaceous and grassy weeds can rapidly grow to dominate the landscape and the management requirements increase significantly. In this paper we document a site based approach to success where woody weeds were managed and then utilised to form part of the long-term weed management solution.

In 2012 Eco Logical Australia developed and tested a management approach that utilised the in-situ mulching of woody weeds as well as chainsaw and clearing saws in areas of higher resilience. This approach created a dense layer of mulch on the ground with a configuration that was particularly suited to suppressing weed germination. Careful management and follow up was still required, however, the mulch slowed weed germination permitting ongoing spot treatment as individual or small weed patches appeared. Over three years this approach achieved a greater than 90% reduction in exotic cover and a greater than 20% reduction in exotic species richness while seeing increases in both native cover and richness which will continue to develop in the long term.

## **The NCC Firesticks Project: applying Aboriginal knowledge, science and integrated fire, weed and pest species management to restore and maintain biodiversity, habitat connectivity and landscape resilience**

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Until recently many Aboriginal people were denied access to their ancestral lands and the opportunities to manage Country in a way that preserves and enhances its cultural and ecological values. This situation is changing with the creation of Indigenous Protected Areas (IPAs) around Australia, including in north-eastern New South Wales, where Aboriginal land managers are directly involved in the management of formalised conservation lands. IPAs currently make up more than 40% of our National Reserve System and in NSW provide core habitat and connectivity for a diverse range of species, including many Threatened species.

The NSW Nature Conservation Council's Federally-funded Firesticks Project has been coordinating a unique collaboration that involves community members and personnel from four Indigenous Protected Areas, three Aboriginal Land Councils, the Northern Rivers Fire and Biodiversity Consortium (NRFABCON), University of Technology Sydney and Government agencies including the NSW Rural Fire Service (RFS), Local Land Services (LLS) and the Office of Environment and Heritage (OEH)

Through the development of fire management plans, relevant training opportunities, and expert guidance the project is building capacity for land managers to implement integrated fire, weed and pest species management strategies to enhance landscape health and effectively protect and maintain ecological and cultural values.

The project is implementing on-ground works and conducting long-term scientific monitoring to establish a greater understanding of the ecological impact of applying low-intensity prescribed burns in a mosaic pattern across different ecosystems. The program aims to employ fire to enhance ecosystem health by improving habitat condition and connectivity within culturally significant but often degraded and highly modified landscapes; providing educational pathways that enable and empower Aboriginal and non-Aboriginal communities to work collaboratively.

### **Climate-ready revegetation: a guide for natural resource managers**

Authors: Nola Hancock<sup>1</sup>, Rebecca Harris<sup>2</sup>, **Linda Broadhurst**<sup>3</sup>, Lesley Hughes<sup>1</sup>

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Rapid environmental change presents challenges and uncertainties for landscape managers. Many restoration and revegetation practitioners recognise that changes to current practices are needed, based on understanding habitat conditions expected in the future, rather than the historical baseline of the past. But how should natural landscapes be managed when the magnitude and direction of projected changes are uncertain and the conditions projected for local sites may not have been previously experienced?

A new publication, *Climate-ready revegetation A guide for natural resource managers*, provides information on how to use on-line tools to gauge if existing vegetation (species and local populations) are likely to be suitable as the climate changes. To make these decisions, information on climate projections for the revegetation site, the climatic tolerance of the existing species (as indicated by the species' distribution), and the likelihood of survival of local populations are required. The Guide provides step-by-step instructions on how to (1) find and use on-line regional climate projections for a local site; (2) evaluate which plant species will be suitable at the site in the future; and (3) consider which strategy for selecting provenances will increase the likelihood of the local population surviving in the future. These steps are designed to acknowledge uncertainties about the nature and scale of physical change and to develop strategies that are as robust and climate-ready as possible, given our current knowledge base.

## **After the gold rush - What happens 'on the ground' after the final payment and the report is done?**

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NSW regional and state-wide natural resource management (NRM) targets have been set for improvements in the condition of soil, water and native vegetation on private agricultural properties that will assist in the long term viability of agricultural communities. Various projects have been funded with the aim of achieving these targets. All of these projects require some level of monitoring, evaluation and measurement of success to justify the investment.

NRM investment decision makers are faced with the dilemma of taking into account available resources and expertise, the commitment to long term monitoring, and a clear justification of knowledge needs.

From 2008 to 2013 the Border Rivers-Gwydir CMA embarked on a biophysical monitoring program to assess ecological outcomes of investment in funded projects designed to implement better land management practices across the catchment. Baseline field surveys of flora, fauna, soils, water quality and in-stream fauna were followed up after three years at selected sites on private properties supported in part by State and Federal government funds. Analyses of trends in these condition indices were inconclusive. This was likely to be due to the relatively short timeframe for monitoring of factors with longer-term ecological responses.

Success was also measured in terms of the degree of land manager engagement and ongoing capacity to implement change. More positive trends were reported for these measures.

Our understanding of both biophysical and social factors substantially influences our ability to evaluate program success and the reasons for success or failure.

### **Beyond the biophysical – the Jaliigirr Biodiversity Alliance Model**

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The Jaliigirr Biodiversity Alliance (JBA) is a voluntary partnership between 20 natural resource management (NRM) stakeholders on the Mid-North Coast of New South Wales. Since forming in 2012, we have developed and delivered a number of large, multi-partner NRM projects across the region. These collaborations provide an opportunity for our partners and their communities to work together at the landscape scale, and provide an efficient and effective way to manage threats to biodiversity across our region. By working together, we can help repair the landscape and provide tangible benefits for biodiversity conservation, agricultural productivity and the community.

The partnership recognises that building landscape connectivity is not a purely bio-physical endeavour, and the Jaliigirr Biodiversity Alliance aims to address this reality through supporting the organisational partnerships, and social and cultural connections, that enable large-scale connectivity conservation to occur in the region.

The Jaliigirr Alliance occurs within the traditional lands of the Gumbaynggirr People and the word Jaliigirr comes from the Gumbaynggirr language and means tree. Our projects are helping to facilitate collaborative caring for country projects between Alliance members. The recently initiated Yandaarra project will encourage our partners to re-evaluate our understanding of what Gumbaynggirr-led Caring for Country might look like, and how it might be practiced in the future.

The Jaliigirr Biodiversity Alliance is a unique partnership in that it provides leadership and equity between individual stakeholders and promotes a collegiate, collaborative, partnership. It has achieved this through establishing unique governance arrangements led by community individuals, rather than government agencies. This autonomy has ensured that long term connectivity conservation remains a social phenomenon that helps people re-connect to each other and to the land.

The Alliance has directly facilitated the work of over 20 organisations, 100 individual landholders, and several hundred volunteers. As a result of this partnership habitat restoration activities have occurred over an area of 1200ha leading to improved connectivity between key biodiversity assets such as the Gondwana Rainforests WHA, National Parks, State Forests and private land. Our partnership has recently been recognised by the NSW Green Globe Awards as winners of the Regional Sustainability Award.

## Improving the success of direct seeding on the Northern Tablelands

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Direct seeding is a practical and cost-effective method for establishing native vegetation in degraded agricultural landscapes. However, the technique is currently unreliable and results are often mixed or below expectation. There is an urgent need to improve direct seeding because of its cost-effectiveness and applications to broad-scale revegetation. We implemented a series of direct-seeding trials to identify barriers impeding the recruitment of direct-seeded natives on the Northern Tablelands. The main barriers were inadequate soil moisture, weed invasion along riplines, predation and desiccation of surface sown seed, and poor recruitment of small-seeded eucalypts. We recommend: 1) good site preparation incorporating deep ripping to build up the soil moisture profile, 2) control of competitive weeds using selective herbicide oversprays to which native species exhibit tolerance, and 3) precision placement of seed beneath the soil surface using a mechanical seeder (for example KB or Burford seeder). In addition, using smoked vermiculite as a bulking agent has the potential to improve native seed germination. To improve the recruitment of small-seeded eucalypts we recommend sowing in a full soil moisture profile at a time of year when follow-up seasonal rain is expected. Seed coating incorporating species of arbuscular and ectomycorrhizae also significantly improve early establishment.

## Designing wildlife connections across the Tasmanian biodiversity hotspot

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The Tasmanian Midlands biodiversity hotspot is feeling effects of climate change - higher temperatures, lower rainfall (400-500mm), dryer autumns and more weather extremes. Greening Australia, in association with partners in natural resource management and research, is creating biodiversity corridors to connect the Central Plateau to the Eastern Tiers in response to a rapid decline in the unique flora and fauna of the region caused by habitat loss, farming systems and climate change. The corridors provide habitat linkages for native mammals and birds isolated within native forest remnants in a sea of agriculture.

Routes for connection were modelled, including identifying 'focal landscapes' - areas of very high natural values (DPIPWE, 2012), and then landscape linkages within and between focal landscapes were developed across the Midlands. Connectivity requirements for animal functional groups were then modelled (Lechner 2014), and optimal pathways for animal movement identified and incorporated into the corridors.

Once corridor pathways were identified Landholders were approached and long-term agreements struck, using the Forestry Rites Act, which allows sharing of costs and benefits (e.g. carbon credits and biodiversity credits). Differences of opinion about attributing values to ecosystem services and extent of compensation for loss of production through stewardship payments were overcome.

Built into this model was provision for changes in corridor and revegetation design in response to results from imbedded research: 1. on sources of tree seed in anticipation of climate change; and 2. habitat structural requirements of different animals groups for home range and long-distance travel via 'corridors' and 'stepping stones'.

## **Environmental watering for riparian vegetation outcomes**

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Environmental water management is critical to the effective conservation and restoration of functional vegetation communities in riparian landscapes, especially in catchments subject to high levels of river regulation. In Australia's Murray-Darling Basin, considerable public investment has been directed towards securing environmental water and planning and monitoring its delivery to a range of large, iconic wetlands for vegetation outcomes. The Commonwealth Environmental Water Office is currently conducting a large, collaborative long-term intervention monitoring project (LTIM) to investigate ecological responses to watering actions in a number of selected areas across the basin including wetlands in the Edward-Wakool, Goulburn, Gwydir, Lachlan, Murrumbidgee and Warrego catchments. With respect to vegetation, this project aims to determine vegetation diversity responses to watering in both the short-term and cumulatively, over a five year period, and from local to basin scales, to inform the adaptive planning and management of environmental water throughout the basin. Here, I will present an overview of the vegetation component of this project to date and synthesise its key findings with respect to setting restoration objectives, designing watering actions and evaluating responses of riparian vegetation to environmental watering.

## **Using agricultural planters to sow native seeds for restoration of Northern NSW vegetation communities**

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The farming landscapes of northern NSW have been extensively cleared for the production of agricultural crops. Recently, attempts have been made to restore some native vegetation through seedling planting and direct seeding to restore ecosystem services that support agriculture. The scale of the revegetation required is much greater than in pastoral landscapes, with associated increases in costs. We explored the use of agricultural machinery already used by landholders in the district (John Deere MaxEmerge planters) to sow seeds of native species. We used a range of native species in different configurations to sow 4 trials in partnership with an advisory group of landholders. The trials revealed that many species from northern NSW revegetation communities can be successfully established using this machinery. Further refinement is needed to improve species mixes, sowing rates and depth and the agronomy of planting native species, however the technique is proved as a means of carrying out landscape-scale revegetation using conventional, and readily available machinery.

## **Lessons from the Aboriginal Riverkeeper Team Project, Georges River, Sydney**

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The Aboriginal Riverkeeper project has been operating within Sydney's Georges River catchment since 2014. It employs and trains a small, full-time team of Aboriginal people in ecological restoration with strong Aboriginal cultural components. The project is funded by the Commonwealth, and involves partners from the private sector (Eco Logical Australia), Local Aboriginal Land Councils, local government and community groups, facilitated by the Georges River Combined Councils Committee. Environmental and socio-cultural outcomes of the project include bush regeneration and weed removal, as well as strengthening the cultural identities of the trainees by engaging them with Aboriginal Elders and knowledge-holders. Through this culture-rich traineeship, the project is continuing the concept of Indigenous Caring for Country in a modern and highly urbanised setting. To assist others to deliver similar successful projects, this paper outlines lessons learned when engaging with both Aboriginal and non-Indigenous project partners to achieve efficient and effective land management works with long-term socio-cultural outcomes.

## **Saving the planet with ecodrama: transformational immersive and experiential theatre within a living stage**

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Ecodrama can be defined as theatre which explores the reciprocal connection between humans and the more-than-human world. It describes works with environmental themes, that attempt to raise consciousness and inspire change; it also explores “sense of place”, identity and community. This paper focuses on an ecodrama event performed in Armidale at the Black Gully Music Festival as part of the EcoArts Australia Ephemera project (November 2016).

Integral to this work was the concept of the Living Stage – a recyclable, biodegradable and partially edible performance space which combines stage design with living plants and community engagement. Armidale’s Living Stage (entitled The Bower Stage) was central to the celebration of the newly restored Black Gully, behind the New England Regional Art Museum (NERAM), which has increasingly become a hub for environmental and creative activity. Using the Bower Stage as our performance space, we created an ecodrama which engaged students from three local High Schools in devising a piece of theatre that encouraged audience members to gain a greater understanding of environmental issues.

Theatre and music created an immersive and experiential performance. The style was vaudeville, and the audience were invited to enter on a journey into “The Environment”, which was presented as a pristine and precious commodity. The themes explored included: our connection with the natural world; climate change; water security; human impacts on the environment and our individual and collective responsibility. Using the performance as a case study, this paper will explore how ecodrama can be a tool for the Arts to make an integral contribution to discourses around important environmental issues – including how immersive performance spaces can invoke emotional responses such as empathy and anger, to act as stimuli for change.

## **Traditional Owner values and aspirations for land, sea and water align with collective impact concepts of regional NRM**

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The Port Phillip & Western Port Catchment Management Authority (PPWCMA) region is home to 4.2 million people. It’s the traditional land, sea and water of the region’s first peoples, the Wurundjeri, the Wadawurrung and the Boon Wurrung. Their former estates are now intensively altered and managed by around 50 local governments and state agencies and over 300 community-based organisations.

The disconnection between Aboriginal people and country within the region is profound and there are very few people employed to actively manage country, and fewer people managing water, coasts and sea country. Wurundjeri elders understand that being actively involved in caring for country is critical to culture and healthy country, but is complex and requires partnerships.

The PPWCMA developed common understanding of the Wurundjeri’s goals and aspirations for involvement in NRM during 2014, namely a focus on strengthening cultural knowledge, improving land management skills, and to care for culturally important places through their Narrap (land) management team. Theirs is a common agenda to that of the CMA to have collective impact with all the partner organisations, groups and individuals wanting healthy country.

## **Analysis of genetic divergence, demography and threats provides guidelines for conservation of *Eucalyptus magnificata***

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*Eucalyptus magnificata*, Northern Blue Box, is an endangered species endemic to the Northern Tablelands. Detailed taxonomic study found *E. magnificata* has a far more limited distribution than previously known, and the species is restricted to public and private lands around the northwestern edge of Oxley Wild Rivers National Park. Assessment of genetic diversity and divergence, population demography and site-specific threats was carried out on the largest populations of *E. magnificata*. Genetic diversity of adult trees was high in all populations. The Enmore (Type) population of *E. magnificata* had the greatest level of genetic divergence, likely due to genetic drift, consistent with its small population size and relatively isolated location. Germination tests were carried out on seeds from the two largest populations, as no seed was available from the smaller sites. Germination rate ranged between 85–97% and was higher in the largest population. Diameter at breast height for over 1,000 trees showed differences between sites congruent with site disturbance and intermittent recruitment. The large proportion of mallees at all sites indicated that these populations might be made up of predominantly older individuals. Presence and severity of land clearing, tree dieback, grazing, mistletoe infestation and fire were made at each site. Moderate to severe tree dieback was found at every *E. magnificata* site and is the primary threat to the species long-term survival. Fragmented vegetation was observed at all sites. Active management actions, including fencing, crash-grazing and revegetation, could be beneficial to the long-term health and survival of *E. magnificata* populations.

### **The use of nest boxes in remnant and restored habitats**

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Large old growth trees containing tree hollows are still being cleared for urban and industrial land development, infrastructure and mining projects. In some instances the removal of tree hollows is ameliorated through the installation of constructed nest boxes in residual or remnant habitats.

The installation of nest boxes is becoming an acceptable component of ecological/biodiversity restoration projects such as biodiversity offset agreements, Species recovery programs, remnant bushland management, community biodiversity restoration projects and development consent conditions to ameliorate loss of tree hollows.

There are many variables involved in the design and installation of nest boxes with no standard approach available. As a result there are many problems encountered with the use of nest boxes. These problems include durability of materials used, tree attachment methods, economics of construction and management, species competition, monitoring, maintenance / replacement and overall responsibility.

Some key factors affecting nest box microclimate are the type of material used and the location of the nest box in a tree in relation to exposure to direct sun and the temperatures recorded within the nest box. Temperatures within a box above 37°C can be lethal to bird eggs and young within the nest box.

In a changing world encompassing climate change scenarios, ongoing loss of hollow bearing trees, increased requirements for offsets and amelioration measures it is important to fully consider the variable aspects of the use and management of nest boxes in any restoration, revegetation or rehabilitation project.

### **A decade of working with private landholders to restore a biodiversity hotspot**

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The Tweed Shire supports internationally recognised biodiversity values including extremely high numbers of locally endemic and threatened species. With only 29% of the Shire's habitat in the formal reserve



system, the significance of private land for landscape-scale connectivity and biodiversity outcomes is critical. Council implemented an integrated private land conservation program in 2006. The program consists of the Biodiversity Grant, River Health Grant programs, Land for Wildlife and Backyard Habitat for Wildlife. These initiatives provide financial incentives for habitat restoration, technical support, education and training for landholders. The program builds community capacity to protect and manage the natural environment. To date, 2,300 hectares of habitat has been restored on 486 properties and 86 kilometres of waterway rehabilitated. Under the Land for Wildlife program, 150 landholders conserve 3.6% of the Shire's bushland outside the formal reserve system. The program complements Council's planning and regulatory framework for biodiversity conservation and has inspired greater community involvement in protecting and managing the Shire's outstanding natural assets. The program has also enabled Council to build enduring relationships with community. Challenges include strategic project prioritisation, measuring on-ground success and maximising return on investment. A number of challenges are emerging due to proposed legislative changes, new weed threats, climate change and other factors.

### **Tracking into the future - cultural indicators for healthy country**

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The teams use CyberTracker to create their own tailor made applications, which are purposely built to map, identify and monitor cultural and ecological values unique to their country. Information collected remains the property of the source and respects Indigenous Cultural & Intellectual Property rights. Information can be shared to enable cross-cultural knowledge exchange. The aim is to identify the impacts, health/condition and effects of management actions and climate change on culturally significant species, ecosystems and landscapes. A key element of the Firesticks Initiative and IPA management is cultural burning practices. Cultural burning replenishes and/or protects cultural sites, features and traditional bush resources. Cultural fire practices and values are underpinned by a fundamental intent and knowledge of cultural custodians to care for community and country, this can be understood through the interconnected relationships and kinship between all elements and beings. The focus of these projects is to engage cross culturally to develop and enable Indigenous methodological frameworks. Through action research the aim is to increase the capacity of Indigenous communities and non-Indigenous stakeholders to recognise and promote Indigenous ways of understanding and caring for Country.

### **Rabbits: their impacts on native pastures, native herbivores and introduced predators**

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Rabbits have long been part of the national landscape but, with diseases like myxomatosis and RHD reducing numbers, they are often overlooked as environmental pests despite being the most commonly encountered wild mammal in southern Australia. Here we show why rabbits must be considered in any program to revegetate or restore ecosystems. Even in low numbers, rabbits determine the abundance of iconic red kangaroos (*Macropus rufus*), holding their numbers below expected pasture carrying capacity. This is because rabbits have the capacity to remove all the protein-rich components of the pasture which red kangaroos need for successful reproduction. We build on an increasing understanding that unless rabbits are held below about 0.5 to 1 rabbit/ha native pastures lose diversity; the most palatable native species disappear and are replaced by introduced unpalatable and sometimes toxic weeds. Given the readily observable impact of rabbits on both native pasture composition and red-kangaroo populations it would be a serious omission not to explore the idea that rabbits also competed with other small herbivorous mammals such as burrowing bettongs (*Bettongia lesueur*) and stick-nest rats (*Leporillus apicalis*) and had as much to do with their extinction as the arrival of cats and foxes, also facilitated by over-abundant rabbits.

## **Ephemera: a case study in how the arts can create empathy for ecological restoration**

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Australia's natural areas have long been a source of inspiration for artists. Ecological art is an artform in which living ecosystems are incorporated into the artwork and many ecological artworks have an ecological restoration function or seek to create an empathy among viewers towards the natural environment.

*Ephemera* was a recent project conducted by Ecoarts Australis (<http://www.ecoartsaustralis.org.au/ephemera>) and funded by Festivals Australia. It happened in conjunction with the Black Gully Music Festival and the 'Environment Science Community Arts People Entertainment' (E.S.C.A.P.E.) program of events. Five artists were employed to create ephemeral artworks around the festival site. These included: unfired pottery made from the clay dug from the Black Gully creek by Andrew Parker; intimate ephemeral artworks created from natural materials along the creek by Greer Taylor; an eel trap sculpture woven using traditional Aboriginal weaving practices by two Indigenous weavers Amy Hammond and Gabi Briggs; and a living stage created by Tania Beer in which performances were staged by students from Armidale High School and Duval High School.

The music festival also included an array of performances from local musicians, activities in New England Regional Art Museum, artisans stalls and stalls from local sustainability groups. The Black Gully site itself has been the result of many years of active ecological restoration by the Armidale community.

It is our contention, that incorporating the arts into ecological restoration programs such as this event allows a greater level of communication with the general public, and allows the creation of emotional affinity for ecological restoration.

## **Restoring complex native riparian habitat in the Tasmanian biodiversity hotspots**

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Riparian restoration in the Tasmanian Midlands biodiversity hotspot represents the largest river revegetation project in Australia – to date 18km of river bank has been planted to a width of 200m from the channel. The biodiversity corridor under construction will connect Eastern Highlands with the Central Plateau, providing habitat linkage for native mammals and birds isolated within native forest remnants in a sea of agriculture. A key element in this \$6million restoration plan is the establishment of 50km of riparian revegetation along the Macquarie River and its tributaries. In a large scale restoration experiment commercial forestry techniques were adapted for use in this riparian zone. All operations had to meet the constraints of the Tasmania Forest Practices Code. A 22 ton excavator with a Wilco cultivation head was used to shatter compacted soils to create individual tree placements (830/ha) with a low profile to prevent erosion by flood. Control of woody weeds decreased structural complexity available for native animals but was necessary logistically. Targeted use of herbicides limited contamination of the waterway. Despite drought then recurrent floods, two years later, >50% of planted local native trees and shrubs are surviving. Survival varies from 80% on sandy loam soils to 30% on cracking clays and <10% on deep aeolian sands. Micro-topography also had a significant effect. *Eucalyptus rodwayi* and *E. ovata* are the most successful tree species. Understorey shrubs have low survival in comparison to trees. Conclusion: Heterogeneity in survival and growth is having the desirable outcome of producing a complex habitat.

## **Using a theory of ecosystem recovery to develop meaningful landholder monitoring in checking for change**

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Most ecological indicators currently used in professional or scientific monitoring change slowly, over decades, not on the shorter time scales over which we hope to adaptively manage. Landholders may collect shorter-term monitoring information, but it is unclear whether the simplified methods usually used

yield analysable data. We aimed to fill this gap and develop quantitative monitoring methods that can detect improvement over short time frames, yet be easily and reliably implemented by landholders to enable widespread use. We first developed a conceptual model of ecosystem recovery involving three broad phases, in which factors that change early in the process are necessary pre-cursors to changes in subsequent phases. We then identified 24 potential indicators of this first phase of recovery and quantified them in 2009, 2011 and 2015 at 20 environmental stewardship sites and 20 matched control sites. At least four indicators showed statistically significant improvement at stewardship sites compared to control sites, and these were primarily related to the structure and/or function of the litter layer. We also tested which indicators could be measured easily and with sufficient accuracy by landholders themselves. The result is a new guide (Checking for Change) to monitoring in the early years of recovery that can be easily used by landholders, schools, and citizen scientists, as well as ecological professionals. The results can be used to support rapid adaptive management, and data can be aggregated at regional, state and national levels to help improve our understanding of and response to the state of our environment.

### **A partnership made in heaven: restoring critically endangered lowland subtropical rainforest in the Upper Austinville Valley**

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The Upper Austinville Valley is one of the last refuges for lowland subtropical rainforest in the Gold Coast hinterland, and provides key habitat for numerous state and nationally listed threatened species. Recent on-ground works have targeted the restoration of the integrity of this area (such as strategic weed removal), and build upon a history of rehabilitation projects in the Valley spanning >10yrs (including the eradication of Madeira vine, and the conversion of old banana plantations to remnant native forest). This presentation will describe the critical components of this effort – engaged partners, innovative restoration techniques, and the iconic species that swayed local hearts and minds and delivered project funding – as well as the regional context for focusing on this endangered ecological community. It will also examine the immediate challenges to preserving this Valley – unchecked recreation, a lack of understanding of local natural values, and recent exotic species incursions – and how these are being overcome. Finally, it will discuss the role that the Valley plays as a refuge within a changing climate, and which species will most likely be the heralds of this change.

### **Continuous monitoring of plant water relations to establish benchmarks for ecosystem health and transplanting protocols**

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Ecosystems consist of biotic components interacting in complex ways with each other and the surrounding abiotic or physical environment. One makes the assumption that we know what healthy ecosystems look like, but often there are pre-emptive warning signs of ecosystem stress that are missed until it is too late. We must move beyond our reliance on simple measures of ecosystem composition and structure to assess ecosystem health and functioning. Measurement of ecosystem functions can be difficult, but is more informative than species lists and cover estimates.

Water is a fundamental component underpinning all life on Earth. It therefore stands to reason that this be a key consideration in assessing ecosystem health. Continuous, non-destructive, high temporal resolution monitoring of plant water relations can provide a simple and useful measure of plant health and productivity. Plants synthesise the six key abiotic parameters (water, light, temperature, humidity, wind, & nutrition) to provide a single continuous output of productivity within prevailing environmental conditions. By using sophisticated yet easy to use tools like Sap Flow Meters and Stem Psychrometers to continuously measure the productivity and health of plants within an ecosystem, we can develop ecosystem health benchmarks and provide early warning systems for the overall health of the ecosystem. Examples of how these tools are being used in old growth river red gum woodlands in the Murray Darling Basin in Australia, and development of transplanting protocols for the establishment of trees in Canada will be given.

## **Restoring Ecological Integrity – the whole and the sum of the parts?**

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The term 'Ecological Integrity' (EI) has now been given primacy, along with "biodiversity" (living variation), within NSW's Biodiversity Conservation Act (2016). EI has been defined as "maintaining the diversity and quality of ecosystems and enhancing their capacity to adapt to change and provide for the needs of future generations" (IUCN, 2016). What is in a name, and what implications can it have for managing biodiversity in NSW?

EI implies connected biological and physical features, forming self-organising, resilient systems spanning a range of spatial scales. Individual features, and the ecosystems they form, have value in their own right. However EI is really concerned with the whole.

EI is now a high-level goal for biodiversity conservation and requires integration of habitat repair with the management of intact ecosystems across whole regions.

EI is clearly a complex and fuzzy concept involving multiple dimensions. Yet our ability to quantify, anticipate and influence change to EI relies on the development of practical indicators. This task is challenged by data limitations and knowledge gaps. Tools at our disposal include existing conceptual models, site-based information, and regional-scale modelling methodologies. We present suggested ways towards quantifying EI based on existing and proposed state-wide spatial modelling.

### **Landscape scale restoration of radiata pine plantations to native forest, Skyline Tier NE Tasmania**

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Restore Skyline Tier is a landscape scale ecological restoration project returning Radiata Pine plantations back to biodiverse native forest. The project is located behind Scamander and Beaumaris on the East Coast of Tasmania.

The establishment of pine plantations (by clearing native forest) was supported by funding from the Federal Government in the late 1960's to mid 1970's. As with other large scale land use change programs (i.e. Managed Investment Schemes) there were some plantations established which in hindsight were ill conceived. In the early 2000's clearfelling of pine plantations on the clearly visible steep slopes of Skyline Tier triggered community interest and concern. A closer inspection of the harvested areas revealed natural regeneration of native species was occurring and this led to a proposal being put to the land managers (then Rayonier now Timberlands/New Forests) for the area to be put back to native forest. After four years of negotiation a trial plot was agreed to and this has now expanded into an agreement to restore 869 ha.

The value of using Assisted Natural Regeneration as opposed to tree planting includes cheaper establishment and maintenance costs, establishment of resilient local provenance species, high species diversity (including orchids, groundcovers, climbers, shrubs and trees) and superior fauna habitat as a result of increased plant and structural diversity. The project has also provided the impetus for employment and training in conservation land management in the local area (over 50 people employed doing ecological restoration work in Break O Day municipality in the last 4 years).

### **Slopes to Summit Bushlinks – living the connectivity dream**

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In 2012, the Slopes 2 Summit (S2S) Partnership, one of the regional partnerships under the Great Eastern Ranges Initiative, was successful with a \$2.3 million Biodiversity Fund Project from the Australian Government's Clean Energy Futures Fund.



Managed by the Holbrook Landcare Network, the S2S Bushlinks project commenced in August 2012 and has implemented over 1200ha of on-ground works to build landscape-scale connectivity across private lands in the Southwest Slopes of NSW - from the wet and dry forest ecosystems of the upper catchment and reserves to the threatened Grassy Box Woodlands of the lower slopes and plains.

The journey through the delivery of such a large project saw the project team grappling with the big questions of connectivity conservation – connectivity for what and how to measure the improvement and the ultimate challenge of translating the connectivity models and approaches to the real world, at the paddock scale. The project provided incentives to landholder to do negotiated works on their properties and was based around a scoring system for proposals that emphasises ecological principles, but also the reality of working in the agricultural landscapes and farm businesses in the mixed farming high rainfall zone (HRZ) in southern NSW. The most important connectivity has turned out to be connectivity to the community we are working in and building relationships that ensure connectivity outcomes outlast the infrastructure.

### **Counting the cost of revegetation: is direct seeding cheaper than planting tube-stock?**

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Direct seeding is often assumed to be a cheaper revegetation option than planting tube-stock, but limited data exist to test this assertion.

At four riparian sites, we assessed plant numbers in areas that had been planted or direct seeded. Cost estimates were made on a per plant basis. Sites were between 3 and 30 months old when assessed.

Tube-stock survival rates ranged from 57% to 100%, while sowing resulted in an average of 3,020 plants/ha (range: 870 – 6,500 plants/ha).

At all sites, species diversity, plant height and plant cover tended to be higher in planted areas than in sown areas.

Across the four sites, the average cost per surviving tube-stock plant was \$13.60, while direct seeding plants cost \$1.70. This equates to a cost of \$40,800/ha for tube-stock and \$5,100/ha for direct seeding to achieve a density of 3,000 plants/ha.

These figures only include the costs of materials and labour to plant and sow. Direct seeding sites require a high level of weed control in the months before and immediately after sowing. This is particularly important in riparian areas, where weed loads are high. As such, site preparation and maintenance costs are greater for sown sites than for planted sites. Other project costs such as fencing, herbivore control and project management can also be considerable, but are similar for both revegetation techniques.

However taking all of these costs into account, current data suggest that direct seeding is cheaper on a per plant basis than planting tube-stock in riparian areas.

### **Managing relictual eucalypt woodlands: growth and mortality studies to forecast old growth habitat feature development and resource bottlenecks**

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*Eucalyptus* species provide many essential resources for fauna such as foraging substrates (trunks, canopies and dead branches), roosting locations and nesting cavities. These resources generally increase with tree age until eventually senescence and death lead to decline. We studied development of such features in the semi-arid temperate woodlands of central New South Wales. There were different relationships between trunk diameter and tree height, canopy size, and canopy senescence, depending on tree species, with additional impacts of tree density. For a subset of trees we measured growth rates and found intrinsic variation among species. Canopy senescence affected growth rate of species differently, with some impact of tree density also detected. We compared ground counts of hollow entrances to counts by an arborist and found estimates of hollow abundance to be more reliable in woodland than in

forest. Based on our ground counts, hollow abundance and the probability of a tree being hollow-bearing increased with trunk size, but varied widely among species and with canopy senescence. For River Red Gums these relationships also varied between populations along the Macquarie and Bogan Rivers. Additionally, early failed ringbarking has resulted in a significant proportion of trees being multi-trunked resulting in a cohort with different allometric characteristics and habitat values to single-stemmed trees. These complex and variable relationships have implications for outcomes of revegetation efforts. Our results are being integrated in a stochastic modelling process to enable estimation of future availability of habitat elements produced by different remnant restoration or green field revegetation strategies.

### **Engaging remote NT aboriginal youth in environmental conservation: the Ngukurr Yangbala (Young People) Project**

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Like many other remote and regional parts of Australia, the remote Aboriginal community of Ngukurr is experiencing high rates of youth unemployment, wellbeing challenges and disengagement from intergenerational cultural knowledge transfer. Many young people drop out of school early, have poor literacy and numeracy skills and there are high rates of pregnancy in teenage girls. To try and address these concerns and develop a pathway to culturally meaningful work, the Ngukurr Yangbala Project was established by the Yugul Mangi Rangers, elders and myself. The project team had worked together for 8 years and trialed approaches to youth engagement in the Ranger program. In 2015 we were lucky enough to attract the attention of international NGO The Nature Conservancy who sought funding for the Yangbala Project vision. We have just completed our first year of three and have established several new Caring for Country and Culture projects including protecting a locally important bush potato patch and building a nursery. The team has also worked on established projects of the Ranger group including: fencing off culturally important wetlands; monitoring fruit production of a favoured bush tucker plant; cross-cultural biodiversity surveys; and are helping create a local flora and fauna field guide in 10 languages! Over 40 young people have been involved in the paid work of the project so far, to various degrees. They have been building a range of skills including: English literacy, digital literacy, numeracy, organisational skills, knowledge about Country and Culture, and getting their driver's license. The project has also been invited to present their work at several conferences such as the Native Title Conference and IUCN World Conservation Congress in Hawaii. We were also a finalist in the 2016 Eureka Prize for Innovation in Citizen Science. The project is instilling pride and hope in the young participants, three of who have recently gained access to study at Macquarie University. We have learnt a lot of lessons, but still have a long way to go!

### **Measuring the recovery of saltmarsh communities impacted by exotic grasses**

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Saltmarshes are found throughout Australia in all climatic regions. They are an important component of coastal areas and are recognized for highly adapted plant species, providing essential habitat for fauna and assisting with sediment stability. Threats to saltmarsh are varied and this vegetation community commonly suffers heavily from anthropogenic impacts associated with urban development, recreation and nutrient runoff. Saltmarshes are susceptible to weed invasion. Exotic grasses like para grass (*Urochloa mutica*) and kikuyu (*Pennisetum clandestinum*) have been recorded throughout Australia as being aggressive invasive species that outcompete native species including saltwater couch (*Sporobolus virginicus*). Both para grass and kikuyu can tolerate high salt levels and extremes of temperature as characterised in saltmarsh communities. A pilot study focusing on the control of invasive weed species was undertaken with Brisbane City Council to establish effective and efficient treatment methods and optimal herbicide rates to control weeds in saltmarsh communities. The positive or negative growth of *S. virginicus* without exotic grass competition was measured across trial plots. Four treatment methods were established at the native - exotic weed interface. Treatments occurred between March and November 2016 with the time taken to apply each method to each plot recorded together with the herbicide rate and volume. Simple statistical analysis showed that glyphosate used in a spray form was the most efficient method when considering both herbicide volume and time for completion. Other results showed a seasonal influence when measuring time and herbicide volumes. Measurements of *S. virginicus* prior to

treatment and on completion showed weed control measures assisted the spread of *S. virginicus* though secondary weed succession also influenced time and herbicides required in each plot.

### **23 years on and still going strong- community efforts for Regent Honeyeater recovery**

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The Regent Honeyeater Recovery Project began in the Capertee Valley in 1993 in response to the significant decline in Regent Honeyeaters (*Anthochaera phrygia*) across its range (the species is now Critically Endangered, with fewer than 500 birds remaining). The Capertee Valley, approximately 50 km north of Lithgow (NSW), is the most important breeding area for the bird. Since 1994, over 110,000 native trees and shrubs have been planted across approximately 270 hectares on more than 40 private properties by a team of dedicated volunteers, coordinated by members of the Capertee Valley Regent Honeyeater Recovery Team. Methods used have evolved over the years and have included planting more shrubs and increasing the diversity of species planted to attract other declining woodland bird species and changing the shape of planting sites to deter competitor species such as Noisy Miners. Survival rates of plantings have varied as a result of factors including the amount of rainfall post-planting and herbivory by both native and introduced animals. Some clear trends have emerged such as plantings on the mid to upper slopes of the valley have been more successful than those planted on the valley floor. Since 2008, bird monitoring of planting sites has shown that they provide important habitat for a number of other threatened and declining woodland bird species. A major key to the success and longevity of the project has been building strong partnerships with the local community in the Capertee Valley, the broader community, species experts and other Government and non-Government organisations.

### **‘Cultural Conservation’: Using Aboriginal Scientific Knowledge to manage the internationally significant Narran Lakes**

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Narran Lake, located on the upper western plains of New South Wales, is a special place where many Aboriginal nations came together to undertake ceremony, exchange valuable items, arrange marriages and renew social bonds. It is a place with internationally significant cultural and environmental values. The Nature Reserve is managed by the Narran Lake Nature Reserve Aboriginal Co-Management Committee (NLNR CMC).

The NLNR CMC has signed a Memorandum of Understanding with NPWS on the management of NLNR, while we are working together with the arrangements within the current MoU we are looking to broaden our input into other areas of management within the Reserve. We are working on a Strategic Plan of Management which will be a guide for our committee and NPWS into the future. The overall goal is to return full management of the Narran Lakes Nature Reserve back to Ualaroi people. Within the SMP there will be other key stakeholders/partners into developing the capacity of our committee to absorb more responsibilities for management of our country. While we recognise this may be somewhat of an awkward conversation for NPWS, being an institution unto itself, to have at times, we are determined to build the capacity to go down the path of full management of the areas under NPWS stewardship.

In the space of Conservation out on “Narran” there are areas of management (Operational) we (TO’s) need to be in control of, not just the visible archaeological values but also the ecological conservation out there. My people once had such a deep knowledge of the entire space out there that it would take several lifetimes to accumulate that knowledge again. Some of which may never be with us again. This is underpinned with the deep respect for knowledge, respect for the ancestors’ knowledge, respect for the knowledge within the landscape. Having total respect for whole of environment. It is planned that we resume training in areas of Conservation through Aboriginal Scientific Knowledge which is a term I call “Cultural Conservation”. How do we do this? We have agreement with NPWS to set aside an area of the Reserve for specific conservation purposes. Through the development of the Plan of Management for this area a number of partners will be engaged with TOs to plan out the training required to reinstate Traditional Management of Country through traditional cultural practices. Much of the work will require

formal scientific study by TO's. UNE are being engaged to provide this vital piece of training. We are currently engaged with UNE in a Developmental Research project on the Aboriginal Archaeology out on Narran.

### **Soil preparation for successful revegetation includes soil microbiology**

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Rehabilitation or more specifically restoration of open cut mine sites often face a topsoil shortfall and are required to revegetate using less than ideal soil media. Rehabilitation of mine overburden often involves the application of fertilisers and/or large quantities of organic materials such as biosolids and municipal composts.

These do have their uses for soil and vegetation improvement but are often not sustainable, requiring further additions and in terms of native revegetation are often counter-productive by encouraging weed species to proliferate and out-compete the target native species.

A more sustainable approach is to revegetate with tubestock or direct seeding utilising microbial inoculation. By inoculating the native plants or seeds with mycorrhizal fungi and in the case of native legumes, dual inoculation with mycorrhizae and native rhizobia, natural nutrient cycles can be re-established. This has the advantage of reducing or eliminating the use of fertilisers, reducing the use of organic matter and providing an initial competitive advantage over weeds.

Here we present the results of small trial utilising commercially available inocula to demonstrate the benefits and discuss methods of application to more broad scale revegetation projects.

### **Effective control of competitors is essential for restoring mainland quoll populations**

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Spotted-tailed quolls (*Dasyurus maculatus maculatus*) are endangered and decreasing, and eastern quolls (*D. viverrinus*) are extinct on mainland Australia. A number of putative causative factors for their decline and demise have been suggested; untargeted historical control of wild dogs, aerial baiting for wild dogs, exploitation competition with foxes and feral cats, habitat loss, bushfire and prescribed burning, poisoning by cane toads, climate change, deliberate killing, road mortality, and intraguild predation. However, the news is not all bad. The largest extant mainland populations of spotted-tailed quolls are in regions where effective introduced predator control has been practiced for a long time. Captive breeding programs for (Tasmanian strain) eastern quolls have been successful, leading to reintroduction possibilities for surplus stock. This raises the question, "is control of introduced predators essential for regeneration and restoration of quoll populations?" Here we use data from southern Queensland and north eastern New South Wales quasi-experiments to suggest the conditions necessary for regeneration and maintenance of extant populations, and for successful reintroductions and restoration where quolls are extinct in eastern Australia.

### **Koala habitat plantings on the Tweed Coast of NSW – characteristics and use by koalas**

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The 2011 Tweed Coast Koala Habitat Study (Phillips *et al.* 2011) found that the Tweed Coast koala population on the Far North Coast of NSW had declined by approximately 50% within the preceding decade. Consequently, Tweed Shire Council, the community, land owners and other public land managers on the Tweed Coast are working together to address threatening processes and promote koala recovery to

prevent localised extinction of this iconic species.

Restoration of koala habitat is one such action. Over 30,000 koala habitat trees have been planted in the last five years on over 35 sites, covering an area in excess of 20ha within the Southern Tweed Coast Koala Management Area. Koala habitat plantings have (and continue to be) planned and undertaken to; 1) best improve connectivity between known koala metapopulations and areas of habitat; and 2) to create new areas of habitat adjoining existing habitat to increase carrying capacity for koalas.

Koalas started utilising koala habitat plantings at 25% of sites within two to three years of their establishment. Koalas, including females with young, continue to use sites. We present a range of site and restoration factors specific to koala habitat plantings on the Tweed Coast (size, configuration and age of planting, koala food tree species and proximity to mapped koala habitat and known metapopulations). These data are presented for sites with and without evidence of usage by koalas.

### **Rainforest revegetation techniques used in the Australian tropical uplands for conservation outcomes**

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During the past 25 years, more than 200 hectares of previously cleared land have been replanted for ecological restoration of rainforest in the tropical uplands of North Queensland, Australia. Techniques have been developed by revegetation practitioners (including community groups, government departments, businesses and landholders) to maximise successful forest re-establishment using local rainforest plant species. Important component actions include: adequate site preparation, species selection, use of advanced seedlings at planting, close tree spacing, and post-planting maintenance during several years. Although these techniques are labour intensive and seem costly they provide clear and rapid results, where the planted trees form a closed canopy within four years. Canopy closure is critical for the suppression of grass and weedy ground vegetation which are considered the major threats to planting success. Following canopy closure, there is typically no need for the regular maintenance activities that account for a substantial proportion of the lifetime costs of planting. These techniques will be outlined, together with the main difficulties faced and their cost implications. Data from replanted sites and areas of passive forest regeneration have quantified the acceleration of recovery that is achieved using these restoration methods. Less intensive interventions (than planting) to accelerate forest regeneration are likely to be less costly, but have been infrequently trialled because of the likely greater time needed to establish canopy cover, attain conservation values and there is substantial potential for highly variable outcomes. We present preliminary findings from systematic trials of a technique aimed at catalysing early-stage regeneration in disused pasture.

### **Application of an eDNA detection framework for invasive species monitoring**

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Environmental DNA (eDNA) is increasingly being used in surveys to establish the presence or absence of target species at restoration and other sampling sites. The idea is that if a species is present at a site, individuals of that species will have released DNA into the environment through discharges such as faeces, skin cells, mucous and gametes. Environmental DNA is gaining popularity as a detection tool because it can have advantages over traditional survey methods in difficult-to-survey locations, such as aquatic habitats, and for difficult-to-detect taxa, such as rare or cryptic species.

However, like any survey method, eDNA does not have perfect sensitivity, meaning there is some chance of failing to detect target DNA when it is present at a site. Failing to account for this imperfect detection can lead to biased estimates of species' distribution and abundance, and the analysis and interpretation of eDNA survey data needs to take this into account.

We have developed a framework to estimate the sensitivity of both the field and laboratory components of

an eDNA survey method, and show how these can be combined to estimate the overall sensitivity. We have applied this framework to species-specific eDNA surveys to estimate the sensitivity, or probability of detection, for three invasive aquatic species present in Australia; *Perca fluviatilis*, *Cyprinus carpio*, and *Misgurnus anguillicaudatus*. We have also developed a method for the detection of spawning in a threatened species, *Macquaria australasica*, and how eDNA can also detect the presence of terrestrial vertebrate species at water sources. Examples from each of these applications will be presented and how eDNA can potentially transform species monitoring.

### **Linking ecosystem services, agrochemicals and yield**

Authors: **Vesna Gagic**, David Kleijn, András Báldi, Gergely Boros, Helene Bracht Jørgensen, Zoltán Elek, Michael P. D. Garratt, G. Arjen de Groot, Katarina Hedlund, Anikó Kovács-Hostyánszki, Lorenzo Marini, Emily Martin, Ines Pevere, Simon G. Potts, Sarah Redlich, Deepa Senapathi, Ingolf Steffan-Dewenter, Stanislaw Świtek, Henrik G. Smith, Viktória Takács, Piotr Tryjanowski, Wim H. van der Putten, Stijn van Gils, Riccardo Bommarco

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Simultaneously enhancing ecosystem services provided by biodiversity above and below ground is recommended to reduce dependence on chemical pesticides and mineral fertilizers in agriculture. However, consequences for crop yield have been poorly evaluated. Above ground, increased landscape complexity is assumed to enhance biological pest control, whereas below ground, soil organic carbon (SOC) is a proxy for several yield-supporting services. In a field experiment replicated in 114 fields across Europe, we found that fertilization reduced the yield benefit of high SOC and pest control. Contrary, in low SOC, fertilized fields aphid abundances were low and biocontrol high, reducing the need for insecticides. We furthermore show that enhancing pest control through increasing landscape complexity can prove disappointing if soil services are not considered. Understanding ecological interdependences between land-use, ecosystem services and yield can help promote environmentally friendly farming by identifying situations where ecosystem services are maximized and agrochemical inputs can be reduced.

### **Ecosystem Services and Profitability in Grazing Systems**

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Ecosystem services provide productive benefits for grazing systems. These include water and mineral cycling, habitat for beneficial organisms, shelter and protection for plants and animals, connectivity and energy capture. Because these services are provided free of cost, economic theory postulates that the profitability of grazing systems cannot be maximised unless these benefits are maximised. This paper briefly explains the philosophy of profit maximisation with respect to ecosystem services and outlines the way in which management can ensure that the providers of these ecosystem services are maintained. The science behind each of these ecosystem service providers will be explained and their role in grazing system productivity and profitability demonstrated. It will be shown that there are six key NRM criteria that ensure that the benefits of ecosystem services can be maximised. Data from our property, which has been using these NRM criteria for the past 7 years, will be used to demonstrate inherent inefficiencies in many grazing systems.

### **Monitoring for monitoring's sake. The need for more targeted monitoring**

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People in the Ecological Restoration Industry have often made the case for more and better monitoring of ecological restoration projects. I am taking a different tack, and arguing that the bulk of so called monitoring being done at present is a waste of time with no good scientific outcomes. What the industry needs is not more monitoring, but better and more meaningful monitoring. We need detailed studies of techniques and their outcomes to develop best practice models and have benchmarks for what standards

can be achieved. Instead of trying to turn each one of the thousands of bush regeneration projects across the country into detailed scientific research, we need simple monitoring and reporting tools for the bulk of projects, and detailed scientific investigations into model projects as a basis for industry benchmarks.

### **To sow, or to plant, that is the question**

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Considerable resources are invested into restoring degraded riparian environments, but the outcomes of such projects are often poorly monitored. Direct seeding and planting of tube-stock are two commonly adopted approaches to revegetating degraded riparian sites, yet the relative outcomes of these two approaches are rarely compared.

We surveyed the outcomes of several riparian restoration projects within the Greater Melbourne area where direct seeding and planting had been used. Survey methods varied according to the nature of the project, but in general, species composition and plant survival, establishment, and heights were assessed.

Both revegetation techniques resulted in native plant establishment at the sites monitored, to varying extents. Direct seeding had often resulted in the establishment of moderate to high plant numbers, but at all sites, sown areas were dominated by one, or a few, species.

It was not possible to determine whether direct seeding was more or less effective than tube-stock planting overall, due to different outcomes at different sites.

Management interventions such as good weed control, protection from herbivores and additional watering in dry times would all improve revegetation outcomes. The combination of direct seeding and planting may be the most effective way to ensure the development of diverse, resilient riparian plant communities at restored sites.

### **Innovative funding models for invasive species research and management: Lessons learned and future directions**

Authors: **Kerinne Harvey**<sup>1</sup>, Andrew McConnachie<sup>1</sup>, John Tracey<sup>1</sup>, Rod Ensby<sup>1</sup>, Cameron Allan<sup>2</sup>, Andy Sheppard<sup>3</sup>, Louise Morin<sup>3</sup>, Peter Turner<sup>4</sup>, Michael Day<sup>5</sup>, Kunjithapatham Dhileepan<sup>5</sup>, Royce Holtkamp<sup>1</sup>, John Heap<sup>6</sup>, Greg Lefoe<sup>7</sup>, Raelene Kwon<sup>7</sup>, John Ireson<sup>8</sup>.

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Restoration and regeneration of ecosystems affected by invasive species requires long-term investment in capacity that matches the time scale of the issue. Sadly, boom and bust funding cycles are a common scenario across all sciences and lead to major losses in capability for research, extension and on-ground management across Australia. Because research, development and adoption is too slow to meet the needs of political cycles, there is a critical need to establish a broader funding base to provide continuity and maintain capacity. Here we present in its early stage the development of a co-dependent partnership model to sustainably fund the future needs of research, development and extension. Using biocontrol as a case study our partnership model, driven by the NSW Biocontrol Taskforce, aims to gain greater regional involvement in biocontrol investment, prioritisation, on-ground operation, monitoring and evaluation. Here we present the successes and lessons learned from existing funding models already established in Queensland and New Zealand, the preliminary consultation and discussion for the feasibility of a partnership model with local and state government, LLS and other interested parties and our proposed partnership funding model for NSW. Based on the sustainable principle of 'beneficiary pays' this model requires the in-kind and financial support from on-ground land management teams, researchers, local, state and federal governments, communities and committees. Collectively, this model encourages communication and consultation to bring together Australia's leading weed biocontrol RD&E agencies for rebuilding capability and capacity, to fast-track and maximise the on-ground delivery of biocontrol agents.

## **Change or fail? Why human behaviour matters for invasive animals management**

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Again and again we hear that many of the problems associated with invasive animal management are really problems of human behaviour. Whatever toxins, guns, or other technologies are used to control pest animals, we still need people to lay the bait, pull the trigger or install the ejector. Sometimes they do. Many times they don't. In this presentation, I will discuss how advances in behavioural sciences can be applied to change behaviour and empower land-owners and managers and to adopt best practice animal control. I will provide examples from our recent work, with the Invasive Animals CRC, highlighting the challenges associated with translating behaviour change principles to practice.

## **Management recommendations for the Diamond Firetail in the Mount Lofty Ranges**

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Diamond Firetails (DFTs) have been declining throughout their national range since the 1980s. In the Mount Lofty Ranges (MLR), the population has contracted east where it now exists in small, isolated and fragmented sub-populations. Whilst habitat clearance is the main influencing factor at the broadest scale, the specific processes affecting the ongoing survival of MLR DFTs are unknown. Being ground-foraging granivores, DFTs are particularly susceptible to disturbances in the ground-layer. I present evidence for the hypothesis that a shortage of food resources is affecting DFT survival, particularly during winter, a pinch-point period for the species.

Throughout the range of DFTs in the MLR, invasive weedy grasses have largely out-competed natives, dominating the understorey and changing temporal patterns of seed production. My research shows that breaking rains in autumn trigger predominantly weedy surface-layer seeds to mass-germinate, leaving very few seeds available in winter for foraging birds. I explore the timing of important life-stages of a suite of understorey species, including the length of phases of growth, seed-set, seed-drop, senescence and germination. Based on this information, I identify species that display the most consistent and sustainable seed production year-round. I recommend the restoration of a combination of native grass and forb species that will together provide an adequate seed-source to sustain the MLR DFT population through the critical period of winter. This approach will secure long-term food resources and improve the longevity of this vulnerable bird species.

## **Joining up the dots: linking landscape restoration with community development in an invasive species management context**

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Invasive species take hold in landscapes that are segmented by land tenure boundaries, fragmented governance regimes and short-term planning cycles. Current management and control approaches are informed by technical expertise in species ecology, however successful implementation also requires sustained and coordinated collective community action.

People working with community members to achieve coordinated invasive species control are usually trained in aspects of wildlife ecology. They hold great expertise in pest control techniques and understand the biophysical, social and economic impacts of pests on agricultural communities. Front-line practitioners also report situations of community conflict, disengagement, frustration and sometimes, great success in coordinated control. Dealing with these different situations extends beyond pest species expertise and requires an understanding of social dynamics.

Working with community to achieve collective action is best understood as a community development exercise. Community development is associated with the use of participatory techniques for planning and evaluation, and may support the devolution of power from government to community members through a range of different mechanisms such as partnerships, collaborations or co-management arrangements.

Each of these require different degrees of participation from the community, industry and government, in a dynamic model of learning and experimentation, if they are to realise their potential. Learning about community development requires reflection on success and failure, as well as leadership commitment to do things differently.

This paper presents empirical data from a program of human dimensions research and makes suggestions for application of these findings in front-line community engagement practice.

### **Collaborating for landscape restoration: a case study of the Brigalow Nandewar Biolinks collaborative governance model**

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Rural policy continues to struggle with the ongoing challenge of finding the best scale for natural resource decision-making. A historic mismatch between catchments, bioregions and local government boundaries has undermined connectivity in both landscape and social systems.

This paper presents a case study of a collaborative governance framework that emerged from community engagement in Catchment Action Planning, to become the foundation of a project implemented during a period of institutional change. Findings show that setting up collaborative protocols is time consuming and can lead to delays in delivering on-ground NRM outcomes. Pressures to meet external accountability requirements create a tension between ideals and implementation of collaborative governance.

However the case study also suggests that collaborative forums may be resilient to disruption and principles of adaptive governance can support community engagement in times of rapid change. These findings suggest that participatory processes that adopt capacity building as a clear objective are likely to be more resilient to the destabilizing effects of change and contribute to building more robust rural communities.

### **Birds in Black Box: Avian community drivers in threatened floodplain woodlands**

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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 many of them are already degraded. The current MDBA plan is unlikely to deliver enough environmental water to maintain or restore them.

To determine the consequences of this for birds, avifaunal assemblages at 36 sites in the Riverland region of South Australia were surveyed and compared. 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. This has implications for woodland birds regionally if hydrological deficiencies are not addressed and landscape-scale restoration of floodplain woodlands is not implemented.

## **Determining the habitat requirements of the Rufous Whistler (*Pachycephala rufiventris*) for woodland restoration**

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The Rufous Whistler *Pachycephala rufiventris* is one of many bird species declining due to woodland clearance in southern Australia; to reverse this, restored vegetation must incorporate the habitat attributes required by this species. To determine these requirements, habitat use by male and female Rufous Whistlers was examined during the 2010/2011 summer/autumn period at sites in remnant vegetation and revegetation in the Monarto region, South Australia. Radio-tracking was used to establish home range size and areas of differential habitat use (hot-spots and cold-spots); vegetation surveys in these areas determined spatial, structural and floristic requirements.

These Rufous Whistlers had home ranges from 5.3 to 132.1 hectares, and the home range of some individuals were contained entirely within revegetation. The largest home ranges were recorded for birds using predominantly remnant vegetation. Factors determining differential habitat use included the amount of plant cover, species diversity and density.

These results suggest that to achieve successful conservation outcomes for Rufous Whistlers, woodland restoration should incorporate plants from a range of genera, provide plant cover of at least 20–30% at a range of vegetation strata, and be planted over the largest area possible. They also indicate that revegetated habitat alone can support a declining species and may be more productive than remnant habitat, perhaps due to the condition or floristic diversity of remnants or the disproportionate clearance of more productive areas. Incorporating these species-specific requirements into revegetation schemes is vital to improve the conservation outcomes of future restoration efforts for declining species.

## **Complexities and fallacies: managing endangered *Themeda* headlands on the North Coast of NSW**

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*Themeda* grasslands on seacliffs and coastal headlands along the NSW coast are a listed Endangered Ecological Community. On the north coast of NSW a number of listed threatened flora species occur within them including *Pultenaea maritima*, *Zieria prostrata*, *Thesium australe* and a number of unique coastal forms of other taxa that may require formal recognition. Current management concepts include regular burning as being important to the health of these systems and that shrub encroachment is a threatening process that can be managed with fire. Some evidence suggests *Themeda* is invigorated with burning. Based on interpretations of paintings and Cooks voyage there is a belief that these headlands were regularly burnt by aboriginal peoples all along the coast. Some have recommended burning yearly. Within the Coffs Harbour region funding has been received to reintroduce burning to seven of the seventeen headlands the community occurs on. 244 monitoring plots were placed across 17 headlands in the Coffs Harbour Region and included BACI fire and macropod exclusion experiments. A conceptual model from our preliminary results is presented which indicate a number of contradictory outcomes from management decisions and how pre-conceived ideas about best management could lead to the unfortunate results.

## **Resilience planning for ecological restoration – what aspects do we need to consider?**

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Under a changing climate, it is essential that habitat restoration planning to enhance ecological systems take full account of modelled climate futures in Australia.

Scenarios for climate-changed regions can lead to a myriad of restoration planning issues. Using a resilience-planning framework can assist in marshalling thoughts and maintaining clarity on goals and the methods to reach those outcomes. Resilience planning forces thinking on what ecosystems are important, if these systems be saved, or if active stewardship could transform these areas into related but different

systems that still maintain their ecological/habitat integrity.

Resilience planning gives metapopulations in restored ecosystems the best chance to respond to a range of perturbations or disturbances by minimising environmental damage and, through scientifically grounded restoration design, allow a dynamic and rapid recovery.

Resilience planning identifies critical elements in the landscape that are ecologically and/or socially important, and the disturbances that are likely to affect those landscape elements into the future. By predicting the impact of disturbances such as climate change on restored landscapes, and the native communities reliant upon them, we can develop management interventions that ensure their ecological integrity. Here we provide on-ground examples of resilience planning at the landscape scale in a variety of agricultural landscapes in Victoria. These include significant widening of seed provenance to develop climate-adapted plant communities, flora and fauna distribution modelling to predict future dispersal with changing conditions, and connectivity modelling underpinned by species specific habitat requirements. In short, resilient landscapes will need to have the flexibility to self-organise and bounce back from both long-term change and shorter-term disturbances.

### **Forb responses to environmental variables: how are they moderated by species origin and lifecycle?**

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Forbs are an important component of diverse grassland communities and provide resources for grassland dependent fauna including mammal, bird, reptile, and invertebrate species. However, we know little about the processes determining community composition or the location of individual species, which may vary widely in their responses to environmental variables. Species origin and lifecycle divide forb species into broad functional groups of species likely to have similar response patterns.

We investigated the influence of environmental variables representing topography, vegetation structure, and soil properties - aspect, topographic wetness index, %grass cover, %litter cover, litter depth, soil phosphorus, %clay, and silt/sand ratio - in determining the occupancy likelihood of grassland forb species, and how their responses are moderated by origin and lifecycle. We surveyed 192 small plots in a 70ha ex-agricultural nature reserve with undulating topology, a variety of soil types, and a diverse mix of native and exotic dominated grassland communities. We used Bayesian analysis to compare the responses of 62 forb species according to origin and lifecycle. The results agreed with our expectations of negative native species responses to phosphorus and biomass, and identified further distinctions between responses of annual and perennial species.

### **Native seed produced under cultivation in the northwestern United States**

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Ecological restoration in the semi-arid temperate Intermountain Region in the northwestern United States is serviced by what is probably the most extensive native seed industry in the world. Seeds of multiple plant materials of numerous grass, and increasingly, forb species are produced in cultivated settings by a variety of growers and companies that specialize in seed production of herbaceous rangeland species. Grass and forb seed production is regarded as a specialized enterprise that requires a high level of skill on the part of the seed grower, both as an agronomist and as a businessperson. It also involves elements of both risk and reward, with most of the seed being produced under speculation to service broadscale restoration. On the other hand, high-priced specialized items may be produced under contract, but the demand for such seed is typically limited by high prices, thus quantities are limited. Seed may be produced either under irrigation or in a dryland farming system. Highest yields are produced in the Columbia Plateau of eastern Washington state, which features fertile soils, mild winters, and a plentiful irrigation supply originating from the dammed Columbia River. However, seed of woody species, particularly shrubs, and some forbs are either difficult to produce under cultivated conditions or are slow to reach reproductive maturity. Thus, wildland collection continues to be the source of seed for these species due to its superior cost effectiveness.

## Ten current restoration scenarios in the continental United States

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Ecological restoration in the United States is growing in terms of the number, size, and diversity of projects. Such efforts are intended to ameliorate past environmental damage and to restore a functioning ecosystem that provides desired levels of ecosystem services. For ten current restoration scenarios across the continental United States, this paper details 1) the impacts of the original disturbance and compounding secondary issues that compel restoration, 2) the corrective practices applied to effect restoration goals, and 3) the prospects for recovery of charismatic or protected species and ecosystem services. Ecosystem-altering impacts include flood control Kissimmee River [Florida]), flood control and navigation (Atchafalaya Basin [Louisiana]), logging and fire suppression (longleaf pine forest [humid Southeast]), invasive plant species (Great Basin, Mojave Desert), damming for hydroelectric power (Elwha River [Washington]), damming for irrigation projects (arid Southwest), nutrient and sediment loading of the watershed (Chesapeake Bay and Mississippi River drainages), and a warming climate (aspen forests). Animal species targeted for recovery include the greater sage-grouse (Great Basin), the red-cockaded woodpecker (longleaf pine forest), the southwestern willow flycatcher (arid Southwest riparian systems), the desert tortoise (Mojave Desert), six salmonid fish (Elwha River), and blue crab and eastern oyster (Chesapeake Bay [Maryland, Virginia]). Iconic woody plant species include big sagebrush (Great Basin), which was removed intentionally and is now being lost due to wildfire; longleaf pine, which was logged and continued to be lost due to fire suppression; and quaking aspen, which suffers from decline due to a host of biotic and abiotic factors believed to be related to climate change.

## Microbats Suppress Pest Insect Populations in NSW Cotton Fields

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Microbats are known to predate major agricultural pests. International studies have shown that this pest control service is worth billions of dollars to farmers each year with regard to pesticide savings. This large economic benefit could provide incentive to Australian land owners to create and maintain bat habitat on-farm via revegetation and ecological restoration. However, scientific evidence highlighting the benefits of habitat restoration in Australia's intensive farming regions for the provision of pest control by microbats is scarce.

Here I present the findings of three years of microbat research in the intensive cotton cropping region of northern NSW. Bat detectors placed inside cotton crops have revealed that both common and threatened species of microbat occur and forage over cotton. The proximity of native vegetation (planted or remnant) adjacent to cotton fields appears to be a limiting factor to the pest control services provided by microbats. DNA profiling of bat droppings has confirmed that microbats are eating significant insect pests on Australian cotton farms. Lepidoptera species comprise 61 per cent of their diet with several significant agricultural pest moths *Endotracha puncticostalis* and *Achyra affinalis* recorded in abundance. My research will guide NRM decisions on how best to manage microbats and maintain the ecosystem processes they support within highly modified agricultural landscapes.

## Potential for improved biodiversity and production outcomes with strategic resting of grazing livestock: A review

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Livestock grazing is often considered to be synonymous with landscape degradation and biodiversity loss, and is commonly a divisive issue between ecologists and those with agricultural interests. However, in some circumstances, grazing by domesticated livestock can simultaneously achieve biodiversity and production outcomes. While reducing grazing intensity may be one way of reducing adverse impacts of livestock, removal of livestock at key stages of plant development (i.e. strategic grazing) may also have the

potential to benefit biodiversity within a livestock production context.

We performed a systematic literature review to identify the positive and negative outcomes of strategic livestock grazing practices upon both biodiversity and production metrics, and determine to what extent there is integration between the two objectives.

We identified a large body of agricultural research focused on animal production outcomes under strategic grazing with little to no consideration of biodiversity objectives, apart from general rangeland sustainability. Similarly, studies predominantly published in ecological journals largely focused on the potential for specific biodiversity outcomes with strategic livestock grazing, but with little attention to production outcomes. Few studies simultaneously investigate the benefits or impacts of strategic grazing on both environmental and production objectives. Our review highlights a disjuncture between ecological and agricultural research, and while there are tangible reasons why this situation exists, we argue that there is an urgent need to integrate the two fields in order to address critical knowledge gaps that are limiting the potential for improved biodiversity outcomes within livestock production systems.

### **Tracking winners and losers in large-scale eucalypt plantations of northern NSW**

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Large-scale timber plantations can dramatically transform landscapes, however little is known about the response of most fauna. We report on trends in birds and mammals during a 17 year longitudinal study on three large-scale plantations of locally indigenous eucalypts in northern NSW. The study began in a farmland mosaic in 1997 and has continued to track occupancy after plantation establishment within the paddock areas. Surveys were undertaken at focal trees located in paddock trees and remnant vegetation that became embedded within the plantations as well as in the plantation matrix itself. Reference sites were also located in adjacent forest. We recorded nine species of arboreal mammals and eight species of nocturnal birds, while camera and box traps recorded 18 ground-dwelling taxa (11 listed as threatened). The majority of species were present, but uncommon, in farmland at the start of our study. Analyses revealed most species were stable over time and, among mammals, a large temporal increase was most notable for common brushtail possum. A potential decline was only observed for eastern chestnut mouse. Winners tended to be generalist species, while losers were more likely to be specialists. Winners and losers were also apparent among birds, though overall there were positive trends in species diversity. Our results confirm the importance of retaining remnant vegetation within plantations. We recommend enhancements should be directed to areas excluded from future harvesting, such as environmental plantings in degraded riparian zones and limiting livestock grazing. The ecosystem implications of increasing generalists such as possums remain unclear.

### **Creating effective institutional arrangements for governance of public/private conservation mosaics**

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Biodiversity in Australia has declined ever since European settlement, and is continuing to decline. Reasons include: grazing, invasive species, fire regimes, changed hydrology and the legacy of vegetation clearing, with climate change exacerbating all of these factors. Despite significant public investment and environmental laws, the evidence suggests that public action has been insufficient to change this trajectory. Threatened species continue to decline, with Australia's most endangered species being those most poorly protected in reserves. 13% of threatened species occur entirely outside protected areas and 21% of those critically endangered have the lowest level of protection. There are economic and institutional barriers to substantial increases in public investment, or more laws or stronger enforcement. Integrated knowledge systems and innovative, inter-disciplinary methodologies are required to overcome the current institutional impediments and to deliver effective connectivity conservation outcomes. This paper will introduce the inter-disciplinary methodologies underpinning the creation of effective institutional arrangements for governance of public/private conservation mosaics, and the intended application of this research in two large-scale wildlife corridors on the west and east coasts of Australia from 2017 onwards.

## **Beneficial effects of restored native vegetation: soil, vegetation and biodiversity. A 25 year chronosequence from Gunnedah, NSW**

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The re-establishment of native vegetation has been used extensively in the Australian landscape with the aim of restoring habitat and providing a range of environmental benefits. To date however, little systematic monitoring has been undertaken in restored native vegetation systems and our understanding of the outcomes and tangible benefits derived from this revegetation remains incomplete. Over the past 25 years, a series of eight "habitat reconstruction" sites (30 ha in total) have been established near Gunnedah, NSW, each comprising a range of native trees and shrubs. These plots were established using a consistent selection of native species in a replicated planting design through the years providing a unique, 25 year chronosequence of sites, each with baseline values against which to measure subsequent environmental change. Here we report on 25 years of data relating to plant survival, soil condition, vegetation and biodiversity. Results demonstrate the multiple benefits that can be derived from such plantings and their cumulative effect through time. The work provides invaluable evidence of long-term, beneficial effects of revegetation in Australia.

## **Problems and prospects: the use of soil information by farmers for soil health management, and lessons learnt for valuing environmental plantings and soil health**

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Soil health is an essential requirement of a well-functioning agroecosystem. Our premise is that with good quality, local soil information, including identification of soil types and their soil health status (here using available soil testing as a proxy) farmers can determine the best course of action to either improve or maintain soil health as well as identify soil health threats such as soil acidity, soil carbon decline, nutrient imbalances and salinity. We examined farmers' participation in gathering soil information at the farm and paddock scale over the last two decades in Australia, by reviewing national-level reporting of soil testing by farmers. However, the level of farmer participation in soil testing has remained stable in the last two decades, with only 25% of landholders participating each year. Data from national-level reporting has a number of limitations in understanding farmers' soil testing practice, and in particular, it was unable to indicate the nature of soil testing, in terms of frequency and intensity, and more importantly why farmers undertook the practice, and what they did with the soil information. The rhetoric is heavy on the use of soil testing as a decision tool, and that it guides best practice, but given that only a quarter of farmers are soil testing, infrequently and in low densities, then the level of information on soil health is poor. The main use of soil testing that is commonly stated is for determining fertiliser requirements, yet data seem to indicate routine practice is just as likely as soil testing when deciding on fertiliser application levels. In contrast to the information poor state regarding soil health, there is strong farmer interest in procuring soil health benefits, through changes in farm practice such as conservation tillage, even if farmers are unable to demonstrate these soil health benefits through soil testing. What are the lessons learnt for valuing environmental plantings and their impact on soil health?

## **Managing a complex problem: Blakely's red gum dieback in the ACT**

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Dieback is a complex environmental problem observed in many of the world's forests and woodlands. It involves a protracted decline in the health and vigour of canopy trees that may be caused by a complex syndrome of natural and anthropogenic factors. Over the last few years, there has been increasing evidence in the ACT region of severe dieback in Blakely's Red gum (*Eucalyptus blakelyi*), a canopy

dominant of the Critically Endangered Box Gum Grassy Woodland ecological community, and foliar dieback observed recently in seven other species of *Eucalyptus*. Defoliation is a key parameter of tree condition and is associated with reduced productivity and tree mortality. Insect herbivory is also important in the local dieback but its role as a primary or secondary factor needs investigation. In this talk, we give an overview of some initiatives being developed in the region with the aim of assessing, monitoring and managing the impacts of the dieback. One of these initiatives is the use of satellite remote sensing as a cost-effective alternative to traditional ground-based assessment of tree condition. The current extent of dieback in *E. blakelyi* in the ACT was mapped using a combination of SPOT 7 multispectral satellite imagery, LiDAR data and aerial photography, with temporal SPOT 5 imagery used to map the dieback changes over time. Multi-criteria analysis can then be used to look for statistically significant correlations between trends over time in vegetation condition with parameters such as climatic variables, topography (e.g. drainage lines and soaks), soil types, land management (e.g. tenure, level of clearing), etc. Understanding the spatial extent and environmental factors correlating with development of the dieback is a step towards improving our understanding of the etiology (i.e. causation) of the dieback and approaches to managing the impacts.

### **Recalcitrant soil C:N ratios, alternate states persist in woodland restoration**

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Globally, ratios of soil carbon and nitrogen (C, N) are constrained within a narrow range, yet at a regional scale tend to vary significantly across vegetation boundaries. These variations highlight differences in below ground function and ecosystem attributes. High C:N ratios are generally characteristic of infertile, native forest soils with a fungi dominated microbial biomass, low quality plant litter, and highly conserved nutrient cycles. In contrast, low C:N ratios are allied with fertile agricultural soils that are bacteria dominated, have high quality litter, and less conserved or “extravagant” nutrient cycles.

Here we present a study on the C:N ratios of ex-pasture woodland restoration soils that tests their recovery along this continuum. We contrast the ratios of total soil C and N against two reference ecotypes (established pastures and native eucalypt woodlands) well replicated at sites throughout the Midlands of Tasmania. Total soil C and N demonstrated high within group correlations. Woodland and pasture soils had significantly different C:N ratios consistent to soil ecotype expectations. The ex-pasture restoration sites, aged from 3 to 22 years, retained the characteristically low C:N ratios of pasture soils and failed to demonstrate a transformational effect with age of planting.

The recalcitrant nature of C:N ratios within these restoration plantings indicates the failure of natural processes to facilitate below ground ecological transformations within the time frames considered. These findings highlight the need to better understand the recovery trajectory of the soil system.

### **The utility of the native fig, *Ficus rubiginosa*, in restoration projects**

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Biodiversity conservation and, increasingly, climate-change resilience are two aims taken into account when selecting species for restoration projects. A third, largely-ignored, aim is for species used in restoration to maintain targeted ecosystem processes and/or attract other species that will do so.

This study focused on the utility of the native fig, *Ficus rubiginosa*, for restoration of rocky outcrops or boulder areas, which provide the microhabitats usually necessary for establishing this species. *Ficus rubiginosa* is the most common and widespread fig in eastern Australia. It is the only large species of fig growing on the western side of the Great Dividing Range and is the most productive, fleshy-fruited tree in the dry rainforest and woodland habitats it occurs in. We tested the influences of habitat-patch size, fig-population size and the number of ripe fruit per tree on bird visitation over a three-year period. More than 80 bird species use fig trees in the New England Northwest region. Two-thirds of these species were insectivores. Conditional-inference-tree analysis showed insectivore visits were positively influenced by the number of ripe fruit on a tree but not by population or fragment size, meaning as few as one fig tree can attract insectivore visitation.

Our results show that *Ficus rubiginosa* is an important resource for many birds and that it is particularly important for attracting insectivorous birds to small habitat patches. *Ficus rubiginosa* facilitates pest-control services by birds in production landscapes and we recommend it as a species for restoration projects, particularly of agriculturally unproductive rocky areas.

### **Designing and delivering urban reforestation for diversified outcomes – the human side of tree planting**

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In late 2013, Logan City Council, with a number of project partners, received Australian Government funding for a project to restore a number of locations in the Slacks Creek corridor, a waterway that links to Moreton Bay in South East Queensland.

Revegetation projects such as these are often focussed on achieving ecological benefits, and budgeted for accordingly.

Social and cultural benefits should also be considered in the design of reforestation projects, particularly urbanised areas such as the Slacks Creek Corridor.

Slacks Creek traverses a range of environments, from highly industrialised and degraded through to more natural habitat, encompassing areas occupied by some of the 217 ethnicities that are represented in the City of Logan.

Since work commenced in early 2014, the Slacks Creek Restoration Project has sought to engage with the community and provide outcomes that will benefit the local community in years to come.

Site design has focussed on creating unique experiences. For example, at Griffith University a contemporary arboretum was designed to provide benefits such as recreation, teaching opportunities, ecotourism, and a seed-bank for threatened plants.

To mark the halfway point of the project, interviews were conducted with a number of people impacted in some way by the Slacks Creek Restoration Project. Their stories show the variety of ways in which revegetation projects can affect individuals. It is hoped by sharing their stories that revegetation practitioners think beyond ecological outcomes and consider the wider implications of planting trees.

### **Is planting arrangement important?**

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Plant arrangements play a major role in natural systems and influence ecological processes such as pollination and competition. However, during revegetation little consideration is given to the position of individual plants within a site in relation to the position other plants of the same species and the mixture of surrounding plants. This raises questions about how arrangements differ between natural and revegetated areas and if this influences how revegetated sites function.

To answer these questions, we described plant arrangements in natural and revegetated areas, with a focus on *Eucalyptus leucoxylon* dominated woodlands. In natural areas, aggregation of individuals of the same species was common and complete admixture of different species was rare, while in revegetated sites the opposite was seen. Next, seed production of *E. leucoxylon* was assessed as a function of abundance (trees per hectare), nearest neighbour distance and degree of aggregation of the trees. Abundance was too coarse to pick up any trends in seed production, but finer scale measures such as nearest neighbour distance and aggregation were better predictors of seed production per capsule. On average, aggregated individuals or those with a near neighbour produced more seeds per capsule than those that were more dispersed. Consequently, mimicking aspects of natural plant arrangements such as aggregation, may improve seed production and increase the chance of revegetated areas becoming self-sustaining.

## Overcoming restoration barriers in a degraded coastal environment

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Restoration techniques that naturally accelerate regeneration by removing ecological barriers, such as limited seed dispersal, could reduce the need for expensive and labour-intensive methods. One potential method to overcome limited seed dispersal is the strategic placement of artificial perches in degraded areas. These perches encourage seed-dispersing birds to fly out from remnant areas to rest and defaecate seed in degraded areas, thereby increasing seed dispersal. This technique has been tested in tropical and temperate systems but is yet to be explored in coastal systems. I aimed to determine the success of artificial perches in a degraded coastal environment by investigating: (1) their ability to attract fruit-consuming birds from nearby remnant vegetation, (2) their potential to increase seed rain in comparison to the open landscape and (3) the seasons in which they are most effective. In this study eight bird species that consume fruit as part of their diet visited the perches. The most common species were the Australian Magpie, Spiny-cheeked Honeyeater and the Australian Raven, which are all greater than 22 cm in size. Smaller seed-dispersers may be less inclined to rest in open areas and risk predation. Artificial perches effectively increased the seed rain of several native fleshy-fruited species into degraded paddocks and were most productive during the summer and autumn months, when the majority of native species are fruiting. The efficiency of perches was decreased in several months through the abundant collection of invasive seed. Potential modifications to the restoration technique may overcome this limitation.

## Biocontrol of weeds: applied ecology and restoration

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For over a century, Australia has successfully implemented the applied discipline of biocontrol as an approach to alleviate issues caused by problematic plant species (weeds). This fledgling technology offered an indication of its potential early in the 20<sup>th</sup> century with the outstanding success achieved against *Opuntia stricta*. Since then, Australia has continued to develop and implement biocontrol (using both insects and pathogens) against a plethora of weed targets, both agricultural and environmental. The benefits of this applied ecological approach lie not only in the efficacy in controlling the weed targets, but because of the environmentally-friendly and self-sustaining attributes of many programs, these benefits very often translate into a natural successive process of ecological restoration. As a result, biocontrol often forms a vital component of integrated weed management strategies. This is recognised at a state and federal level, with several significant recent funding commitments being made towards existing and new weed biocontrol programs. Significant investment has also been made by NSW DPI to develop the first insect biocontrol quarantine facility in the State, allowing novel research to be undertaken on priority weed species. This talk will look at a couple of the historically successful biocontrol of weeds programs in Australia, focussing on the role these programs have had in restoring ecological balance to the ecosystems that were once invaded. The talk will conclude with a look at current and future priorities for, and the role that biocontrol of weeds will play in, a changing world.

## Grazing for conservation in semi-arid Australia

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Grazing management that promotes both ecological and production outcomes has the potential to improve conservation on a large scale and complement the current reserve system. There is evidence to suggest strategic grazing regimes where stock are frequently rotated and paddocks rested may achieve this. However, previous research has revealed conflicting results and little research has been undertaken in semi-arid Australia. This presentation will address key findings from my PhD project, which aimed to explore the potential to integrate livestock production and conservation in NSW semi-arid rangelands and the associated trade-offs. Floristic surveys and Landscape Function Analysis (LFA) were undertaken across

paired sites comparing ungrazed areas currently managed for conservation, areas that are continuously grazed for the majority of the year, and alternatively grazed areas where paddocks are regularly rested. Areas managed for conservation and under alternative grazing management had higher understorey floristic richness and diversity than traditionally grazed areas. In addition, landscape function was greater in areas managed for conservation than continuously grazed areas, but there was little difference in landscape function or diversity between the alternatively grazed and conservation areas. These results suggest there is potential for alternative grazing practices to achieve similar conservation outcomes to areas with livestock removed in NSW semi-arid rangelands. Further research is necessary to understand the effects of different grazing strategies under different climatic conditions and vegetation communities to improve integration of conservation and agricultural production in semi-arid Australia.

### **When too much is never enough: macropod grazing and the management of native forbs in grassy vegetation**

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Kangaroo densities are a concern for managers wishing to maintain or restore ground layer vegetation, particularly in regions where the loss of higher order predators has occurred. At the extreme ends of the total grazing pressure gradient, it is clear that losses of diversity and ecosystem function are a problem. However, where total grazing pressure is at intermediate levels, contradictory impressions can be formed within the one landscape, when the following states are simultaneously apparent: 1) Low diversity where dense litter has accumulated under trees, shrubs and tall grass; 2) The protection of grazing-sensitive species by fallen timber, tall grasses and shrubs; 3) High diversity where bare ground results from intensive grazing; and 4) Reduced flowering and loss of grazing-sensitive species where grazing is intensive. Management to increase the diversity of native species in the ground-layer must juggle these counteracting processes through the control of total grazing pressure to maintain variation in sward structure. Location-specific management tailored to the different forb functional types is important to foster existing diversity, and the use of patch burning and selective grazing protection can provide further precision in management. Seasonal conditions can assist or inhibit management efforts either directly as stresses (heat, cold, drought, waterlogging), or indirectly through variation in total grazing pressure (a product of annual net primary production and macropod density). The long-term objective is to achieve forb population sizes and densities sufficiently high to provide resilience in the face of these disturbances and stresses.

### **WINBA = FIRE: developing a fire and seasons calendar for Wattleridge IPA**

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The Banbai rangers of Wattleridge Indigenous Protected Area (IPA) are undergoing a revival of 'cultural burning'- using fire as a management tool to regenerate native vegetation, protect ecological and cultural values and reduce the threat of wildfire on their country.

Through participatory action research, a PhD researcher and the Banbai rangers are working collaboratively to better understand the changes that occur when low intensity cultural burns are reintroduced to the IPA. Together we have developed two-way ecological monitoring of the effect of fire on the threatened black grevillea (*Grevillea scortechinii* subsp. *sarmentosa*) and culturally significant echidna (*Tachyglossus aculeatus*). A Before-After-Control-Impact fire experiment is also underway, with changes to vegetation, habitat and fuel hazards to be compared following a large, moderate intensity fire and a small, low intensity fire.

This research, together with fauna data collected through the Firesticks project, literature review, Indigenous knowledge and direct observations, is helping us to develop WINBA = FIRE, a fire and seasons calendar for Wattleridge IPA, which enables land managers to:

- i. Determine appropriate timings and types of burn that may be applied in relation to vegetation type and fire history
- ii. Identify and interpret biocultural indicators of ecosystem health and fire responses
- iii. Use the information as an educational resource for fire practitioners, community and local schools.

We hope that through the production of WINBA = FIRE, we will demonstrate how scientists and Indigenous communities successfully work together to manage fire. Although WINBA=FIRE has only recently been published, it has been featured by organisations such as CSIRO, Atlas of Living Australia and Bureau of Meteorology.

### **Using behavioural science to improve the management of invasive animals: A case study involving the domestic cat**

Authors: **Lynette McLeod**<sup>1,2</sup>, Donald Hine<sup>1,2</sup>, Andrew Bengsen<sup>3</sup>

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The domestic cat (*Felis catus*) impacts upon native fauna through predation and disease transmission, and is a threat to faunal community integrity and restoration. Management of the domestic cat relies on all community members adopting appropriate management practices towards both owned and unowned (stray, wild-living) animals. Getting people to change their behaviour, and sustain these changes over time can be a challenging process. To achieve effective behavioural change policy makers and practitioners need to improve their understanding of internal and external factors that influence people's decision making and behaviour. Such an understanding will help them design better communication strategies and more effective interventions to achieve their objectives.

This paper will present the results from a case study involving the domestic cat. It will step through the intervention development process, guided by the principles from the behavioural sciences, then present the results from a randomised control trial evaluating the effectiveness of online cat management communication strategies.

### **The role of e-Technology in restoration ecology**

Authors: **Paul D. Meek**, Guy Ballard, Greg Falzon, Karl Vernes, Peter Fleming

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Programs to restore Australian ecosystems cannot ignore the impact and threat to flora and fauna, water and soil by introduced pest animals. Contrary to popular belief, the widespread control of foxes (and feral cats) and more importantly the mitigation of their impacts cannot be achieved by "rewilding" all Australian ecosystems with dingoes. We present scientific evidence collected over the last 5-8 years using new technologies, i.e. camera traps and GPS logs, that makes it possible to accurately support this statement. Monitoring ecosystem health and recovery is integral to any program and new technologies are making this task more robust, although improvements are required. We are combining new technologies like camera traps, song meters and thermal cameras with computer science to develop remote sensing systems that are automated to reduce human resource demands. The applications for computer assisted technologies in ecological monitoring is significant and given the political aspiration but economic drought for including monitoring into land management practices, technology can provide some solutions. We also provide an overview of how we are developing monitoring tools using new and emerging technologies in pest management research that will foster more robust monitoring opportunities for all restoration and regeneration projects.

## **Strategic revegetation: applying eucalypt flowering phenologies to rebuild landscapes for nectarivorous birds**

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Nectar-feeding birds are prominent in the heavily-cleared Mount Lofty Ranges (MLR), with many species moving within the MLR to exploit seasonal flushes of flowering. However, most species are declining, and three species are already extinct. The disproportionate clearance of good-quality eucalypt woodland, creating an inadequacy in nectar availability at certain times of the year, or in particular years, is likely contributing to these declines. Consequently, to arrest such declines, floral resources must be re-established.

Restoring region-wide floral resources to better sustain nectar-feeding birds requires knowledge of the flowering seasons of key nectar-producing plants, such as *Eucalyptus leucoxylon*. Populations of *E. leucoxylon* flower at different times of the year, such that there are plants in flower somewhere within the MLR in every month of the year. In general, individuals within local populations flower at the same time each year, but the timing of flowering onset can differ between neighbouring plants. Assuming that flowering time is heritable, sourcing seeds for revegetation without knowledge of the flowering phenologies of individuals or populations could profoundly influence when plantings produce nectar in new habitats.

Two strategies should be considered for re-establishing floral resources in the MLR: (1) identifying periods of the year when nectar resources are limiting for birds and planting species or individuals to fill that gap; and (2) reconstructing new habitats that provide a year-round supply of nectar to reduce the need for nectarivorous birds to move. For heavily-fragmented systems such as the MLR, the latter approach is likely to be better.

## **Planning for effective wildlife habitat restoration – a wildlife corridor system designed for application at the local government level in North Eastern NSW**

Author: **David Milledge**

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A key habitats and corridors system designed to recover and conserve the most vulnerable terrestrial vertebrate species in the Lismore City Council LGA is described. The system grouped conservation-priority species with core habitat in the LGA into assemblages on the basis of their zoogeographical origin, habitat preference, conservation status and dispersal capability. These assemblages were then prioritised on perceived level of risk from key threatening processes, particularly climate change and other perturbations that result in habitat isolation, fragmentation and degradation.

The LGA's mapped vegetation types were scored as key habitats for the assemblages and ranked on the basis of their significance to these assemblages. Blocks of habitat of greatest significance to the highest priority assemblages were identified from vegetation mapping and selection of corridors focused on linking these blocks or refuges following the least fragmented corridors across the LGA. Final corridor selection was influenced by records of conservation-priority species, particularly those species comprising the highest priority assemblages. Extra linkages were provided by applying buffers to major and minor watercourses.

The system generally followed the occurrence of wet forests within the LGA, providing connectivity between refuges of greatest benefit to the assemblages considered at greatest risk. It also provided a focus for the most cost-effective actions to establish linkages across the LGA through regeneration of gaps and restoration of vegetation condition to benefit the highest priority assemblages. Ranking of the corridors on the basis of their significance in linking habitat blocks, other important areas and to habitat in adjoining LGAs enabled their prioritisation for restoration works.

## **Patterns of vertebrate responses to applying contemporary indigenous burning practices in indigenous protected areas in North Eastern NSW**

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The Firesticks fauna monitoring project is assessing the responses of three terrestrial vertebrate groups to the application of cool burns in a mosaic pattern in four Indigenous Protected Areas (IPAs) in northern eastern NSW. Such burning is attempting to mimic past indigenous use of fire, considered beneficial to biodiversity conservation.

The three vertebrate groups selected for monitoring comprise low and ground foraging birds, small terrestrial mammals and low foraging micro-bats. These groups were selected as likely to be most responsive to the burning practices being applied and were relatively easy to survey using methods providing quantitative data.

A standard survey methodology has been applied in four 2ha plots in each IPA over the past four years, sampling a range of vegetation communities characteristic of the IPA. In the first two years, surveying focused on establishing a pre-burn baseline against which to monitor post-burning responses.

To date, nine of the total 16 plots have been burnt, two by unplanned hot fires and the remainder by controlled cooler burns.

Responses of the target groups and their component species post-burning has varied, although most plots are in the very early stages of regeneration. The IPAs also sample a wide range of environments, from the coast across the Dividing Range to the western slopes, resulting in substantial differences in the composition of target vertebrate groups between the IPAs.

However, some broad patterns post-burning are apparent, particularly in the plots burnt by unplanned fires as these represent the longest burnt. Patterns include changes in bird and small mammal assemblages due to structural changes and increases in numbers of some bird species due possibly to food accessibility and also to an increase in food availability. These and other patterns are briefly discussed.

### **Site based evaluation of revegetation using terrestrial laser scanning**

Authors: **Jasmine Muir**<sup>1,2,3,4</sup>, Stuart Phinn<sup>2,3</sup>, Peter Scarth<sup>2,3,4</sup>, Teresa Eyre<sup>4</sup>

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Monitoring and evaluation of site restoration efforts, to determine if the desired characteristics have been restored, is a crucial part of restoration ecology. It involves the assessment of a suite of attributes of the “restored” site – in relation to an undisturbed, or ‘reference’ site of the same vegetation type.

Terrestrial laser scanning (TLS) is a ground based form of lidar (light detection and ranging) that generates highly accurate three dimensional point clouds of positional coordinates of leaves, branches and trunks at a stand scale (typically 1ha). It can be used to characterize a site by direct measurement of structural attributes, such as stem density, tree height, diameter at breast height and basal area. It also introduces the potential for quantifying attributes that are not readily measured in the field, such as the foliage area volume density, biomass, plant area index and canopy density. Estimates of vegetation structure over large areas can be obtained by linking multiple TLS plots to multispectral or synthetic aperture radar satellite imagery, airborne laser scanning or aerial imagery. Using the attributes measured by TLS, this presentation demonstrates an example application for deriving a condition index to assess and monitor restoration efforts, and compare against sites in the reference condition. The method has been tested in an open eucalypt woodland of south eastern Queensland, but it is applicable to any vegetation community, where a paired ‘reference’ site is available. Further testing is planned for vegetation communities in semi-arid and coastal areas of Queensland.

## **Restoration: a personal journey**

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I describe my efforts over 14 years to restore and manage grassy woodlands and open forests on the 1000 ha New England grazing property, 'Barn Gully'. I argue that to effectively tackle climate change, we need to restore tree cover in a way that enhances landscape function and minimises climatic impacts. In this context, the re-establishment of trees on 'Barn Gully' offers an example of what can be achieved.

With my background as an ecologist, I was initially attracted to the property because, despite what appeared to be a history of overgrazing and limited productive capacity, it retained remarkable floristic diversity, abundant wildlife and areas of high quality native vegetation. My initial aims were to protect the high quality vegetation, restore native ground and tree cover, and expand areas where the groundcover was dominated by original native tussock grasses. I was not seeking to run the property as a fully commercial entity. At first, I focussed on controlling potentially invasive weeds and building fences to better control grazing. Livestock were excluded altogether when I accepted a stewardship agreement with the Federal Government.

My management priorities have changed over the years. For example, feral pig populations and my efforts to control them have increased. Natural regeneration of trees has exceeded my expectations, with tens of thousands of tree seedlings being established in repeated recruitment events during prolonged wet spells.

## **Improved methods to measure and predict mine rehabilitation success and sustainability**

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Reinstatement of a "self-sustaining native ecosystem" is an increasingly common revegetation goal for open cut mines in Australia. This is usually applied as a regulatory requirement for mine closure. The environmental authority holder must ensure and demonstrate that rehabilitation outcomes are met and sustained. Further, the regulator must also be satisfied that the likelihood of failure is low to avoid transfer of future site remediation liabilities from the mining company to the State. As a consequence, there is a growing appreciation that current assessment methodologies for ecological restoration outcomes of mine rehabilitation are subjective and inadequate to provide the high degree of confidence needed to certify progressive rehabilitation or accept the surrender of lease at mine closure.

The BioCondition Assessment method was applied to revegetation at Meandu mine, an open-cut coal mine in southeast Queensland. Sixty-five permanent sites established in revegetation ranging from one year to 26 years old, were assessed for 12 attributes. The scores for these attributes were compared to benchmark scores based on local remnant vegetation, which represents the mine closure goal of a self-sustaining eucalypt woodland. The BioCondition scores distinguished sites that were lacking in eucalypts, and likely to require management intervention.

The growth trajectory of the revegetation was modelled using the Ecosystem Dynamics Simulator (a calibrated tree-growth model) to project the likelihood of the revegetation meeting the benchmark within the life of the mine. No site was likely to meet the outcome within 60 years, however some were developing as eucalypt woodlands.

## **From plantings to the paddock: are ground-dwelling beetles moving through fragmented agricultural landscapes?**

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Biodiversity conservation often focuses on protecting native vegetation patches, while the surrounding

farmland is regarded as having limited biodiversity value. However, there are few opportunities for restoring native patches in highly modified landscapes. Changes in farm management practices may thus be a more practical way of maintaining biodiversity and important ecosystem functions such as pollination and biological pest control. We compared the spatial and temporal distribution patterns of ground-dwelling beetle assemblages in a mixed-cropping landscape. Conducted in mixed-cropping farms in the NSW Lachlan Catchment, ground-dwelling beetles were pitfall trapped along 400 m transects that extended from remnant woodland patches into four contrasting farm management types (crop, fallow, biodiversity plantings, novel application of woody debris over harvested paddock) during an entire growing season. Results on the habitat preferences of beetles and the effects of seasonal change will be presented, based on a large data set of 495 species and 11,360 individuals. Unexpectedly, we found that majority of native ground-dwelling beetles use a variety of land-uses outside remnant vegetation as habitat and can respond favourably to ground-cover management in farmlands, particularly in drier areas during summer. Our findings indicate that suitable farm management practices may provide benefits for beetle diversity that match, and at certain times exceed, the conservation benefits of costlier restoration efforts such as revegetation. Relevant ecological mechanisms such as seasonal movement, edge effects and plant-insect associations will also be discussed.

### **Predicting vegetation restoration outcomes for biodiversity offsetting**

Authors: **Ian Oliver**<sup>1</sup>, Josh Dorrrough<sup>1</sup>, Megan McNellie<sup>1</sup>, Jian Yen<sup>2</sup>, Michael Somerville<sup>1</sup>, Shawn Capararo<sup>1</sup>, Chris Watson<sup>1</sup>, John Seidel<sup>1</sup>, Peter Vesk<sup>2</sup>

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The NSW Biodiversity Conservation Bill was passed by the NSW Parliament in November 2016. Part 6 of the new Act will establish the biodiversity offsets scheme. A key element of the scheme is the establishment of a biodiversity assessment method (BAM) which includes a 'scientific method' (object L of the Bill) for (i) assessing the impacts on biodiversity values from proposed development at development sites, and (ii) predicting the gains in biodiversity values from restoration actions at offset/stewardship sites.

This presentation will introduce the newly designed method for assessing one of the BAM's biodiversity values - Vegetation Integrity. We will discuss the components of the new approach and the rationale for changes from previous condition assessment approaches. We will explain the derivation of new data-driven condition benchmarks which draw upon an archive of more than 40,000 vegetation plots. And most importantly we will show how ecological theory and formal expert elicitation is being used to predict the likely gains in condition attributes and therefore biodiversity values at offset/stewardship sites.

### **Australian Cotton RiverCare Champion**

Authors: Stacey Vogel<sup>1</sup>, **Mark Palfreyman**<sup>2</sup>

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In March 2016 CottonInfo, launched the National Cotton Rivercare project. Lead by CottonInfo's Natural Resource Technical Specialist, Stacey Vogel, the project aims to increase cotton growers and the broader communities awareness of the value of riverine environments within cotton landscapes. To help achieve this Cotton grower and zoologist Mark Palfreyman from Toobeah in southern QLD was appointed to the position of National Cotton RiverCare champion. In this role Mark is working with CottonInfo to document the condition and diversity of biodiversity on his farm 'Taraba', how their management decisions impact on the condition of their riverine areas and the benefits healthy riverine areas are providing their farming business. Mark and Stacey have been monitoring the condition of native vegetation and water quality on the farm and recently worked with an ecologist to undertake a fauna survey which documented 136 species over the four days of the survey. Under the program, cotton growers and the wider cotton community can follow the progress of Mark and his family via twitter, facebook and the CottonInfo website and youtube channel. The project to date has just over a 1000 social media followers and has proven to be a successful engagement tool.

## **Translocation of *Ruppia tuberosa* in the Coorong, South Australia: promising but unsustainable**

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*Ruppia tuberosa* is a key aquatic plant in the southern Coorong, trapping fine sediments, dampening wave action, providing habitat for small fish and providing food resources (foliage, seeds and turions) for a wide variety of birds. It was once abundant and widespread around the margins of the southern Coorong. However, during the Millennium drought, from 2002 to 2010, *R. tuberosa* progressively disappeared from the South Lagoon of the Coorong. Even when the River Murray flows returned in late 2010, *R. tuberosa* still did not recover. Consequently, a translocation program was established to facilitate recovery.

Surface sediment containing the seeds of *R. tuberosa* was harvested from the margins of Lake Cantara in autumn 2013 and autumn 2014. Seeds were distributed at an estimated density of 700 seeds/m<sup>2</sup> across two sites and 20 ha in 2013 and across an additional three sites and 41 ha in 2014. While the two sites that received sediment in autumn 2013 had, by the second and third years, both reached the target of a vigorous population of at least 30% of cores with shoots, other targets were not met or, if met, were not sustained. However, failure to meet these targets was likely due to the ongoing issue of falling water levels in spring disrupting seed and turion production for *R. tuberosa* and not the translocation program *per se*. Consequently, further translocations will not be sustainable and should cease until the issue of falling water levels in spring are addressed for the southern Coorong.

## **Bird responses to large-scale revegetation at Cygnet Park, Kangaroo Island, using systematic area searches**

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From 2007 to 2012, 165 hectares were planted with some 200 species on Cygnet Park, Kangaroo Island, focussing on re-establishing: (a) populations of rare and threatened plant species, (b) populations of Drooping Sheoak, which are a key seed source for the endangered Glossy Black Cockatoo, and (c) the largely non-existent shrubby understorey of the critically endangered ecological community of *Eucalyptus cneorifolia* woodland.

Additional bird species (e.g., Crescent Honeyeaters, New Holland Honeyeaters, Brown Thornbills, Superb Fairy-wrens, Grey Fantails and Golden Whistlers) have also benefited, while some grassland birds (e.g., Australian Magpies and Australasian Pipits) have been disadvantaged. These changes are illustrated through a number of criteria, including (a) abundances, (b) area of occupation (AOO) and (c) density per hectare of revegetation, derived from data collected in a baseline census (systematic area searches) conducted in 2009, and a further 11 censuses since (up to September 2016). Over this time, there has been an increase from 0.4 to 6.4 birds per hectare in the areas revegetated. In 2016, some 2,500 birds were using the 300 ha property, close to triple the birds in 2009.

The advantages and disadvantages of this comprehensive monitoring program are discussed, particularly in the context of long-term sustainability of revegetation, and is pertinent for planning and design of future revegetation programs.

## **Maximising on-farm rewards by removing weeds and replacing with native plants**

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Native vegetation in agricultural landscapes has been shown to provide ecosystem services such as habitat for beneficial arthropods, habitat for wildlife, erosion control, and carbon storage. Choosing which species to use for revegetation to meet management objectives can be a daunting task. The information is spread over multiple sources and is often difficult to access. Here, we've created a one-stop-shop of native plant selection that allows users to navigate options with ease.

The database combines key attributes of 5000 native vegetation species for three Queensland catchments,

the Fitzroy, Condamine and Goondiwindi. The application allows users to define their management objectives. For example, interest in capturing the services of beneficial arthropods for pest control, and drought tolerant plants, and the application then provides a list of locally relevant and available native plants for ground cover, understory, mid-story and over-story species.

This one-stop-shop makes on-the-ground decision making and tailoring native vegetation to specific criteria a breeze. Our next steps will be to package this rich data base into a menu driven app suitable for smart phones.

### **Setting measurable goals in restoration: a case study using pollination**

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One of the key steps in effective restoration is the setting of appropriate goals and developing ways to measure their success. Yet, many restoration projects often leap into on-ground action with goals poorly linked with measures of success. As a case study, we reviewed the literature to investigate the number of studies that specifically performed restoration projects with the goal of improving pollination success. This could take the form of restoring pollinator community richness and/or abundance (a measure ecosystem structure), pollination services of benefit to people (a measure of ecosystem services) and/or the reproduction of pollinator dependent plants (a measure of ecosystem functioning). Most studies that set out with a goal to increase pollination services measured success by conducting surveys of pollinator structure to gauge richness and/or abundances post-restoration. Few studies that claimed to have the goal of restoring pollination services actually measured whether pollination services or ecosystem functioning improved as a result of the restoration action. Designing restoration projects that explicitly link goals with appropriate measures of success will improve our understanding of the mechanisms driving restoration success.

### **Habitat restoration and avian responses around Cowra, NSW, and lessons learnt**

Authors: **Julian Reid**, John Rankin, Madeleine Rankin, Neale Coutanche, Maret Vesk, Nick Nicholls, Vanessa Cain, Dan Florance, Sue Proust

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The Cowra Woodland Birds Program, CWBP, run by volunteers for 16 years, is a BirdLife Australia project with the ambitious goal of reversing the decline of woodland birds in the Cowra District. We have established 130 survey sites on private and public land in the Cowra Local Government Area, conducting quarterly bird counts for 15 years, with 92 active sites. CWBP has also instigated or partnered in many habitat restoration activities, monitoring bird responses to some of these interventions. The primary aim here is to document avian responses to habitat restoration, and various successes, failures and perverse outcomes, while also addressing some hard-won lessons where revegetation success and restoration outcomes have been poor.

With 90% of the native tree cover cleared from the more fertile and productive lower slopes and valley floors in the Cowra LGA, there is an imperative to revegetate for biodiversity. An example is given of a small cemetery bushland reserve that has lost much of its bird habitat value over 15 years despite conservation-management intervention. Elsewhere some replanting efforts have failed, some have been successful in terms of plant survival and growth but have had poor bird outcomes (Noisy Miner dominance), while others have attracted the species of woodland birds that most concern the CWBP (restoration success).

Impediments to revegetation and habitat restoration include climatic factors, inflexible funding arrangements, planted species composition, inadequate site preparation or follow-up care (watering, weeding), browsing by native and exotic herbivores, and Noisy Miner colonisation.

## **Wool growers and on-farm biodiversity: reflections on *Land, Water and Wool*, ten years on**

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We investigated the relationships between wool profits and biodiversity on the Northern Tablelands of NSW between 2002 and 2007. The project found that not only are profitable wool production and biodiversity conservation compatible, they are interdependent in all wool production systems to varying degrees. The project identified 42 ways in which local woolgrowers manage for profitable, biodiverse wool production, but not all practices suit each grower or management system. The project also answered ten questions about the relationship between biodiversity and production posed by the growers at the outset. Management that consistently achieves high production per head, high groundcover, a high biomass of diverse, productive and palatable pastures and crops, clean water supplies, and with 10–30% of the property vegetated with healthy timber and shrubs, is likely to achieve relatively high levels of biodiversity and be profitable. Southern New England woolgrowers conserve a lot of biodiversity on their properties at their own expense and are managing their farms in various ways that are good for the environment. Most of their beneficial management is based on environmental and financial win-wins. However, the financial realities of running a farm business impose limits on what is possible. Smart policies make biodiversity enhancement on private land a valuable and profitable activity, not a cost burden.

### **Networking for fire and restoration**

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Nature Conservation Council NSW's (NCC) Bushfire Program has recently launched a Fire and Restoration Network hub. The site is a place for practitioners and researchers to share experiences, information, challenges and new ideas about how fire can be used to manage and rehabilitate degraded landscapes and restore ecological integrity.

Practitioners working in this field are from diverse agencies and organisations and thus face challenges with communication amongst themselves and finding who to contact when seeking advice, experience and/or expertise in this field. This project aims to create a 'community of practice' for people with a shared passion and interest in using fire for ecological restoration. The hub is fostering an inclusive network where practitioners can inform, support and advise each other and help build on-ground capacity.

Management of the network is handled by NCC Bushfire Program staff, with the support of a range of topic moderators, mentors and volunteers. We are aiming to reach a point where the network is driven by our members and the content they contribute.

Interest in the network has come from local Council staff, Bushcare and Landcare groups, natural resource management agencies, fire agencies, academics, community members and volunteers. Each in their own way is invested in the management of public and/or privately owned land, and have experience or an interest in the use of fire for restoration. Through the interactions of these people from diverse groups we are encouraging best practice, sharing knowledge, and supporting innovative practice.

### **Restore and renew: providing evolutionary, environmental and ecological information on a large scale to support restoration practices**

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The flagship project Restore & Renew, is a world-first initiative that will create a comprehensive and easy to use website readily accessible by the community and supporting effective and sustainable land restoration. Utilising novel whole-genome sequencing and environmental modelling techniques, the project will uncover an unparalleled level of information to understand how genetic diversity is partitioned across the landscape, and if genetic provenances are associated with climatic and environmental variables. The project will collect, analyse and share genetic, adaptive, environmental, and ecological data for over



200 plant species commonly used in restoration projects across Australia's Eastern seaboard and representing the regional floristic, ecological and phylogenetic diversity. No other project on this scale and scope exists worldwide and I will present the concept and preliminary outcomes of this large-scale study. Restore & Renew will deliver a readily accessible resource of comprehensive restoration and management guidelines on an unprecedented scale. This enduring community resource will improve the success and long-term viability of land restoration projects, as well as improve predictive capacity to respond to climate change. Beside supporting restoration practices, the project will also provide significant information from species to landscape levels, discover regions of high genetic diversity, identify commonalities among taxonomic and functional groups that will improve our ability to generalise beyond the 200 species, and enable us to explore how species and assemblages are likely to respond through time. Understanding and predicting how plants will grow and interact in changing ecosystems is vital to conserving, or restoring, resilient natural habitats.

### **Efficient scarification methods for dormancy breaking of ten *Acacia* species**

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The genus *Acacia* is a key component of many Australian landscapes and has an important role in ecosystem regeneration due to their ability to enrich the soil thorough nitrogen fixing. This study was conducted to evaluate the effects of physical scarification, mechanical scarification and boiling water treatments on seed germination of native Australian *Acacia* spp. that present physical seed dormancy produced by a water-impermeable seed coat. Seeds were collected from natural populations of NSW Australia and tested for their reaction to dormancy breaking treatments in germination cabinets at different temperature conditions. All the treatments increased germination percentage significantly, but the responses for germination after treatment was highly depend on each species. We also tested combination of environmental conditions and scarification treatments. The results obtained are intended to be used in the selection of the scarification treatment that is the most time, economically and labor convenient for broad scale revegetation using direct seeding. Our main target for revegetation is the area of the Moree Plains, Narrabri and Gwydir Shires, situated in the North-West NSW, but due to the broad distribution of the species, it could be extended to other environments.

### **Some approaches to integrate topographic, soil, hydrological and microclimate variability for resilient landscape repair and revegetation**

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Resilience in production landscapes can be enhanced by integrating the ecosystem services provided by native and planted vegetation. Integrating multiple ecosystem services on the ground requires knowledge of the feedback effects of land cover/use on natural processes by first observing landscape patterns and determining the landscape functions that underlie them. By understanding this it is possible to *integrate multiple landscape functions* that improve the productivity and resilience of farming/grazing landscapes. But what does this mean and how can it be applied in the field? This presentation will outline some approaches for resilient landscape repair and revegetation that specifically integrates topographic, soil, ecohydrological (e.g. stormwater runoff) and microclimate variability across a landscape. Examples from applied farmer experiments, our own research findings and peer-reviewed literature are used to highlight the important components of some of the different methods available.

### **Lantana control in ecological restoration**

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Lantana is a weed of national significance which infests large areas blocking natural regeneration. Cost effective control of lantana over extensive areas with excellent regeneration and biodiversity outcomes has

been achieved on the north coast of NSW. This talk will include a short, quite dramatic (1-2 minute) video presentation of before and after lantana control via the splatter technique. An introductory explanation will be provided by the speaker.

### **Lessons learned for large scale biodiversity tree planting projects**

Authors: Daniel Cole<sup>1</sup>, Gregory L. Siepen<sup>2</sup>

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Large scale tree plantings to restore lands affected by degradation and to provide more trees for government, local people and community needs, as well as for biodiversity conservation are increasingly being attempted. However, as well intentioned as these projects start out being, many can be negatively affected when all the effects and processes are not fully thought through.

The authors will present the major lessons learned from large-scale tree planting for biodiversity outcomes completed in Queensland, Australia, including planning issues; securing access to suitable lands; community and stakeholder engagement; planting methodologies and procurement. They will touch on issues related to implementation of the project; delve into maintenance issues, governance and project management; discuss risk management and contingency planning.

Examples will be presented showing how perceived issues were overcome, leading to successful outcomes for the environment and community.

### **Improving Aboriginal engagement through Cultural Science**

Author: Geoff Simpson

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Many environmental challenges are complex and require long and sustained programs involving community participation over an extended period. Studies have shown that the key to long-term community engagement is people's hearts and minds. This talk considers how the key to people's hearts and minds in the Australian context lies in Aboriginal culture, and specifically the cultural framework Aboriginal people lived that connects them with Country through their kinship relationships.

It is well known that Aboriginal people have lived in harmony sustaining this landscape for at least 40,000 years. This sustained approach included clear kinship roles and responsibilities under the LORE that connects people to their place in the world. This current research is exploring how those old ways can address environmental degradation and sustain Aboriginal people's engagement in landscape management in today's society.

We believe that communities can sustain their involvement in on ground management if engagement is purposeful, meaningful and connected with cultural obligations and responsibilities. We are testing this approach in collaboration with Aboriginal people and other partners in the Willandra Lakes Region World Heritage Area through a habitat conservation program for the endangered Malleefowl (*Leipoa ocellata*).

### **Bringing fire back to the Bunyas: putting people back in the landscape**

Authors: Mick Smith, Dave Calland

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Historically, the Bunya Mountains in South East Queensland were the site for large cultural gathering of Aboriginal groups coinciding with bumper crops of nutritious Bunya nuts. Aboriginal people used strategic fire management practices in the Bunya Mountains to facilitate access to and from the Bunya gatherings, and to create ideal habitat mosaics for hunting and gathering.

Since the removal of Aboriginal people from the region from the 1870's, the absence of traditional fire management has led to a significant decline in the extent and health of the eucalyptus woodland and the unique bunya grasslands.

A series of meetings in 2007/8 between the Indigenous community, government and non-government land management agencies and stakeholders acknowledged the need for a change in fire management practices in order to preserve the unique cultural and environmental values of the Bunya mountains region. These meetings led to the formation of the Bunya Mountains Murri Ranger team who have developed a range of practical land management skills and strong cultural competency. The team's training has resulted in an experienced and accredited Murri Ranger team using fire as a primary management tool.

Over several years an integrated approach to burning has evolved, acknowledging science, utilising modern fire control equipment, incorporating Indigenous knowledge and compliant with the bureaucratic framework. Through a partnership with the Queensland University of Technology (QUT), a monitoring and evaluation process is being developed to gauge the effectiveness of traditional burning practice in retaining the cultural and environmental values of the Bunya mountains region.

### **Resilience to exotic invasion via resource use in grassland restoration**

Authors: **Monique E. Smith**<sup>1</sup>, José M. Facelli<sup>1</sup>, Leanne Rosser<sup>2</sup>

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Creating plant communities that are resilient to invasion of exotic plants is one of the greatest challenges for ecological restoration. One suggestion is to plant native species that either cover a diversity of functional traits or have traits similar to likely invaders, thus leaving less resources available for exotics to invade. In a field trial we tested the hypothesis that if revegetated communities contain a diversity of functional traits and are planted at high density they will be more resilient to exotic invasion.

We used three functional trait diversity treatments: C3 and C4 grasses on their own and together, and two levels of planting density high (44 plants/m<sup>2</sup>) or low (20 plants/m<sup>2</sup>). To evaluate the effect of these planting strategies and subsequent exotic invasions on the revegetated native plants there was a weeded treatment included in the trial. To gauge differences in resource use soil moisture was monitored for 12 months and soil nutrient availability measured at the end.

As predicted, the biomass of exotic species was overall lower in the high density plots. The effect of functional diversity was less clear which is likely a result of the C3 plants having an extra growing season than the C4 plants and it being a very wet year making them competitive against the exotics. The native grasses were also smaller in the high density plots therefore the trade-off between resilience to invasion and appropriate levels of competition between natives needs to be considered by land managers.

### **Cotton growers benefit from biodiversity and ecosystem services**

Authors: **Rhiannon Smith**, Nick Reid

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Biodiversity provides a range of ecosystem services to cotton growers and the wider community. Examples include carbon (C) sequestration, erosion mitigation and natural pest control. These ecosystem services can be worth billions of dollars in: (1) product promotion (e.g. for low carbon emissions and environmental footprints); (2) tradable assets (e.g. carbon and biodiversity offsets), and (3) avoided costs (e.g. pesticide use). This research investigates the biodiversity present on cotton farms and the benefits to cotton growers who manage and restore native habitats on-farm for biodiversity conservation.

Our research indicates that riparian ecosystems are especially important for biodiversity conservation and ecosystem service provision. Riparian vegetation is home to natural pest control agents that aren't found elsewhere on the floodplain, and provide a valuable natural pest control service. River red gum-dominated woodlands and forests also store and sequester large amounts of C. In the lower Namoi region of northern NSW, C storage in river red gum-dominated ecosystems averaged  $216 \pm 20 \text{ t C ha}^{-1}$ . C sequestration in river red gum-dominated woodlands averaged  $2.54 \pm 1.06 \text{ t C ha}^{-1} \text{ yr}^{-1}$  during the La Niña conditions experienced during 2008–2012 in woody biomass. Organic C stored in the soil of river red gum ecosystems translates into more stable soils, with lower rates of aggregate slaking and dispersion compared to soils with low organic C content. Our research shows that growers who manage and maintain native vegetation, particularly riparian vegetation, for biodiversity conservation and ecosystem service provision have the potential to attract economic benefits while minimising their environmental footprint.

## **Approaching local eradication of Coral Tree *Erythrina x sykesii* at Wilsons Creek and Huonbrook, north east NSW**

Authors: **Barbara Stewart**, Marg East

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Wilsons Creek Huonbrook Landcare (WCHL) is nearing the end of a three year NSW Environmental Trust-funded project that aims to eradicate Coral Tree *Erythrina x sykesii* from two tributaries in the headwaters of the Richmond River, north east NSW.

The draft Australian Weed Strategy identifies eradication as a cost-effective management goal, generally referring to permanent removal of early incursions of weed species. Established and widespread weed species are more usually candidates for containment and asset protection approaches. In 2005, WCHL received funding to develop a weed management strategy, based on surveys of accessible public land on roadside and creeks. We identified a suite of species for which local eradication was feasible (no seed set and typically dispersed by floodwaters and machinery).

Coral Tree was prioritised. A widespread horticultural hybrid that does not set seed, Coral Tree spreads vegetatively from trunk and stem fragments. Inexpert management rarely kills the wood and typically produces sprouting debris. In waterways, fallen trunks grow into dense thickets, diverting watercourses and competing with high conservation value native vegetation. Our general approach has been to start at the top of the catchment and work downstream. We have raised awareness of Coral Tree and other weed management issues, provided landholders with advice about how to manage the trees (and how not to), invited information about private land occurrences and engaged stakeholders. Minor tributaries and other private land sites in the subcatchments are now being treated. Progress has been beyond expectations and the challenge will be to maintain momentum.

### **Don't beat around the bush**

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The Northern Agricultural Catchments Council's (NACC) Rivers and Wetlands Project has supported private landholders to restore vegetation along rivers, creeks and wetlands.

NACC is one of Australia's 56 regional NRM organisations working to accomplish nation-wide management, restoration and protection of Australia's natural environment by addressing national environmental priorities at the regional level.

NACC's vision is to build a healthy, diverse, vibrant and productive land, water and sea-scape - in which local communities and individuals care about environmental stewardship and take real action to protect and manage the amazing natural assets of the Northern Agricultural Region (NAR) of Western Australia.

Waterways in the NAR provide important habitat and food sources for native flora and fauna. And even though rivers and wetlands occupy a small proportion of the NAR, they commonly support a higher diversity of plants and animals than the surrounding landscape. However, permanent and seasonal water also often supports invasive weeds, attracts pests and can be used as stock watering points causing erosion and water contamination.

Through the life of this project more than 55 local land managers protected over 4,000 hectares of remnant native riparian vegetation. On-ground works have included revegetation, fencing to protect remnant vegetation and exclude stock from sensitive areas, weed control and installation of alternative watering points and stock crossings. Land managers involved reported increased sightings of native fauna, natural regeneration of local flora and enhanced farm productivity as a result of the project.

### **How is insect mediated ecosystem functioning affected by clearance and reforestation?**

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Deforestation for agriculture has significantly reduced global rainforest extent with consequences for biodiversity and ecosystem functioning. Insects comprise a large proportion of rainforest diversity but many forest dependant species and the functional roles they play can become lost after clearing. Often pastures on pre-existing rainforest lands are subsequently abandoned, for various reasons, providing potential for natural rainforest regeneration. However, rainforest recovery and ecosystem processes can be slow following extended periods of use. Therefore an assisted natural regeneration approach can be used to accelerate the recovery of rainforest, but it is unknown whether it may also accelerate the return of insect diversity and their functionality. Insects play significant roles in the reproduction, establishment and maintenance of plant species in rainforests.

Most rainforest plants rely on pollinators in which insects are largely responsible. Insect herbivores can impact both plant growth and species densities and insect detritivores play an important role in the nutrient cycle. I will review information about the roles of insects in these functions in rainforest regeneration and restoration, and outline a study to quantify the recovery of insect diversity and functionality in the Gold Coast Hinterland following long term pasture land use in regenerating rainforest undergoing two different recovery pathways: unassisted and assisted natural regeneration. Differences in recovery pathways will be tested using a space-for-time approach together with manipulative experiments to assess insect mediated leaf litter decomposition, seedling herbivory and pollination.

### **Silviculture Lab 504 – the war on ‘dieback’ and ongoing experiments**

Author: **Michael Taylor**

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In the 1970’s, as tensions of the Cold War were building, a war was starting against the spread of ‘dieback’ in Australia. Multiple causes were tipping the balance in ecosystems of New England. The expansionist policies of Australian agriculture were threatening our homeland. Under these conditions Jon and Vicki Taylor took it upon themselves to start experimenting at “The Hill” or known these days as Silviculture Lab 504.

Despite centuries of scientific knowledge, propaganda persisted and the only way to discover the real story on tree establishment was to conduct experiments on home soil. Subjective reasoning such as “it just didn’t feel right” and the propaganda that ‘dieback’ didn’t exist was of course controversial in light of work being done in Silviculture Lab 504.

From the mid 1980’s, 2500 acres was being carved up into tree plots big and small of different shapes and designs. Social acceptance for their experiments on ‘pine’ trees was gained by claiming they were for animal shelter and would produce timber for the war effort. Unbeknownst they had killed thousands of trees either by suffocation, poisoning, torture, dehydration or death by beetles. The only thing keeping the experiments going was the large number of trees remaining.

Through the 1990’s collaborations with scientists and researchers and events such as Treefest, helped gloss over the failures. Inspired, they expanded their tree collecting and began to win over sceptics with their use of exotics.

Jump forward to 2010 and the next generation has moved into Silviculture Lab 504. Michael Taylor is also believed to have killed thousands of trees. History repeats itself with his claims of tree species to provide shelter to more native birds, insects and even koalas, and trees producing valuable timbers and maybe even Black Truffles. Time will tell whether his suspicions and anecdotal evidence will be written into science as the war on ‘dieback’ continues at Silviculture Lab 504.

### **Implementing a landholder duty of care approach to stewardship - it might be like nailing jelly to a fence post**

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This presentation/paper will explore what are the legal and practical issues of an environmental duty of care approach (including consideration of the challenges and some options to make such an approach both effective and beneficial) from the perspective of agencies charged with implementation.

## **A first approximation national report of changes in revegetation extent**

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Revegetation is a major public-private strategy to protect natural resources, repair stressed ecosystems and habitats and is essential for maintaining sustainable production and delivery of ecosystem services. Revegetation and rehabilitation activities are funded via public or private investment, or a combination of both, at national, state and regional levels. A capacity to routinely track changes and trends in revegetation type, extent and condition at a national level has lagged behind considerable investments over several decades in on-ground strategic revegetation activities and changes in land management practices. The extent of revegetation may be derived from multiple sources including: regional surveys, remote sensing, catchment-based data and site-based inventory. States and territories use a range of methods to record and report site and landscape scale revegetation extent. Despite the development and endorsement of national standards for the tracking changes in the type, extent and condition of revegetation, these standards have not been systematically or comprehensively adopted at regional, state and national levels. The national standard was used to report on the extent of national revegetation using the best available regional and national scale data and information; the Australian Bureau of Statistics (ABS) Agricultural Census and the National Carbon Accounting System (NCAS). This approach provides a first approximation of changes in the extent of revegetation or rehabilitated land in Australia. Systematic and comprehensive monitoring and reporting of revegetation extent at site and landscape scales are critical for consistently evaluating successes of revegetation outcomes. Improved accuracy of reports would be achieved by using the national standard.

### **Urban ecosystem function - don't forget the fox**

Authors: **Alison Towerton**, Peter Ridgeway

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Remote cameras are used for a wide variety of applications including monitoring both native and pest species but also to raise the awareness of landholders and land managers in what fauna is using their backyard, paddock or reserve. Cameras have been placed across a number of landscapes in the Greater Sydney region over the past four years. While the quality of camera deployment and duration has varied, more than 40 native and exotic species have been recorded. Landholders have displayed both surprise and concern for the species found on their properties, with some encouraged to take on restoration activities.

One of the most common species recorded across the landscape has been the European red fox. The fox is known to predate upon domestic, livestock and native species, spreading disease and also increasing the spread of weeds. Restoration activities often neglect the impact of invasive fauna species due to a lack of knowledge of their presence at a site or a perceived inability to deal with the species.

Fox densities in urban Sydney and its surrounds are high but dealing with such a successful and elusive pest is difficult as the most effective methods of control are restricted in their availability for use. Highly coordinated approaches and more options for urban and peri-urban (private and public) control of foxes need to be considered for the successful long-term restoration of wildlife and ecosystem function in these areas.

### **Grazing reinforces the competitive exclusion of small-bodied birds by aggressive miners**

Authors: **James D. Val<sup>1</sup>**, David J. Eldridge<sup>2</sup>

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Grazing by domestic stock is sometimes promoted as a management tool to achieve biodiversity outcomes. Here we examine the impacts and benefits of grazing on bird richness and abundance in three vegetation communities in central west New South Wales. Birds were surveyed using the standard two hectare twenty minute search at 108 sites and each site sampled four times over a 2 year period. We used Structural Equation Modelling to analyse the effects of grazing and the influence of habitat complexity and

Manorina Miners (Noisy and Yellow-throated Miners) on the richness and abundance of birds. Our models showed that Miner abundance had a direct negative effect on the richness and abundance of all small birds, particularly small insectivores, small nectarivores, small ground foraging birds and declining woodland birds. Small insectivores were twice as abundant in the absence of miners. Miners also had a significant positive effect on richness and abundance of large birds, including large ground foraging birds. Increasing levels of historic grazing reduced habitat complexity facilitating the competitive exclusion of small birds by aggressive Miners. The results of the study highlight the importance of structural complexity not only as habitat for woodland birds but most importantly as barriers to the invasion and competitive dominance of Miners. These findings suggest that any management recommendations to reduce tree and shrub density to promote grassy woodlands and remove 'invasive species or woody weeds' may have significant negative consequences for the conservation of birds.

### **Drivers of riparian condition to prioritise restoration, regeneration and revegetation in the NSW North Coast Bioregion**

Authors: **Ben E. Vincent**<sup>1</sup>, Sarah J. Mika<sup>1</sup>, Darren S. Ryder<sup>1</sup>, Adrienne Burns<sup>1</sup>, John Schmidt<sup>2</sup>

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The Ecosystem Health Monitoring Program (Ecohealth) is a comprehensive catchment-scale monitoring framework for aquatic ecosystem health in the North Coast Bioregion of NSW. By identifying and quantifying mechanisms of change to determine a condition score, the program can help prioritise and direct management actions. Ecosystem health is assessed using a combination of biophysical and chemical indicators. Riparian vegetation is a critical component of the Ecohealth program as it plays a geomorphic and biological role supporting diverse habitats that contain high levels of biodiversity. The Ecohealth riparian vegetation condition is determined by a site-based rapid riparian assessment and spatial data for catchment scale condition. Indicators include the cover, composition, structure, habitat and connectivity of vegetation, with a focus on mechanisms regulating vegetation condition such as fencing, clearing, animal impacts and regeneration.

Regional-scale riparian condition was assessed as poor in upland tablelands, good in midland hills on the escarpment, poor on floodplains and moderate in estuaries. At both catchment and sub-catchment scales, riparian condition was consistently better in higher elevations and poorer lower in the catchment. Temporal differences in riparian condition were directly related to site-based management actions, with actively managed sites maintaining or improving condition, and degraded sites declining in condition if unmanaged. We identified key drivers of riparian condition in the Bioregion as weed control (restoration), riparian fencing (regeneration) and riparian plantings (revegetation). Regional scale assessments of riparian condition using site-based data are rare, and are important for understanding spatial patterns and drivers of condition to inform management priorities.

### **Community volunteers facilitate ecosystem recovery of Armidale creekland plantings**

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Ecological restoration is not simply a matter of planting, mulching, some aftercare and walking away. A successful result can be dependent upon not only more thorough weed management during the establishment phase of the new ecosystem, but also more detailed adjustment to refine the species placement in response to individual species successes and failures. The engagement of community volunteers can also make a huge difference in long term restoration processes.

A major community project on Dumaresq Creek aimed to establish native plants in order to increase the health, biodiversity and beauty of Armidale's riparian environment.

In response to patchy revegetation success at one site and community concern regarding ongoing herbicide use for weed control on the site, community volunteers, with the support of Landcare, designed and undertook a program of manual weed removal followed by suppressing weeds with newspaper and mulch and replanting with seedlings and seed.

Results show that recovery of ecological function and structure is occurring, marked by success of

replacement plantings in problem areas, on-site regeneration of both planted and naturally occurring species, increased native plant diversity, effective introduction of groundcover species, effective weed control without herbicide use, increased soil health and organic matter, stabilisation of soil and trapping of sediment by groundcover species during flooding, activity of invertebrates and use of the site by small lizards and birds. Improved health of the plantings has increased the pleasure of many people who walk past the area on a daily basis. The opportunity to be a part of ongoing enhancement of the site has utilised skills and enthusiasm of community volunteers and fostered community ownership of the plantings.

### **Ryegrass and fescue allelopathy may inhibit plant growth and seed germination**

Authors: **Melanie Whitelaw-Weckert**<sup>1</sup>, Jennifer Bannister<sup>1</sup>, Robert Lamont<sup>1</sup>, Jim Pratley<sup>2</sup>, Mark Norton<sup>3</sup>, Chris Penfold<sup>4</sup>

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We are investigating the effects of different under-vine cover cropping systems on soil microbial biodiversity, grapevine health and wine quality. Our project aims to develop novel under-vine management systems that would ultimately reduce the need for any herbicide, cultivation, mowing or imported mulch by growing self-perpetuating desirable plant species. We expect the successful species will either be self-regenerating annuals or summer-dormant perennials, commencing growth in autumn to smother weeds, providing root matter to improve soil structure, and then either dying off in spring (the annuals) to leave a mulch or becoming dormant before extracting valuable moisture (native grass). In 2014, trials were initiated in five commercial vineyards: one in NSW (Griffith) and four in South Australia (Nuriootpa, Langhorne Creek, Waikerie and Clare Valley). Two Australian native grass species studied were the wallaby grasses (*Rytidosperma geniculata* cv Oxley, and *Rytidosperma caespitosa* cv. Evans).

Our field results show that different cover crop species had distinctive effects on grapevine growth and health, including colonisation of the root by beneficial arbuscular mycorrhizal fungal (AMF). Some species decreased AMF colonisation (e.g. *Festuca longiafolia* cv. Predator (hard fescue) and *Lolium rigidum* cv. Safeguard (rigid ryegrass), whereas AMF colonisation was enhanced by the wallaby grasses and the *Medicago* and *Trifolium* spp.. Interestingly, 'Next Generation Sequencing' of the vineyard soil showed that the wallaby grasses were strongly associated with Glomeromycota, the fungal division containing the AMF. Why have the fescue and ryegrass decreased AMF colonisation? Our laboratory studies indicate that the leaves of the ryegrass and fescue species used in our field trials were colonised by endophytic *Epichloë* fungi. These endophytes are known to cause the grasses to produce allelochemicals harmful to neighbouring plants, reducing AMF colonisation. This discovery led us to initiate assays to investigate the effects of leachates from the fescue and ryegrass on grapevine growth and germination of grass and clover seed. Our results thus far indicate that the root exudate from Safeguard ryegrass is deleterious to grapevine growth and may be deleterious to grass seed germination and growth. Further studies will examine whether this effect is caused by direct action of the allelochemical alone, or by changes in soil microbial community function and structure.

### **Grazing animals as tools for grassland management**

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Each grazing animal has a slasher out the front, four cultivators underneath and a fertiliser spreader out the back. This model comes from Tim Wright of 'Lana' Uralla, who has used these tools over the last 25 years or so to convert the grassy woodlands on his property from being *Aristida ramosa* dominant to complex and productive pastures dominated by the more desirable and often grazing-sensitive native grasses. Tim's success belies the conclusions of David Eldridge's recent paper which asserts that grazing by domesticated livestock always degrades rangelands. Greg Lodge and I were able to show that, by matching heavy grazing and rest with their different phenologies, it is possible to change the dominance of the undesirable *Aristida ramosa* to a pasture rich in *Rytidosperma bipartitum*. Unfortunately this procedure left the grassland with very low ground cover during the first few years of the treatment.

Further studies funded by the then Meat Research Council (MRC) found that rests from grazing at critical times of the year were effective in prolonging the life of native perennial grasses. There is now good evidence that grazing animals are effective tools for manipulating the species composition of grasslands towards perennial native grass dominance. However, to be effective, the stock density must be high with a long rest timed to the phenology of the preferred species. The duration of the graze period can be very short (say <1 day) in which case the stock density must be very high (say >5,000 dse/ha).

### **Australian native grass breeding systems in relation to the choice of source material for revegetation**

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By far the majority of studies concerning the choice of source material for revegetation by either direct seed harvesting or for seed increase have come from North America. A feature of their native grasses is that by far the majority are cross-pollinated and mechanisms for the prevention of self-pollination are common. Recent publications now question whether local seed sources are always best. Artificial selection for specific functional traits important in revegetation are mooted in the recent literature. The aim is to produce restoration-ready seed supplies of native perennial grasses while still conserving genetic diversity. Species that are either self-pollinating (such as *Sporobolus airoides* or *Elymus multisetus*) or apomictic (such as *Poa secunda*) are not considered as good candidates for any recurrent selection and so some authors specifically exclude them for this reason. Studies of the breeding systems of Australian native grasses to date show that self-pollination is very common and that no specific mechanisms (except for a few dioecious species) preventing self-pollination have been recorded. Even *Spinifex sericeus* (a dioecious species) reproduces vegetatively by rhizomes and stolons and seedling survival is very rare. The reproductive systems of many groups are complex resulting in a range of ploidy levels (such as in the *Rytidosperma caespitosum* complex), some with partly apomictic and partly selfed or cross-pollinated and with different ploidy levels, often with difference reproductive mechanisms for the different levels. Simple principles such as 'local is best' are clearly inadequate for producing restoration-ready seed supplies of Australian native grasses.

### **Moving Mountains – twice: Rebuilding montane and sub-alpine ecosystems in Kosciuszko National Park, Australia**

Author: **Gabriel Wilks**

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Kosciuszko National Park contains the continent's highest mountains and is recognised as an International Biosphere Reserve (UNESCO 2010). The Snowy Mountains Hydro-Electric Scheme (constructed 1949 - 1974) remains one of the world's most complex hydro-electric schemes. In environmental terms, the construction of the 'Snowy Scheme' had significant negative impacts on the biota and landscapes within Kosciuszko National Park as well as downstream water catchments

Rehabilitation to stabilise massive spoil dumps on riverbanks and re-establish native vegetation on land barren for fifty years has yielded outstanding results in terms of habitat creation for flora and fauna. Designing and constructing habitat for fauna species such as the Southern Corroboree Frog (*Pseudophryne corroboree*), a Critically Endangered IUCN species, has been an extension to standards and techniques set by the Rehabilitation Program.

Rehabilitation of large spoil dumps was identified as a high priority for the Program. Snowy Adit Spoil Dump has been a key rehabilitation project and will be presented as a case study. This site was largely devoid of native vegetation for forty years, and used as a rock sourcing quarry. The mountain of rock removed from underground tunnels has been moved around on site to create stable benches and slopes to allow extensive planting to reflect surrounding vegetation. Pre and post surveys clearly demonstrate that within a six year period, natural ecosystem processes have commenced being reinstated at Snowy Adit.

## Enabling “Restoration, Regeneration and Revegetation” – the role of Landcare

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Restore Regenerate Revegetate – it’s worthwhile to reflect on the meaning and nature of these words – they are all active words – acknowledging that we, as people in the landscape, exert an influence over the state of our ecosystems. What is often overlooked by many in the NRM sphere is the importance of ‘the people in the landscape’ and that if we are going to influence environmental outcomes, THE key is to influence the people that manage those environments.

No amount of science, no amount of legislation, no amount of subsidy will produce lasting change unless it is owned and adaptively managed by those closest to their environment. This occurs best when we ensure that the land managers are part of the process of leaning, designing and implementing. This was and still is the basis of the Landcare model, established over 25 years ago. Internationally recognised as a successful game changer that enabled land managers and communities to be active, Landcare supported land managers and communities to be informed and involved in the management of their landscapes.

However, we have seen a steady decline over the past 15 years in the understanding of this model and the support that is needed to build the ownership and encourage the co-investment of land managers and their communities, to repair restore and revegetate the natural resource base upon which we all (human and non-human) depend for our air water and food. We have seen the focus shift from building enabled communities that can respond to and tackle the challenges as their own, to one of providing community engagement for involvement in the programs of others. Drawing upon my 30 years of experience as a Landholder and Landcarer, this session explores the factors required to underpin the development of an ethic that restores rehabilitates and revegetates our landscape now and long into the future.

### **The importance of soils to restoration: some knowns and unknowns**

Authors: **Brian Wilson**<sup>1</sup>, John Lemon<sup>2</sup>

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We are often told that soils are a fundamental component of terrestrial ecosystems and that soils are therefore a crucial component of any restoration project. However, we are rarely told why, or the extent to which, soils can influence the success of a restoration project and the environmental outcomes that might be achieved. Using a range of empirical and experimental studies in Eastern Australia we discuss the importance of soils to the planning, implementation and outcome of restoration projects. From effective assessment of sites and soils for appropriate restoration actions, to implementation and measurable outcomes of restoration projects, we will highlight some of the knowns and unknowns relating to soils in the restoration context.

### **Practical Application of Language in Western Landscapes of NSW**

Authors: **Jason Wilson**<sup>1,2</sup>, Rhonda Ashby<sup>1,3</sup>, Brenda Macbride<sup>1</sup>

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Our presentation looks at how we deliver culturally sensitive learning about the broader landscape to schools, universities and the general public. We will talk about how many elements are incorporated in how we define change in field based trips to look at country and different times and visit places of significant spiritual and cultural importance and explain how this affects our current lives.

A number of slides will provide the field based trips and camps that have underpinned actions and activities that connect our Aboriginal community and our non-Indigenous counterparts to landscapes in Western NSW.

Language is a very important element in community engagement, we take great pride in teaching, immersing and encouraging all participants to speak and understand the meaning of vegetation, water,

the night sky and landscape features through Aboriginal eyes.

We will combine our finding with projects conducted with UNE and other learning institutions focusing on future pathways forward, hopefully bridging the gap in accepting our cultural science and influencing western learning techniques with physical and spiritual relationships.

### **Restoring Country: Minyumai Rangers integrate fire and weed management to improve biodiversity outcomes on a north coast Indigenous Protected Area**

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Minyumai IPA is a 2162.6 hectare ex-grazing property linking to Bundjalung near Evans Head on the far north coast of NSW. With over 17 plant communities and over 24 threatened animal species, Minyumai is a special place that we are looking after and restoring in a way that puts us closer in touch with our land and our cultural traditions. We use a combination of traditional ways of burning, alongside modern weed management techniques, to revive the health of our plant communities and achieve regeneration of native groundcovers in areas once dominated by pasture weeds. Although we have a long way and many decades before we can say that our country is healthy again, we are working hard to convert it back to the original native vegetation with funding assistance from Federal Government's Indigenous Protected Areas program, the Nature Conservation Council's Firesticks and the NSW Environmental Trust. Results from our fire and weeding trials in ex-pasture areas to date show regeneration of 23 native species (including 7 tree species), although we are also planting to supplement this regeneration. We've learned many lessons - including the need to religiously follow up weed treatments and deal with feral animals. Three part-time and 6 casual Rangers are strongly engaged in the project and are developing strong competencies in ecological fire management, weeding, native plant recognition and project coordination.

### **Management of Biodiversity Offsets – Whitehaven Coal Case Study**

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Whitehaven Coal are obligated to manage ~20,000ha of land in NSW North West Slopes and Plains region as Biodiversity Offsets for the companies coal mining operations. The objective for the majority of the Biodiversity Offsets is to restore Box Gum Woodland communities through the implementation of Biodiversity Management Plans.

Whitehaven Coal implement a range of land and biodiversity management strategies working towards the ecological restoration of Box Gum Woodlands including access and grazing management, feral animal management, weed control, seed collection and revegetation, bushfire management, habitat augmentation and specific threatened species mitigation actions.

Whitehaven Coal's approach is to standardise our management on Biodiversity Offset Areas (where practicable); and use the scale of management to enable better biodiversity outcomes both in terms of overall landscape restoration as well as at an individual patch level. The other opportunity for Whitehaven Coal is to better utilise resources to drive more cost efficient biodiversity outcomes. This presentation will outline general case studies of actual biodiversity management being implemented by Whitehaven Coal.

### **Metabolic changes and emotional well-being responses after temporary reversion to a traditional hunting and gathering lifestyle in the Gibson Desert: a project outline**

Authors: **Boyd R. Wright**<sup>1,2,3</sup>, Peter Quain<sup>4</sup>, Matt Flavel<sup>5</sup>

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Modern lifestyles in 'consumer' societies are characterised by greatly reduced physical activity, substantial



dietary changes, and marked physical and spiritual detachment from the natural world compared to traditional hunter-gather lifestyles. Previous research among Australian Aboriginal peoples has demonstrated that temporary reversion to a hunter-gatherer lifestyle greatly improves metabolic abnormalities associated with diseases and health conditions such as diabetes and obesity. However, whether temporary immersion in such a lifestyle can also impact psychological aspects of a person's well-being is unknown. This presentation will firstly discuss current research being undertaken among the Pintupi Aboriginal people of the Gibson Desert to document traditional plant and insect foods. Secondly, an outline will be presented of an ambitious future study to be conducted with the Pintupi people on the impacts of temporary reversion to a hunter-gatherer lifestyle on physiological, emotional and spiritual wellness responses. Topics to be covered in the talk include: 1) study design and the various physical and emotional attributes to be monitored among participants during the 8-10 week study period; 2) the environmental conditions and food and water resources of the Gibson Desert; 3) the historical and cultural background of the Pintupi Aboriginal peoples; and 4) the necessity for cultural burning prior to the study to ensure availability of adequate food resources. Beyond scientific outcomes, this project has strong potential to deeply entrench in project participant's traditional skills and knowledge relating to patch burning strategies, food procurement and processing, and management of traditional water resources.

### **Regeneration and resilience in agriculture, 'Lana', Uralla, NSW**

Author: **Tim Wright**

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Lana is a fine wool and cattle property to the south west of Armidale/Uralla. It is owned and managed by Tim Wright whose family have been on Lana since the early 1950's. Lana has been a wildlife reserve since the mid-1960's. The property was run fairly conventionally from the 1950's to the late 1980's, with pasture improvement and top-dressing with superphosphate and introduced pasture species. Grazing was relatively unplanned, with short rests compared to graze periods. This management ultimately led to the country going backwards. Pastures needed to be regularly re-sown and finances barely broke even –and not in drought times. From 1990 Tim changed his management approach, first with cell grazing and later with Planned Grazing and Holistic Management. This management has been in place now for upwards of 20 years. The management involves stock typically grazing for just two-three days in large mobs, with pastures then rested for over 95% of the time. The emphasis is on using livestock (sheep and cattle) as slashers, burners, mowers and fertiliser spreaders. Once large paddocks have been broken up strategically to better distribute livestock and nutrients. There is now considerable native plant diversity in the pastures and biodiversity improvements across the whole property. Fertiliser is rarely applied, stock are calm and wool quality and conception rates are extremely high. There is major natural tree regeneration on the property with once eroded riparian areas healed and water clear. The balance sheets are also great.

### **The domestic cat: pet and pest in the Australian landscape**

Authors: **Frances Zewe**<sup>1</sup>, Guy Ballard<sup>1,2</sup>, Gerhard Koertner<sup>1</sup>, Peter Fleming<sup>1,3</sup>, Karl Vernes<sup>1</sup>, Nick Reid<sup>1</sup>

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Domestic cats (*Felis catus*) were introduced to Australia in the 1800s and are now naturalised across the continent. Australian scientists have been studying the ecology of these invasive felids since the 1960s, prompting the Australian Federal Government to launch a 'Threatened Species Strategy' and an aspirational target of culling 2 million feral cats by 2020. Most of the research supporting the Government's plan was conducted in arid- and semi-arid zones of Australia, where: 1) mammal declines have been particularly severe; and 2) cat density fluctuates dramatically with stochastic weather cycles. Far less is known about cats and their impacts in the extensive temperate forests of eastern Australia, which may provide a more stable environment for feral cats.

Our research explored the lifestyle and habits of free-roaming cats in temperate forest sites in Eastern Australia. This is a fascinating area to study cats because of the suite of sympatric predators with which they coexist – dingoes (*Canis familiaris*), red foxes (*Vulpes vulpes*) and native, spotted-tailed quolls (*Dasyurus maculatus*). Our results demonstrate a high and relatively stable population of feral cats in high-altitude temperate forests. Their impacts on threatened and other fauna in these environments still require

quantification. Removing cats from the landscape must focus on demonstrating their negative impacts, the feasibility of control tools and implementation of a targeted strategy to ameliorate those impacts. This presentation discusses research into feral cat ecology in the New England Tablelands and demonstrates how this research can inform science-based cat management.

## **Resilience of semi-arid riparian vegetation to grazing and climate change**

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Grazing and climate change represent two major threats to semi-arid wetland vegetation. These vegetation communities typically support a high amount of biodiversity in relation to surrounding uplands and provide critical ecosystem services, especially pasture growth and important water sources for livestock and domestic use. This study aimed to identify components of semi-arid riparian vegetation that may be most sensitive to climate change and examine the effectiveness of current grazing management practices (i.e. fencing) in increasing these systems' resilience to such pressures. This study was conducted in the Queensland portion of the Warrego River catchment in the northern Murray-Darling Basin of south-eastern Australia. Mesocosm experiments were conducted to examine the effects of current grazing management on vegetation resilience as well as the response of emerging plant communities to a range of heating and flooding scenarios. The results suggest that both climate change and grazing have the potential to significantly affect plant recruitment from seed and population dynamics in these habitats. However, semi-arid riparian vegetation has also been observed to maintain resilience even when faced with high grazing pressures, high temperatures, variable hydrological regimes and prolonged droughts. Controlled grazing methods through the construction of fencing, however, may not be the most effective or efficient means of conservation for these communities and other management options, e.g. environmental flow delivery, may better promote their conservation and restoration.

## **Posters**

### **Monitoring landscape recovery in a World Heritage Area**

Authors: **Thomas Barrett**<sup>1</sup>, John Leys<sup>2</sup>, David Bye<sup>3</sup>, Mal Ridges<sup>1</sup>, Sandy Booth<sup>3</sup>, Dan Rosendahl<sup>5</sup>,

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The Willandra Lakes Region World Heritage Area (WLRWHA) is 300,000 hectares with roughly 60% falling on private pastoral properties and the rest within Mungo National Park. Over 30 years ago the Willandra Lakes Region was declared World Heritage in recognition of its outstanding universal value as an example of planet Earth's geological and human history.

The number one threat to these internationally significant values is erosion. In this semi-arid landscape erosion is caused by a combination of low ground cover, often as a result of grazing pressure, wind and water. The NSW Office of Environment and Heritage's, WLRWHA and Science Division Staff have developed GIS models using the Multi-Criteria Analysis Shell for Decision Support (MCAS-S) software to map areas prone to erosion and monitor the efficacy of interventions designed to control erosion and promote natural regeneration.

This poster will present the analysis undertaken to evaluate erosion control and landscape recovery for two types of intervention methods: 1) movement of stock watering points away from areas of high archaeological values, and 2) fencing off areas of high archeological values to reduce stock access.

Landsat fractional ground cover data was analysed for the period 1998 to 2014 at sites where erosion control actions were implemented. Results indicate that moving water points was more effective at controlling erosion and promoting natural regeneration than fencing. The success of the recovery of a site was dependent on soil type and severely degraded, or scalded, sites did not show any signs of recovery.

## If you build it will they come: colonisation and use of revegetation by insect pollinators

Author: **John Butler**

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Revegetation is used to offset vegetation clearance and as a panacea for landscape-scale losses of biodiversity and ecosystem services. Ultimately, newly-established plant communities need to be self-sustaining, requiring individual plants to survive and reproduce. To reproduce, many plants require pollinators (i.e., birds and insects), yet pollinators may fail to colonise revegetation, or lag considerably behind the plants. Consequently, a better understanding of the relationship between pollinators and plants in revegetation is required to determine if new plantings can be self-sustaining.

This particular study focused on insects and their colonisation of recently revegetated sites (1-4 years post-planting), as well as their interactions with plant communities on Cygnet Park, Kangaroo Island. Results showed species richness increased with the age of revegetation, such that by four years, the revegetation had similar pollinator species richness to a comparison remnant site. Furthermore, pollinator networks, based on observations of insects at flowers, showed dramatic increases in network size (total number of observed interactions) with age of revegetation, reflecting increased flower production and increased floral visitors. Honeybees (*Apis mellifera*) were the dominant floral visitors at insect pollinated plants for both revegetation and remnant sites. Reproductive outputs showed that some plant species did better in revegetation, while others did better in remnant sites.

These findings indicate that revegetation sites can develop insect-pollinator networks similar to remnant sites after four years, such that they are likely to become self-sustaining plant communities. However, further research into particular plants species that do not fare as well in revegetation would be prudent to ensure their self-sustainability.

### Evaluation of phenotypic diversity of buffel grass (*Pennisetum ciliare*) in Ethiopia

Authors: Ricardo A. Sánchez<sup>1,2</sup>, Carlos R. Morales<sup>2</sup>, Jean Hanson<sup>3</sup>, Chris Jones<sup>3</sup>, Pedro Jurado<sup>4</sup>, Eduardo Santellano<sup>2</sup>, Alicia Melgoza<sup>2</sup>, **Nadiezhdha R. Cabral**<sup>1,5</sup>

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Native of Africa, buffel grass produces high yields, tolerates droughts and grows vigorously. In Africa, forage production may have negative consequences due to climate change. Forage genetic diversity offers an opportunity to make new selection and develop new varieties to face the challenges of climate change. The objective of this study was to estimate phenotypic diversity of 147 accessions and 10 cultivars of buffel grass held at ILRI, Ethiopia. The study was carried out at Zwai, Ethiopia during 2014. Ecotypes were established in field plots. The variables measured for seed yield were: Days to 50% flowering, spikes per plant, spikelets per spike and caryopsis per spike and for forage production were: plant height and forage height. Principal component and cluster analyses were performed. In general, the buffel grass ecotypes reflected high variability in all characteristics measured. About 73 % of variation was explained by the first two components which related to biomass production and dispersion and propagation, in a principal component analysis. Four cluster ( $P < 0.0001$ ) were identified from the 157 accessions. Group IV, consisting of six accessions having exceptional characteristics related to agronomic performance including: plant height and forage height, number of spikelets per spike and caryopsis per spike. The results obtained indicate that there is a significant opportunity to use the collection to improve this species through a plant breeding program. Exploring the natural variability through a morphological characterization could be used to select the best accessions with some characteristics of interest for rehabilitation of agricultural land, control of soil erosion and forage production.

## **Identifying forest structure to improve landscape connectivity in fragmented landscapes**

Authors: **Nicoló Camarretta**<sup>1</sup>, Tanya Bailey<sup>1,2</sup>, Brad Potts<sup>1</sup>, Mark Hunt<sup>1</sup>, Neil Davidson<sup>1,2</sup>

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Fragmentation, modification and loss of natural habitats are some of the most important threats to biodiversity management and conservation. It is estimated that two billion ha of degraded forest lands are in need of restoration worldwide. Ecological restoration is defined as “the process of assisting the recovery of an ecosystem that has been degraded, damaged or destroyed”. A recent literature review recognised that structural connectivity generally provides good habitat for native species in the landscape, and can be utilised as an indicator of biodiversity complexity.

This project will focus on the measurement and assessment of forest structural attributes in the Tasmanian Midlands, a highly fragmented production landscape. Particularly, it aims to produce an operational protocol to measure and assess these attributes in a timely and cost effective way. It will involve the use of a combination of ground based surveys and remotely sensed data at different scales, from stand/local level to landscape and regional level.

The novel information on forest structure acquired during the execution of this project, as well as the latest knowledge on habitat needs for the different animal guilds occurring in the Tasmanian Midlands, will be utilised to model and map current species dispersal and landscape connectivity.

## **Slopes2Summit Bushlinks – two case studies translating science to action**

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The Slopes to Summit (S2S) Bushlinks project works with farmers in the mixed farming HRZ in southern NSW to do revegetation and remnant enhancement on farms for improved wildlife connectivity.

The poster explains two case studies of how the connectivity model (Doerr et al 2010) has been applied to real on-ground work at the paddock scale, and how the motivations and thought processes of the landholders and the Project officer influenced what happened on the ground, and how the scenarios relate to the bigger connectivity picture in the Slopes2Summit area.

## **Wompoo Gorge restoration**

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Wompoo Gorge is a 78 hectare property located at Huonbrook in the Byron Shire, Northern New South Wales, Australia. The property contains high levels of vegetation diversity including critically endangered lowland subtropical rainforest and a stand of eucalypt forest on an escarpment. It is located between Goonengerry National Park to the east and Nightcap National Park to the west. Coopers Creek runs along the length of the property. Following implementation of ecological restoration works over eight years the property has been acquired by NSW National Parks and Wildlife Service and now links World Heritage listed Nightcap National Park to Goonengerry National Park in an identified climate change and wildlife corridor.

Over eight years the project has very successfully restored lowland subtropical rainforest over 40 hectares contributing to enhanced connectivity and improved habitat for threatened species. Dense areas of lantana had been blocking rainforest regeneration for over 30 years. Systematic control of lantana and other weeds has triggered rapid regeneration of rainforest. Threatened species recorded on the property include 17 fauna species (Pouched Frog, Stephen's Banded Snake, Bush-hen, Albert's Lyrebird, Wompoo Fruit-Dove, Red-crowned Fruit-Dove, Superb Fruit-Dove, Sooty Owl, Marbled Frogmouth, White-eared Monarch, Red-legged Pademelon, Eastern Tube-nosed Bat, Golden-tipped Bat, Grey-headed Flying-fox, Large-footed Myotis, Little Bent-wing Bat, Eastern Long-eared Bat & Eastern Freshwater Cod) and 10 flora species (Southern Ochrosia, Arrow-head Vine, Thorny Pea, Ravine Orchid, Red Bopple Nut, Red Lilly Pilly, Rusty Rose Walnut, White Laceflower, Waxy Sarcophilus, Flax Lily).

## A revegetation strategy using a fragmentation-sensitive generic focal species metapopulation model

Authors: **Else Foster**<sup>1,2</sup>, Jamie Love<sup>1</sup>, Romina Rader<sup>2</sup>, Nick Reid<sup>2</sup>, Michael Drielsma<sup>1,2</sup>

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A challenge devising revegetation strategies in fragmented landscapes is conserving for the widest possible spectrum of biodiversity. The purpose of habitat network reconstruction should be to facilitate the persistence of populations. However, the location of revegetation sites often fails to account for metapopulation persistence and dispersal processes operating across spatial scales.

Our objective was to consider the metapopulation processes of fragmentation-sensitive species to identify existing dispersal pathways and highlight connectivity gaps. Population persistence could be facilitated by re-connecting habitat networks across regional and broader scales, with assumed benefit to the dispersal needs of less sensitive species.

Predicted occupancy and metapopulation capacity was calculated for a generic focal species derived from fragmentation-sensitive woodland birds and mammals. A metapopulation connectivity analysis predicted regional dispersal links to identify likely routes through which individuals may move to contribute to the viability of the metapopulation. We used the revegetation programmes of the Brigalow–Nandewar Biolinks project, eastern NSW, Australia, to demonstrate our approach.

Under the current landscape, the majority of populations were of limited viability. Low value links between populations provided greatest opportunity for revegetation and facilitating persistence. Where regional connectivity did not indicate a pathway between populations, broader-scale connectivity provided guidance for revegetation.

The metapopulation-based modelling, coupled with a habitat dispersal network analysis, provided a platform from which to inform revegetation locations for the persistence of biodiversity. Our approach has application for directing on-ground action to support viable populations, assess the impact of revegetation schemes or monitor the progress of staged implementation.

## Effects of invertebrates and insecticide on plant establishment in seed based revegetation in Tasmania

Authors: **Yolanda Hanusch**<sup>1</sup>, Tanya Bailey<sup>1,2</sup>, Mark Hunt<sup>1</sup>, Neil Davidson<sup>1,2</sup>

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A large proportion of dry sclerophyll forest and grasslands have been cleared and altered in the Tasmanian Midlands, a nationally recognised biodiversity hotspot. Recently, large scale revegetation projects have been undertaken on private land by Greening Australia and the University of Tasmania to buffer and connect remnant vegetation. While planting of individual trees, particularly *Eucalyptus* spp., has been the main focus so far, current research is exploring seed based restoration techniques (direct seeding). Direct seeding has the potential to be a cost and time effective method of introducing a diverse range of species over large areas, however, the success of previous efforts have been highly variable in the Tasmanian Midlands.

In the first of a series of direct seeding trials aimed at improving plant establishment and species diversity, a range of treatments were tested in a 4ha trial established in July 2015. An insecticide (active ingredient Bifenthrin) treatment significantly improved the early establishment of a range of tree and shrub species compared to all other treatments at this site. This current Honours project aims to assess seed predators and predation and to test if insecticide is useful and likely to improve the success of direct seeding at multiple sites in the Tasmanian Midlands. We are testing the impact of the insecticide at four more trial sites established in 2016 using the same direct seeding techniques and plant species. In order to gain greater insight into invertebrate seed predation and predators, pitfall trapping and seed removal experiments are being used.

## **Abbott's Green Army or a genuine, structured industry workforce; what do we really need to address the enormous landscape restoration challenge we face?**

Author: **David Hudson**

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The Green Army has now gone the same way as its predecessors stretching back 20 odd years (Green Corps, Landcare Environment Action Program et al). How is it that this model has had so many reincarnations? Some might say because it's a fantastic use of public funds producing wide-ranging, positive outcomes. The reality is that there isn't a single shred of evidence to support the model as good public policy. Anecdotes yes, evidence no. It's one of those feel-good programs that make great photo opportunities for politicians. I contend that the landscape restoration 'industry' is invisible, or at best opaque, to policy makers, and there is no concerted push-back from the sector, let alone getting on the front foot and telling the politicians what's really needed.

In 2007 I attended a roadshow delivered by the ACTU, ACF and Climate Institute promoting the new 'Green Jobs'. The presenters clearly had a focus on blue collar jobs - tradies doing something with a 'green' tinge e.g. electricians installing solar panels, plumbers installing water saving devices etc. I asked them about 'my' industry - landscape restoration. There were uncomfortable glances before agreeing that we did important work but they hadn't the funds to investigate us, and (here's the kicker) they couldn't work out how to engage with us - they couldn't find a peak body or any sort of national structure to approach. Therein lies the problem.

Of course there are the National Landcare Network and NRM Regions Australia and the Australian Coastal Society; and the Australian Association of Bush Regenerators and the Society for Ecological Restoration Australia. Then there are Indigenous Ranger programs, various Parks agencies, Local Government, Bush Heritage Australia, Australian Wildlife Conservancy and the National Trust, Greening Australia and Conservation Volunteers Australia, and many more; all with their own agendas.

I propose that all the industry players need to get together to identify common ground. For a start they could define the industry - 'Landscape Restoration and Protection' perhaps. Then try to identify the number of people employed/actively engaged in the sector, where they are and what they do. And yes, that includes people earning a living as well as volunteers. Then, somehow, craft an alliance to speak for the whole industry (think ACROSS).

### **An experimental trial to assess the response of biodiversity to ecological thinning of regrowth**

Authors: **Bradley Law**<sup>1</sup>, Leroy Gonsalves<sup>1</sup>, Cathy Waters<sup>2</sup>, Traacey Brassil<sup>1</sup>, Ian Toole<sup>2</sup>, Patrick Tap<sup>3</sup>

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Cypress pine regrowth in western NSW often occurs as dense 'wheatfields' which 'lock-up' and remain unchanged for decades. While thinning to restore habitat values has been suggested for cypress forests, the science is lacking in identifying benefits for biodiversity. In 2015, a chronosequence study was undertaken to assess long-term temporal effects of thinning cypress regrowth on biodiversity in the Pilliga forests of NSW. In that study, we measured biodiversity (bats, birds, ground mammals, reptiles, invertebrates and floristics) and habitat values (coarse woody debris and stem density) at sites 7-40 years post-thinning as well as sites that were long undisturbed and dense unthinned, regrowth. Results indicated that thinning benefited diversity of most taxa, while negative impacts on diversity were not detected. To provide an experimental assessment of the responses of biodiversity and habitat values to thinning, a trial was established in 2016, also in the Pilliga forests. The experimental thinning trial will measure the response of the same fauna groups and habitat values assessed in the chronosequence study. Experimental sites (12 ha) represent thinning undertaken at two different stages of cypress regeneration (early regeneration that is 'locked up' ('early thinning') and mature cypress ('late or commercial thinning')). Pre-thinning biodiversity and habitat surveys were completed (March 2016) at 4 replicates of each treatment and paired control sites for each of the two thinning treatments as well as long undisturbed reference sites. Thinning was undertaken between May and October 2016 with post-thinning surveys to commence in March 2017.

## Estimating macropod grazing density and defining activity patterns using camera trap image analysis

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**Background:** macropods are widespread and mobile native herbivores that can pose a management issue for restoration projects, either as desirable or nuisance species. Thus, monitoring their presence may be essential. Macropods are traditionally monitored via dung counts or visual surveys. Both are intensive and subject to inaccuracy from environmental influences. We required a method for efficient and reliable monitoring of macropods, both presence and abundance, that could be applied in different environments.

**Aims:** to develop an efficient and reliable camera-based method for monitoring macropod abundance and defining their activity patterns.

**Methods:** we focused time-lapse camera traps on defined grazing plots in an enclosed area then reduced the known population of macropods before repeating our measures. Pellet counts were undertaken at each plot in each sampling period to contrast with camera-based counts. From the data, we estimated macropod density and developed time-activity budgets of macropods.

**Key Results:** camera-based estimates correlated well with pellet counts and provided a density estimate that closely approximated the known values. It additionally permitted us to develop temporal activity profiles for each plot and the population as a whole.

**Conclusions:** the camera-based method was efficient and reliable. It is relevant to a range of situations where monitoring of vegetation and herbivores is required, for example in response to restoration efforts. Benefits of this method include reduced field time, and a reference collection of plot-based photographs of the grazing macropods. These latter can be used for additional purposes, such as behavioural studies.

**Implications:** the method is applicable at plot and landscape scale (subject to resourcing), and could be applied to other herbivores, such as goats (*Capra hircus*). Quantifying herbivore presence and activity patterns can be related to grazing or browsing impacts in restoration sites and the same data can be re-analysed to assess other behaviours.

## Direct seeding technologies as a tool for restoration in the Tasmanian Midlands

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Direct seeding involves the sowing of seed directly into a prepared site and has the potential to provide a cost effective and efficient tool for restoration of native vegetation in fragmented agricultural landscapes. However, in Tasmania the success of direct seeding has been highly variable, often resulting in a limited suite of species establishing. Issues such as weed competition, herbivory, poor germination (due to lack of information on specific species requirements), seed predation and climatic and soil factors may play a role in poor outcomes.

This PhD project will focus on understanding the constraints on the success of direct seeding in the dry Tasmanian Midlands in order to refine and improve current practice. The research aims to: (1) assess the long term outcomes of previous direct seeding restoration projects; (2) identify species and treatments which optimise the success of direct seeding; (3) investigate the seed biology of recalcitrant species and improve germination in the laboratory and field, and (4) investigate direct seeding as a strategy for understory and structural complexity enrichment in established tree plantings.

Techniques being trialled in replicated field trials at multiple sites across the Midlands include the use of photodegradable polymers, insecticide, soil wetting agent, irrigation and caging from browsing animals. The results of this project will allow for improvement in the current direct seeding approaches in Tasmania and have the potential to be applied in other dry agricultural districts in south eastern Australia.

## **Restoring old-fields - can diversity and abundance of biota indicate key ecosystem functioning**

Authors: **Tina Schroeder**<sup>1</sup>, Suzanne Prober<sup>2</sup>, Richard Hobbs<sup>3</sup>, Rachel Standish<sup>1</sup>

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Restoration of degraded landscapes has become increasingly important for conservation of species and their habitat owing to rapid environmental change and ongoing habitat destruction. Old-field restoration funded by the emerging carbon market has the potential to contribute to conservation outcomes. Here we present a study that will investigate the relationship between biodiversity and ecosystem functioning in restored old-fields. We are particularly interested to test whether the addition of habitat elements can enhance revegetation activities by increasing diversity of biota and the level of a key ecosystem function they provide.

The study will measure abundance and diversity of litter-dwelling arthropods and soil microbes and the litter decomposition rate in restored and remnant sites across the mid-west of Western Australia. Restored sites have been planted with a mixture of local *Eucalyptus* and *Acacia* species using standard restoration practices (direct seeding, tube stock). Remnant sites will be selected from known malleefowl (*Leipoa ocellata*) habitat across the study region. Malleefowl habitat was chosen as a benchmark, because this species is highly dependent on the decomposition process for reproduction (i.e. incubation of their eggs).

The study will also experimentally test the benefits of adding habitat components such as leaf-litter, coarse woody debris and commercially available products (i.e. mulch, soil enhancements) for restoring litter-dwelling arthropods, soil microbes and litter decomposition. Results will provide valuable insights into the relationship between biotic diversity and litter decomposition, and whether adding habitat components can enhance this function, ultimately improving conservation outcomes at higher trophic levels.

## **Abrolhos islands restoration**

Authors: **Jessica Stingemore**, Maryke Gray, Sarah Graham

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The Abrolhos islands are a chain of 122 islands that lie approximately 70 km off the coast of Geraldton. With over 144 species of native plants, the islands of the Abrolhos offer unique and diverse habitats ranging from limestone flats, coastal heathlands and saltmarsh to large dune systems and mangroves. These habitats provide refuge to a range of animals, many of which are not found anywhere else, and have extremely vulnerable populations. The Abrolhos archipelago also supports millions of breeding seabirds each year, making it one of the most important seabird breeding sites in Australia.

Introduced weeds, clearing of vegetation, rubbish and human disturbance has led to changes in the natural habitat that many of these animals rely on. As a result, many populations no longer exist and a number of species are now listed as threatened or endangered including the Australian Sealion, Australian Lesser Noddy, Abrolhos Painted Button Quail, Australian Fairy Tern and the Abrolhos Spiny-tailed skink.

In response, Central Regional TAFE's, Batavia Coast Maritime Institute (BCMI) in partnership with the Northern Agricultural Catchments Council (NACC) are working together to restore habitat at key sites across the Abrolhos islands. Through strategic restoration activities the project aims to protect these habitats whilst engaging and providing valuable skills to students and members of the community.

## **Vegetation recruitment in differently aged rehabilitated patches of monsoonal vine forest in the Northern Territory, Australia**

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Monsoon rainforests in the Northern Territory, Australia comprise many small (<5ha) patches. Coastal vine forest near Darwin is a dry monsoonal rainforest which has been severely affected by urban development and cyclones. Rehabilitation of vine forest at East Point Recreational Reserve has been

ongoing with rehabilitated stands (RS) of various ages from 6 to 42 years, and a remnant community. Rehabilitation involved planting seedlings of pioneer species and advanced regeneration of climax species rely on a nearby forest remnant. We assessed whether advanced regeneration of climax species was dispersal limited and rehabilitation using pioneers eventually converges on remnant forest tree diversity. We predicted that if the advanced regeneration in these patches was dispersal limited the patches would be dominated by planted pioneers. We measured seedling diversity in different aged RS for comparison with the seedling diversity in the remnant forest. In young stands pioneer species from different growth forms established easily and achieved a closed canopy. Climax species established once canopy closure was achieved. However, even the oldest rehabilitated stand (42 years) had not begun to converge on the climax species diversity contained in the nearby remnant. This is because planted pioneers dominated the overstory for years and seeds from climax species could not disperse as readily as pioneers. Few seeds of climax species were dispersed to neighboring stands, and it appeared that pioneer species exert competition for space and resources, causing recruitment limitation in rehabilitated stands. Choosing 'pioneer' species carefully is the key to successful rainforest rehabilitation.

### **Revegetation and fire: testing the capacity of revegetation to recover from fires**

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Revegetation needs to be self-sustaining and resilient and have the capacity to recover from perturbations, like fire. Plants re-establish post-fire by re-sprouting or via seeds, with the seeds held in canopy or soil seed banks. As revegetation grows, fuel loads increase and the revegetation becomes increasingly vulnerable to fire. This is particularly true for dense, multi-species understorey plantings such as those at Cygnet Park on Kangaroo Island, where fuel loads within five years of planting are adequate to carry a fire. The ability of revegetation to recover from fire will depend on the time required by the plants to establish adequate seed banks and/or sufficient reserves and tissues to allow re-sprouting. The development of seed banks and a capacity to re-sprout is being explored in five to ten year-old revegetation at Cygnet Park, using small scale *ex situ* and *in situ* burns. Preliminary results indicate that revegetation sites at Cygnet Park younger than 5 years-old would not fully recover from a bushfire as the seed bank reserves were insufficient to allow reestablishment of some species. Small scale experimental *in-situ* burns are currently being undertaken to better assess the capacity of different-aged revegetation to recover from fire. The results have implications for managing fires that may threaten revegetation areas prematurely, before the revegetation has built resilience to recover from fire.

### **Predicting provenance performance in restoration plantings of *Eucalyptus pauciflora* in the Tasmanian Midlands**

Authors: **Akira Weller-Wong**, Tanya Bailey, Archana Gauli, Peter Harrison, René Vaillancourt, Brad Potts

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Provenance selection is important in ensuring the long-term success of restoration plantings. The use of local seed has traditionally been favoured in restoration plantings as these sources likely have a long history of site adaptation. However, in the face of global climate change this strategy is being increasingly questioned. It has been argued that the climatic resilience of restoration plantings can be enhanced by supplementing local seed with provenances 'pre-adapted' to the predicted future climate of a restoration site. Such strategies make the assumption that plant populations are locally adapted to their home-site climate. However, if adaptation to non-climatic factors outweighs climatic adaptation then the use of a provenancing strategy which only considers climate may result in maladaptation. We here report the performance of local and non-local provenances of *Eucalyptus pauciflora* in field trials in the Tasmanian Midlands. The trials comprised of open-pollinated seed-lots collected from 37 provenances across the natural geographic and ecological range of *E. pauciflora* in Tasmania in addition to 15 mainland provenances. Using the relationship between home-site environment and direct (survival, reproduction) and indirect (growth) measures of 6-year provenance fitness, we address three questions: i) do local provenances have greater early-age fitness than non-local provenances; ii) can home-site climate predict provenance performance; and iii) does the addition of edaphic factors outweigh the influence of climate on provenance performance? Answers to these questions will help to better inform provenance selection in order to increase the long-term resilience of global restoration projects.

## **Habitat restoration of localised threatened species (Newry golden wattle and Moonee quassia)**

Author: **Mick Webb**

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Conservation projects on the North Coast have aimed to restore habitat of localised fragmented flora species. Newry Golden Wattle (*Acacia chrysotricha*) is a tree from 6 to 15 m tall with densely hairy branchlets, finely or deeply fissured bark and feathery and 'wattle'-like leaves. It is restricted to only two locations south of Bellingen in Northern NSW, listed as Endangered under the NSW Threatened Species Act. The Moonee Quassia (*Quassia* sp. Mooney Creek) is a shrub/ small tree that grows to 2 metres high. Leaves are narrow, about 10 cm long and arranged alternately along the stem. They are glossy dark green above, paler below. Main population found in Moonee near Coffs Harbour, extends to the north to Maclean, listed as Endangered under the EPBC Act.

Two separate conservation projects are being undertaken in public reserves and private properties. It is working to ensure the population's viability in the long term by implementing conservation management actions identified by the Office of Environment and Heritage. Both species are threatened by weed encroachment, urban development and logging activities. It is also under threat from fire where fire management regimes are inappropriate.

EnviTE Environment bush regenerators are working with landowners and public reserve managers to reduce the threat of weeds, raising threats to community, monitoring species in known localities and recording any new sightings. A series of speciality workshops have occurred to help raise community awareness of the importance of these species and its habitat requirements.

## **Fishbowls**

### **Walking the Tightrope...Striking the right balance between retention and restoration**

Facilitator: **Francesca Andreoni**

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Designing effective policy that can manage the multiple complexities of industries such as agriculture, mining or urban and industrial development – whilst retaining and restoring ecological function important for biodiversity, water, soil and climate is no small challenge. This interactive discussion will explore how to strike the right balance between protecting native vegetation, and supporting restoration, regeneration and replanting. Based on a series of questions, the session will cover current state and federal policy settings that impact on the restoration and regeneration efforts and outcomes of scientists, land managers and volunteers. In particular where the balance should be struck, how effectively the mitigation hierarchy is reflected in policy settings, and how we can change aspects of current policy and practice in our various respective roles.

### **Brigalow–Nandewar Biolinks – achievements and challenges in a collaborative approach to protect, restore and manage native vegetation on farms**

Facilitator: **Liz Blair**

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The Brigalow–Nandewar Biolinks project is in the final year of a six-year initiative to protect, restore and manage native vegetation in northern-inland NSW. Biolinks is supported by the Australian Government's Biodiversity Fund and uses a collaborative governance model to bring together NRM agencies Northern Tablelands and North West Local Land Services, Landcare networks, the University of New England, postgraduate students, Office of Environment and Heritage, ecologists, seed collectors, nurseries, revegetation specialists, and farmers and graziers.

The aim of the ~\$5M Brigalow–Nandewar Biolinks program is to strengthen the partnership between biodiversity and agriculture by restoring the region's natural assets. By June 2017 we will have revegetated 1550 ha with native vegetation; restored, protected and enhanced 500 ha of existing native vegetation, and managed threats to biodiversity in over 3000 ha of agricultural lands. A key objective is to build

community capacity. Almost 100 landholders have undertaken on-ground works, and we have engaged with many more via field days, workshops and events, case studies and publication of guidelines. Our successful collaborative governance model includes a joint steering committee of stakeholder representatives to oversee projects and provide advice and direction on approaches and actions. We have developed and continue to maintain a native seed bank of locally sourced seed from northern inland NSW for use throughout the region. Biolinks has supported seven PhD students and associated researchers investigating various issues relevant to revegetation and restoration of native vegetation on farms.

Six project partners will discuss their contribution for 3–5 minutes each, describing important design elements (role, function, how the group worked), success factors and highlights, and key lessons learnt, followed by a ‘fishbowl’ discussion with the panel and audience.

Confirmed participants: **Nick C. H. Reid, Michael Drielsma, Anya Salmon, David Carr, Gordon Williams**

### **Challenges and solutions for on-ground restoration**

Facilitator: **Nick Reid**

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Restoration projects are often a gamble. Even with all the proper planning, knowledge and practical experience on offer, there are risks and uncertainty when it comes to implementing projects in the field. Spectacular success or epic failure, and unexpected outcomes are all possible. However, there are lessons to be learnt from past projects that can inform future efforts, and shared learning is the overarching aim of this conference. We have assembled a panel of restoration experts to answer delegates’ questions and discuss delegates’ challenges in their various restoration and offset management projects. In this facilitated fishbowl discussion, we invite delegates to raise their burning issues, challenges and problems in on-ground restoration, as well as contributing their knowledge and experience to inform solutions to others’ problems. The session should highlight gaps in understanding where further research is required.

Confirmed participants: **Richard Hobbs, David Paton, David Norton, Paul Gibson-Roy, Tein McDonald**

