

STATE NRM CONFERENCE 2015



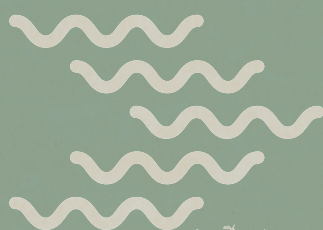
Finding the Balance:



Healthy Environment,



Productive Economy



21-23 September 2015

Mandurah Performing Arts Centre,
Western Australia

PROCEEDINGS



natural resource
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NRM WA



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STATE NRM CONFERENCE 2015

Finding the Balance: Healthy Environment, Productive Economy

Welcome

The theme: Finding the balance: healthy environment, productive economy was agreed early on by the hard working organising committee.

As our State undergoes a focus on development, it is important to pay equal attention to the natural assets: abundant and unique biodiversity, healthy soils, fresh water, coasts and importantly active and engaged community members.

Operating in a world with of changing environment, economy and society, you will hear of groups who have been successful in undertaking long term programs that improve land and water management, actively involve communities, and conserve natural capital.

In these endeavours we can all play a role, from personal commitment to care to participating and playing important roles in community groups, regional NRM organisations, in industry and government.

NRM WA and the State Natural Resource Management Office and invite you to fully participate in 'Finding the Balance'.

We encourage you to listen, engage and question and most importantly enjoy the conference.

John Holley	Dr Kathleen Broderick
Director	Executive Manager
State NRM Office	NRM WA

Conference Committee

John Holley

Co-Convenor
State NRM Office
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natural resource
management office



Kathleen Broderick

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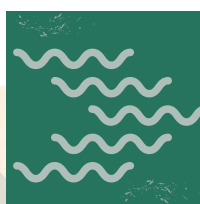


Bob Pond

Department of Water (DoW)
www.water.wa.gov.au



Government of Western Australia
Department of Water





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Keynote Speakers



Dr Denis A Saunders, AM

Dr Denis Saunders AM was the former Chief Research Scientist at the CSIRO Divisions of Wildlife Research, Wildlife and Rangelands Research, Wildlife and Ecology and Sustainable Ecosystems where he spent 30 years, and the former president of WWF Australia. His research interests include the integration of nature conservation in agricultural landscapes; the ecology, behaviour and taxonomy of black cockatoos and the effects of development on their distribution and abundance; and state of the environment reporting on biodiversity.

Dr Saunders received the 'Individual in Government Award' from the Society for Conservation Biology, the Distinguished Scholarship Award of the International Association of Landscape Ecology and the D.L. Serventy Medal from the Royal Australasian Ornithologists Union.

In 2005, he was made a member of the General Division of the Order of Australia (AM) for 'service to nature conservation, particularly through the study of Australian birds and the development of landscape ecology in Australia'. He is on the editorial board of Biological Conservation (2002–present), and was editor of Conservation Biology (1994–2002), chair of Birds Australia Emu Review Committee and has convened multi- and inter-disciplinary conferences on wildlife conservation.

He has written 2 books and more than 130 scientific papers, chapters in books, reports or other publications. He has also edited eight scientific books including four in Surrey Beatty and Sons influential Nature Conservation series.



Winthrop Professor Carmen Lawrence

After training as a research psychologist at the University of Western Australia and lecturing in a number of Australian universities, Dr Lawrence entered politics in 1986, serving at both State and Federal levels for 21 years. She was at various times W.A Minister for Education and Aboriginal affairs and was the first woman Premier and Treasurer of a State government.

She shifted to Federal politics in 1994 when she was elected as the Member for Fremantle and was appointed Minister for Health and Human Services and Minister assisting the Prime Minister on the Status of Women.

She has held various portfolios in Opposition, including Indigenous Affairs, Environment, Industry and Innovation and was elected national President of the Labor Party in 2004.

She retired from politics in 2007. She is now Director of the Centre for the Study of Social Change in the School of Psychology at the University of Western Australia and Chair of the Australian Heritage Council.



Dawn Hawthorn-Jackson

Dawn is the Managing Director of Emu Consulting. She has a background in natural resource management, social studies and community engagement. She has, over the last 20 years, worked with communities, not-for-profit organisations, farmers, industry and individuals throughout South Australia.

Her business Emu Consulting specialises in Environmental Management, Aboriginal Cultural Awareness, Communication and Community Engagement.





Verity James – Master of Ceremonies

Verity James was a broadcaster with the ABC for 25 years both in the Eastern States and in WA. She has presented all manner of radio shows from current affairs to lifestyle to specialist language, political and music shows. Verity also presented ABC Television news for 10 years and been a panel member and reporter for the Logie nominated ABC show 'Can We Help' for 2 years. Verity has been the voice for a number of documentaries and for 3 years fronted the ABC's series on the Festival of Perth.

During the last 5 years as a freelancer Verity has owned and run a fresh produce business, been co-partners in a scuba diving business, been MC for many conferences, seminars, workshops and award nights, including at least 10 return visits for The Royal Australian Institute of Architects, SPASA awards, TAB, Social Workers Assoc, Industry and Export Awards, as well as Leeuwin Estate Concerts featuring Kiri Te Kanawa and Tom Jones to name a couple, plus a huge variety of private and Government events including the Similcast of the Berlin Philharmonic and Vienna Philharmonic concerts over that time.

Verity was chosen to host the visits of the Dalai Lama which involved managing 18,000 people. She has recorded voice-overs for a variety of events and some commercials (notably she is the face of Bailey's Fertilisers), has become a funeral celebrant (which she loves!) and has just finished a 2 year contract writing for 'The Sunday Times' newspaper. She was a core writers for the WA Spice Magazine which came to a close in July and continues on a casual basis in radio for the ABC. Her professionalism and warmth mean that Verity is a very busy person. Verity also has continued much of her charity work with The Australian Red Cross with whom she is an augural Ambassador, Lifeline WA, Vision Cambodia and numerous others. Last year Verity began tutoring students at Edith Cowan University in broadcasting and took on the role of Program Director of the Mundaring Truffle Festival.

GRID ONLINE GIS

GRID is the easy-to-use, online GIS, in use by a range of NRM groups. GRID was built by the NRM community, for the NRM community.

For the **NRM staff member**, it runs in a web browser, and lets them add and edit spatial data, view and enquire about spatial data, and produce hardcopy maps and other reports from the system.

For **NRM project managers**, the system provides means for them to report on work being done on their projects. The system allows for visual inspection of on-ground works, and provides mechanisms for reporting.



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Program

Monday 21 September 2015

10.45 am	Boat Cruise
5.30 pm	Welcome Reception
7.30 am	Pre-Conference Day closes

Tuesday 22 September 2015


8.00 am	Registration opens		
8.30 am		Conference Opening with Master of Ceremonies – Verity James The Boardwalk Theatre	
8.45 am	Welcome to Country: Harry Nannup (Elder), The Boardwalk Theatre		
8.55 am	Welcome by Hon. Ken Baston MLC, Minister for Agriculture and Food; Fisheries in The Boardwalk Theatre		
9.10 am		Keynote Address: Winthrop Professor Carmen Lawrence Care not plunder The Boardwalk Theatre	
10.00 am		Keynote Address: Dr Denis A Saunders AM Cockies and cockies; a journey through a period of great change in rural landscapes and in society’s expectations of land managers The Boardwalk Theatre	
10.50 am	Morning Tea amongst the exhibits		
STREAM	BIODIVERSITY CONSERVATION The Boardwalk Theatre	MONITORING Fishtrap Theatre	SUSTAINABLE AGRICULTURE Dance Studio
11.20 am	 Restoring Flora and Habitats on the Amazing Abrolhos Maryke Gray Batavia Coast Maritime Institute/ Durack Institute of Technology <ul style="list-style-type: none">Restoring biodiversity by planting local provenance plant species and undertaking threat abatement measures.Working with Abrolhos’ stakeholders to protect one of the largest seabird breeding areas in Australia.Community capacity building through training, workshops, field work and displays, improving NRM knowledge and understanding.	 Can Bird-Monitoring be Used to Assess the Ecological Outcomes of Nature Resource Management? Nic Dunlop Conservation Council WA <ul style="list-style-type: none">The assessment of ecological outcomes requires the long-term monitoring of appropriate indicators.Monitoring needs to be technically sound, targeted at the NRM objectives and carried out by up-skilled volunteers.A comprehensive bird monitoring framework based on the ‘standard search’ method and functional groups analysis is proposed.	 Large Scale Low Cost Biodiverse Reforestation Carbon Sinks Kent Broad Carbon Neutral <ul style="list-style-type: none">Implications of historic over clearing of agricultural land in the SW of WA.Economic, social and environmental drivers to revegetate degraded and unprofitable cleared agricultural land areas.What do we want our grandchildren to say in 2050 in response to our efforts in 2015?

STREAM	BIODIVERSITY CONSERVATION The Boardwalk Theatre	MONITORING Fishtrap Theatre	SUSTAINABLE AGRICULTURE Dance Studio
11.50 am	 <p>A Peninsula of Competing Priorities – Threatened and Priority one Ecosystems (TECs and PECs) on the Broome Peninsula Louise Beames and Tim Willing Envirocons Kimberley</p> <ul style="list-style-type: none"> • Monsoon Vine Thicket, the Kimberley's only nationally Endangered ecosystem, occurs throughout Broome, at it's southern-most extent. • Minyjuru, within the restricted Broome PEC, provides a much coveted sweet fruit and traditional Yawuru Mayi. • Urban expansion and development is among the greatest threat to the endemic, restricted Cable Beach Ghost Gum and other Broome PEC/TEC's. 	 <p>Provision of Photo-monitoring Services for NRM Projects Felicity Beswick Northern Agricultural Catchments Council</p> <ul style="list-style-type: none"> • Introduction to the smartphone app Photomon. • Demonstration of the back-end database that supports Photomon. • Establishing new projects using Photomon Services. 	 <p>Environmental Plantings can Provide a Commercial Return: Sandalwood's promise Liz Barbour and Joerg Bohlmann The University of Western Australia</p> <ul style="list-style-type: none"> • Sandalwood is an excellent environmental planting choice— deep-rooted, water-regulating perennial and multi-species planting. • Commercial potential dependent on heartwood oil production. Formation is initially unpredictable but reliable with age. • Basic gene level research has provided tools to manage tree plantings for commercial return.
12.20 pm	Lunch amongst the exhibits		
1.20 pm	Lunch continues as well as Poster Sessions		
STREAM	CAPACITY The Boardwalk Theatre	BIOSECURITY Fishtrap Theatre	PARTNERSHIPS Dance Studio
1.50 pm	 <p>Changes in the NRM / Landcare Officer role and finding the balance – Past, present and future Rodger Walker Northern Agricultural Catchments Council</p> <ul style="list-style-type: none"> • Technology continues to revolutionise the field officer role and opportunities to understand and communicate on-ground changes. • Declining levels of field officer numbers and agency support poses important implications to local and regional NRM outcomes. • Community interaction and feedback continues to support the effectiveness of the role but how much responsibility should the community shoulder? 	 <p>Project Dieback – Action and Opportunities for Protecting Biodiversity Assets Elissa Forbes South Coast Natural Resource Management Inc.</p> <ul style="list-style-type: none"> • The relentless spread of <i>Phytophthora</i> Dieback requires an urgent coordinated response at landscape scale. • Project Dieback takes a multi-faceted approach to management and investment, including planning, communication and delivery guided by an Investment Framework. • Targeted and collaborative efforts are needed to achieve effective and meaningful outcomes. The Framework provides tools to achieve this. 	 <p>Building Partnerships for Conservation Tony Jupp The Nature Conservancy</p> <ul style="list-style-type: none"> • How The Nature Conservancy (TNC) is working with partners to improve conservation outcomes in WA. • Examples on TNC's WA projects, their challenges and successes. • Regions include the Kimberley, Western Desert, Gondwana Link, south western bays and estuaries.



Tuesday 22 September 2015 (continued)

STREAM	CAPACITY The Boardwalk Theatre	BIOSECURITY Fishtrap Theatre	PARTNERSHIPS Dance Studio
2.20 pm	 <p>Small Investment Big Outcomes: Celebrating Landcare on the South Coast David Broadhurst South Coast Natural Resource Management Inc.</p> <ul style="list-style-type: none"> • Turning \$19,000 into \$150,000, maximising your 'bang for buck'. • You don't have to spend big for big outcomes. • Future opportunities for corporate sponsorship and participation. 	 <p>A Symbiotic Relationship – Research and Community Action for Feral Pig Control Sue Metcalf and Peter Adams Chittering Landcare</p> <ul style="list-style-type: none"> • Community action is supported by good research. • Research enables better responses to vertebrate pests. • Agricultural and environmental benefits with practical application of research. 	 <p>Peron Naturaliste Partnership – Regional Coastal Adaptation Planning Joanne Ludbrook Peron Naturaliste Partnership</p> <ul style="list-style-type: none"> • Coastal Hazard and Risk Assessment. • Coastal Community Engagement • Coastal Monitoring for long term adaptation planning.
2.50 pm	<p>Strengthening Landcare in WA Jill Richardson and Dr Aruni Jayasekera WA Landcare Network</p> <ul style="list-style-type: none"> • What is a peak body and how does it achieve 'representativeness' for its members? • Advocacy for community based landcare groups—what does this mean? Description of a successful issue. • Identifying issues and challenges of landcare groups in WA, and ways to address them. 	<p>Here Comes the Bride ... Again. The Necessity on Ongoing Bridal Creeper Control Andrea Salmond and Ella Maesepp Katanning LCDC</p> <ul style="list-style-type: none"> • Katanning and four other shires have been doing Bridal Creeper control for the last six years. • A team has formed with local governments, Main Roads, private contractors, volunteers and neighbouring Landcare groups. • A wide variety of engagement techniques have been used over the years to ensure project success. 	<p>Fire Leadership, Management and Collaboration in the WA Rangelands John Silver Rangelands NRM</p> <ul style="list-style-type: none"> • To combat the threatening wildfire process we need more 'good' fire integrated at the landscape scale. • We need to increase the capacity of land managers if fuel loads are to be managed while enhancing both the continuity and structure of vegetation. • The Fire Leadership Group is passionate about advancing a shared vision and the driving principles behind fire management as the primary land management tool.
3.20 pm	Afternoon tea		
STREAM	BIODIVERSITY CONSERVATION The Boardwalk Theatre	INNOVATION TECHNOLOGY Fishtrap Theatre	TECHNOLOGY Dance Studio
3.50 pm	 <p>Pilbara freshwater fishes: field guide and documentary Dr David Morgan Murdoch University – Freshwater Fish Group and Fish Health Unit, Centre for Fish and Fisheries Research</p> <ul style="list-style-type: none"> • The freshwater fishes of the Pilbara region are unique and fascinating yet are largely unheralded. • A documentary and field guide were produced to highlight the fauna and help their conservation. • The project has been highly successful with ~7000 views of the documentary. 	 <p>Act Local; Think Global – The Importance of Sharing Local Species Project Data for Global Conservation Impact Richard McLellan Northern Agricultural Catchments Council</p> <ul style="list-style-type: none"> • The Living Planet Report shows a 52% decline in species' populations all around the world. • This a complex and concerning statistic that masks the true plight of many species' populations. • It is critical to tackle the global problem at the local and regional scale. 	 <p>NARvis: taking Natural Resource Management into the cloud Emma Jackson and Sarah Samulkiewicz-Taylor Northern Agricultural Catchments Council</p> <ul style="list-style-type: none"> • Engaging community groups with maps. • Using ArcGIS Online to promote NRM. • Providing a portal for regional NRM information.

STREAM	BIODIVERSITY CONSERVATION The Boardwalk Theatre	INNOVATION TECHNOLOGY Fishtrap Theatre	TECHNOLOGY Dance Studio
4.20 pm	 <p>Conserving south-western Australia's rarest and most threatened freshwater fishes Stephen Beatty School of Veterinary & Life Sciences – Murdoch University</p> <ul style="list-style-type: none"> • Collaborative project gathered information critical for the conservation of the most endangered south-west fishes. • Surveys of >150 sites occurred over two years for the Western Trout Minnow, Little Pygmy Perch, Balston's Pygmy Perch. • Their abundances, distributional ranges and life-cycles were determined. Key threats assessed with implications for management. 	 <p>Aquila Project – Detecting Target Weeds Using Crowd Sourced Volunteers to Search Ultra High-Resolution Aerial Imagery Over the Internet John Szymanski West Kimberley Rubber Vine Eradication Program</p> <ul style="list-style-type: none"> • Aquila Methodology—Putting together off-the-shelf technologies and volunteers to achieve a marvellous result. • Evaluation of the Aquila Project. Plant detection results and community engagement. • Aquila Mark 2. The next step in making a successful tool even better. 	 <p>The Living Lakes of Gondwana Link – Tapping into Google Earth and Other Digital Resources for Networking and Promotion Basil Schur, Dr Louise Duxbury and Keith Bradbry Green Skills</p> <ul style="list-style-type: none"> • Achievements and future directions for the South Coast wetland conservation program, now in its third decade. • The Living Lakes of Gondwana Link aims to utilise internet/digital interactivity to promote networking, promotion and support. • Illustrations of internet linked and digital presentations will be displayed.
4.50 pm	 <p>Midwest Pests: Invasive Aquatic Pests in Southern Pilbara Rivers Dr Colin Johnson Durack Institute of Technology's Batavia Coast Maritime Institute</p> <ul style="list-style-type: none"> • Surveys of Midwest Rivers to determine current distributions of introduced species. • Potential for new 'pest' species and range expansions. • Increasing NRM knowledge throughout the community through training, workshops, field work and displays. 	 <p>Incorporating Climate Change into NRM Emma Jackson, Guy Boggs, Jodie Deeley, Kaylene Parker, Elizabeth Kingston, Kelly Fulker and Mike Christensen Northern Agricultural Catchments Council</p> <ul style="list-style-type: none"> • NRM planning for climate change—how is this being addressed by NRM groups? • Using MCASS-S to model NRM priorities in a changing climate. • Climate tools for the future. 	 <p>#DoMoreGood: Using @Twitter to Increase your #NRM Group Impact – by @Richard McLellan Richard McLellan Northern Agricultural Catchments Council</p> <ul style="list-style-type: none"> • Twitter has professional benefits that extend far beyond 'social' media communications. • Twitter is not just for communicators. It should be used by CEOs, program/project staff, etc. • We'll get staff started in promoting their work and that of their organisation.
5.20 pm	Day 1 concludes		
6.30pm to late	<p>2015 WA Landcare Awards Presentation Mandurah Convention and Exhibition Centre, 22 Ormsby Terrace, Mandurah</p> <p>Held since Landcare was launched nationally, the Landcare Awards recognise the volunteers who are the backbone to the grass-roots movement—one of the leading volunteer forces in Australia.</p> <p>The 2015 WA Landcare Awards will be presented at a gala dinner as part of the 2015 State Natural Resource Management Conference. There are nine categories:</p> <ul style="list-style-type: none"> • Australian Government Individual Landcarer • Australian Government Landcare Facilitator or Coordinator • Australian Government Innovation in Sustainable Farm Practices • Australian Government Partnerships with Landcare • Coastcare Award • Junior Landcare Team • Manpower Young Landcare Leader • Indigenous Land Corporation Land Management • Fairfax Media Landcare Community Group. <p>All winners of the WA Landcare Awards will go forward as finalists to the 2016 National Landcare Awards.</p>		



Wednesday 23 September 2015

8.30 am	Welcome		
8.50 am		<p>Keynote Address: Dawn Hawthorn-Jackson, Managing Director, Emu Consulting</p> <p>Building Meaningful Relationships Between Natural Resource Management Organisations and Traditional Owners</p> <ul style="list-style-type: none"> • Creating platforms for policies and procedures to be ongoing. <p>The Boardwalk Theatre</p>	
9.40 am	<p>Indigenous People, NRM and Landcare – Practical Examples in Western Australia</p> <p>Mitch Jeffery Indigenous NRM and MERI, Biodiversity Conservation Division, Department of the Environment</p> <p>The main focus of this panel session is on practical examples of how Aboriginal people in Western Australia are already participating in NRM and landcare activities and how these local, on ground initiatives are contributing to community partnerships, regional and national priorities such as Closing the Gap and potential social, environmental and economic outcomes.</p> <p>All of these example showcase the importance of working through a partnership approach and that the opportunities for Aboriginal involvement in the delivery of NRM and agriculture outcomes is only limited by the capacity and experience of Aboriginal people and organisations such as landcare groups, regional NRM organisations and governments to identify the most suitable and practicable level of support and commitment. While direct support funding is important, it's the broader opportunities to be involved in NRM, agriculture and landcare that matter, allowing Aboriginal people to continue to protect and manage their land and sea country for future generations.</p> <p>The format will be 3 x 10 minute presentations describing three key areas of Aboriginal investment in NRM, followed by 30 minutes of Q&A and discussion.</p> <p>Chair Mitch Jeffery Indigenous NRM and MERI Policy Officer with the Biodiversity Conservation Division, Department of the Environment</p> <p>Panel members are:</p> <ul style="list-style-type: none"> • Mark Chmielewski Program Manager of the Indigenous Landholder Service with the Department of Agriculture and Food WA • Kelly Flugge Southern Agricultural Indigenous Landholder Service Program Manager with Department of Agriculture and Food WA • Carl Beck CEO with South Coast NRM 		The Boardwalk Theatre
10.30 am	Morning Tea amongst the exhibits		
STREAM	INDIGENOUS The Boardwalk Theatre	COMMUNITY Fishtrap Theatre	RANGELANDS MANAGEMENT Dance Studio
11.00 am	 <p>Development of an Indigenous 'Ranger Incubator Framework'</p> <p>Chris Curnow Rangelands NRM</p> <ul style="list-style-type: none"> • Rangelands NRM has developed a 'ranger incubation framework'—a step-wise tool to guide aspiring ranger groups through the phases of a ranger program. • Three phases include 'discovering', 'planning' and 'doing'. • Rangelands NRM engages with Traditional Owners and Aboriginal land managers to identify support for land management projects throughout the rangelands regions of WA. 	<p>Raising Interest in Another Kingdom: Tales of a Successful Citizen Science Project</p> <p>Roz Hart WA Naturalists' Club</p> <ul style="list-style-type: none"> • Exciting children and adults in outdoor pursuits: treasure hunting for fungi. • Raising awareness of the excitement of science in our backyards and urban bushlands. • Science and community, benefits for all. 	 <p>Control of <i>Opuntia Elatior</i> on Wydgee Station</p> <p>Andrew Reeves Department of Agriculture and Food</p> <ul style="list-style-type: none"> • State NRM funding of an inactive producer group has given the community a focus. • A high profile infestation of cactus on the great northern highway has been controlled. • A partnership arrangement has controlled 2,000 hectares of cactus that threatened a river system.

STREAM	INDIGENOUS The Boardwalk Theatre	COMMUNITY Fishtrap Theatre	RANGELANDS MANAGEMENT Dance Studio
11.30 am	 <p>Growing Community Capacity and Banking with Kimberley Seeds Ayesha Moss and Louise Beames EnviroNS Kimberley</p>	 <p>How to make efficient use of technology in NRM space Piers Higgs GAIA Resources</p> <ul style="list-style-type: none"> • Collaborate. • Lessons learned from other projects. • Future trends. 	<p>Landscape Scale Projects – Reducing Threats to Biodiversity in the Pilbara Bioregion Ian Cotton and Gaye McKenzie Rangelands NRM / Pilbara Corridors</p> <ul style="list-style-type: none"> • Landscape-scale projects encompass multiple tenures and complex values. • The Pilbara Corridors Project is a coordinated approach to connectivity. • Land management through a diverse group of stakeholders sharing knowledge and collaborating.
12.00 pm	Lunch amongst the exhibits		
STREAM	WETLANDS The Boardwalk Theatre	COMMUNITY INVOLVEMENT Fishtrap Theatre	BIODIVERSITY AND SUSTAINABLE AGRICULTURE Dance Studio
1.30 pm	 <p>Vegetated Floating Islands Enhance the Ability of Wetlands to Reduce Nutrients and Other Pollutants Bernie Masters FIA Technology Pty Ltd</p> <ul style="list-style-type: none"> • Wetlands are now being widely used around the world to improve water quality. • Bacterial/algal biofilms undertake most pollutant reduction, with plants playing an essential but minor role. • Floating islands designed to maximise biofilm development significantly enhance a wetland's pollution removing ability. 	 <p>Working with the community to increase environmental skills and knowledge in NRM Mick Davis Shire of Kalamunda</p> <ul style="list-style-type: none"> • How do you identify and increase environmental skills in community groups? • Identifying skills and knowledge gaps is important, but so is making training useful and fun. • Monitoring uptake of skills and knowledge is important but how do we do it effectively? 	 <p>Implications of Climate Change on the Aestivating Salamanderfish, <i>Lepidogalaxias aalamandroides</i> Mees and the Black-Stripe Minnow, <i>Galaxiella nigrostriata</i> Shipway Gary Ogston, Stephen Beatty, Dave Morgan, Brad Pusey and Alan Lymbery Murdoch University</p> <ul style="list-style-type: none"> • Climate change has impacted on south-western Australia through reduced rainfall and increased temperatures. • Variables of significance for salamanderfish and black-stripe minnow are directly impacted by climate change. • Population losses were observed with more projected losses likely due to climate change.
2.00 pm	 <p>Planting with machines: Using mature vegetative divisions for ready-made wetland habitat Joby Rand Blackwood Basin Group</p> <ul style="list-style-type: none"> • Importance of reed bed habitat in wetlands. • Outline of techniques the BBG has used to create reed beds. • Lessons learnt using different techniques: comparing; seedlings and relocation of mature stock planted by hand and using machinery. 	 <p>Bird Monitoring and Natural Resource Management Suzanne Mather BirdLife Western Australia</p> <ul style="list-style-type: none"> • BirdLife Australia was a pioneer organization in Australian citizen science. • It has a large, skilled and motivated volunteer network and the capacity to engage with the wider community. • It has worked collaboratively in supporting agencies, NGOs (including NRM Councils) and communities managing terrestrial habitats, wetlands, estuaries and pest species. 	 <p>Let's Talk Soil Carbon Dave Cullen C-Wise</p> <ul style="list-style-type: none"> • What is soil carbon? • How do you build soil carbon? Practical examples in agriculture and rehabilitation. • What is the impact of soil carbon on the triple bottom line?



Wednesday 23 September 2015 (continued)

2.30 pm	<p>'NRM Futures' Q&A Session</p> <p>The panel session will outline key influences on the future of NRM in WA and provide opportunity for an interactive Q&A session. The format will be 3 x 10 minute presentations describing three key areas for future change followed by 40 minutes of Q&A and discussion.</p> <p>Chair Dr Ron Edwards National Landcare Advisory Council Member</p> <p>Collecting and Using Data Dr Denis A Saunders AM Wentworth Group of Concerned Scientists</p> <p>Technology is increasingly used to measure and monitor, evaluate and organise. It also allows for unique ways of interacting with data and with others and influencing decisions. At the same time, the cost of technology has drastically decreased, for example remote cameras to monitor feral animal numbers and habits, drone surveillance of hard to access areas.</p> <p>We need a strategic approach to the collection of data required to monitor change in natural resource assets and set priorities on allocation of resources to management of these assets.</p> <p>The challenge for NRM is how to best use big data and make the most of the digital possibilities available to us. Who should collect the data? What skills and knowledge will help us make best use of what is already available and be ready for what is to come? How can we use new technologies?</p> <p>Engagement Brian Ramsay Inovact Consulting</p> <p>Strong relationships and networks in NRM have underpinned achievements to date:</p> <ul style="list-style-type: none"> • Resource management plans at regional and subregional level enabling investment. • Networks of specialist staffs, data, and knowledge systems underpinning planning and management. • Engagement and strategic investment in capacity enables and leverages involvement and delivery of on ground change. <p>Relationships have been strained from time to time, changing policy settings and decreasing government investment have shifted power relations and provided challenges for all involved. Decreased funding means, now more than ever, coordination and collaboration and leverage are needed to achieve desired outcomes. How can the NRM sector learn from these experiences and other from sectors to strengthen and build engagement into the future?</p> <p>Investment Sue Middleton</p> <p>Public funds are under pressure with aging population, increased costs of health and education and so on. The portion of environment and agriculture funding is about 1% of the total budget and is unlikely to increase, while the challenges we face are enormous and potentially growing.</p> <p>The challenge for NRM is to demonstrate value for \$, and diversify the way funds are generated. However, it is unclear what that actually means and how to go about the transition. NLAC have recently undertaken a project to see if economic value in agricultural production could be attributed to landcare activity. How do we communicate to ensure new and further investment? Economic impact? Social benefit?</p>	The Boardwalk Theatre
3.30 pm	Conference concludes	

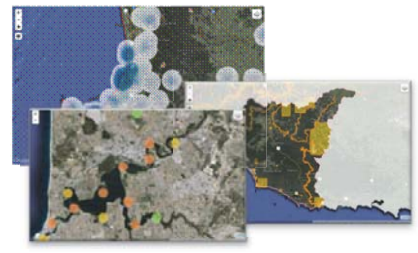
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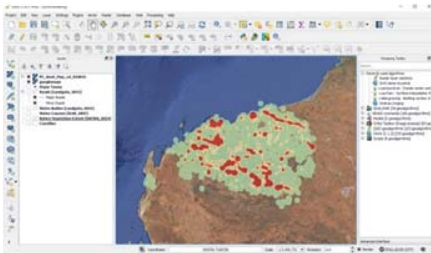
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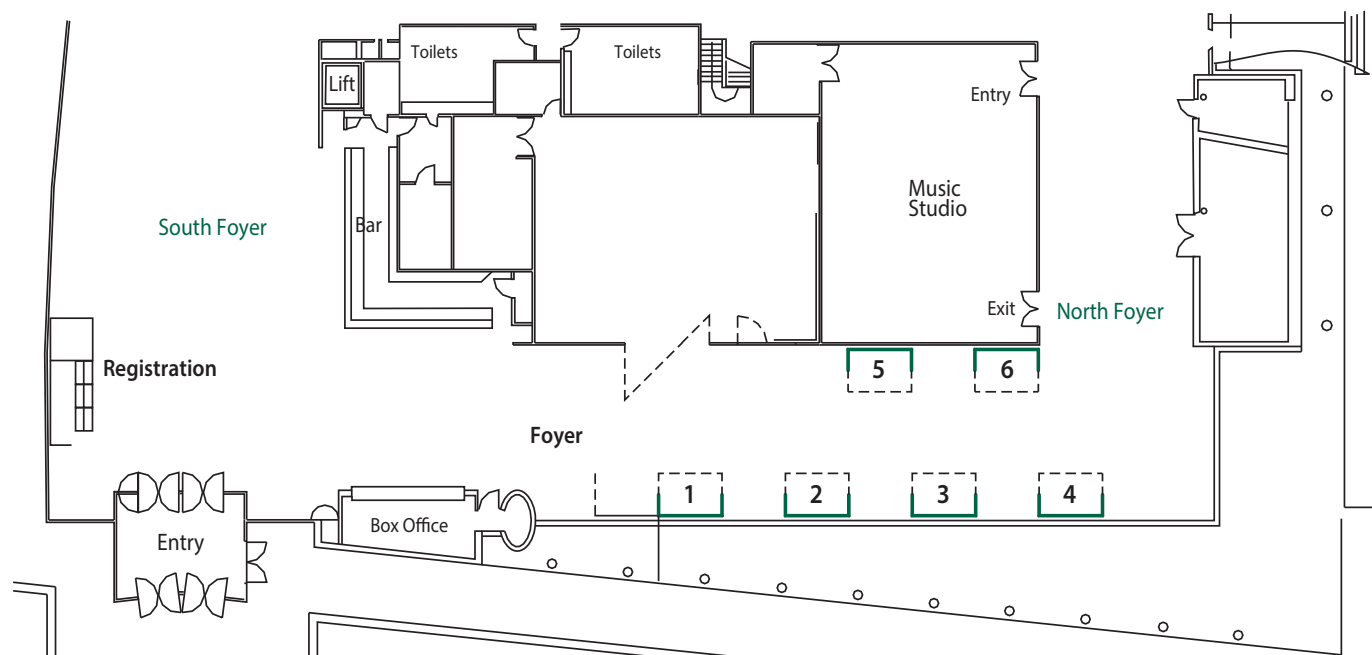


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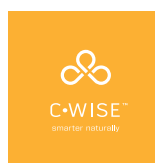
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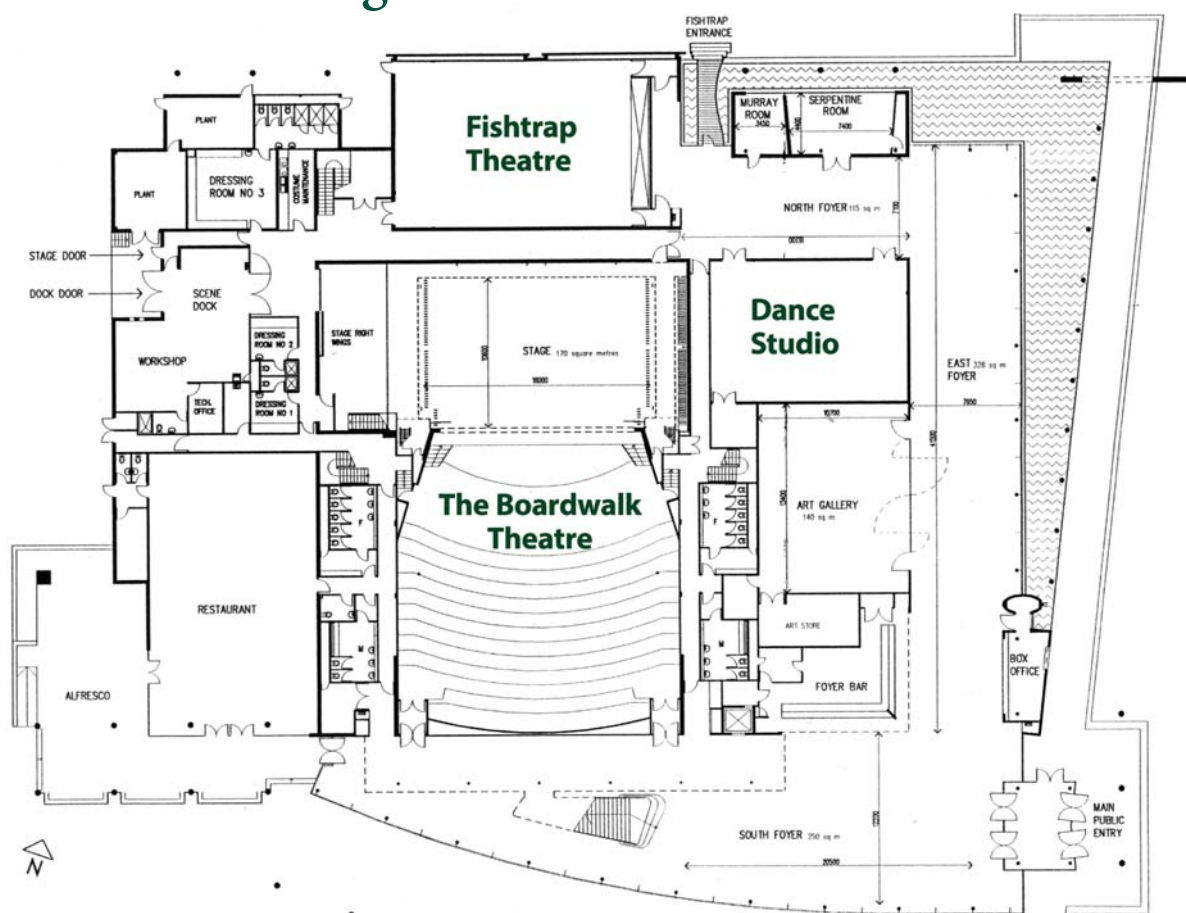
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Building Meaningful Relationships Between Natural Resource Management Organisations & Traditional Owners

PRESENTER:



Dawn Hawthorn-Jackson

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BIOGRAPHY:

Dawn is the Managing Director of Emu Consulting. She has a background in natural resource management, social studies and community engagement. She has over the last 20 years, worked with communities, not-for-profit organisations, farmers, industry and individuals throughout South Australia. Her business Emu Consulting specialises in Environmental Management, Aboriginal Cultural Awareness, Communication and Community Engagement.

Abstract

Understanding and appreciating Indigenous people's connection to country is of paramount importance when working in partnership with them to address natural resource management (NRM) matters. Developing respectful relationships can take time, patience and a willingness to engage with local community members in their communities.

In South Australia, NRM organisations have to date shown great commitment to supporting Indigenous communities. Whilst some impressive achievements in Indigenous NRM have been achieved, many opportunities have not been realised. I believe there is room to improve NRM outcomes through the deployment of greater community engagement practices.

My presentation will focus on my experiences as an NRM practitioner working with Indigenous people and communities, throughout South Australia. Whilst I will share my story, I will also offer community engagement strategies that I find useful when working in partnership with my Aboriginal colleagues and communities and case studies to share for consideration. Aspects I will cover include:

- My story.
- Understanding and valuing differences and diversity.
- The value of respect and collaboration.
- The community realities of past policies.
- Bureaucratic time vs Aboriginal time.
- Bridge building strategies.

Cockies and cockies; a journey through a period of great change in rural landscapes and in society's expectations of land managers

PRESENTER:



Denis Saunders

Abstract

Over the past 60 years the environment of southwestern Australia has undergone great change.

What is now known as the WA Wheatbelt is an area of incredible international biotic diversity which has been extensively cleared, with the remaining native vegetation fragmented into thousands of patches; some very small and some very large. My own journey involved field work in the Wheatbelt from 1968 until the present, during which I was able to witness the widespread environmental degradation that resulted from these changes in the landscape.

As a result of increasing awareness of the importance of our unique flora and fauna and the need to address the processes leading to the degradation of agricultural land, Australian society is changing its expectations of those managing the environment, and that includes those engaged in farming and pastoral industries. Not only are farmers and pastoralists being asked to produce food and fibre as in the past, but also to do so in ways that do not degrade the resource base further. So not only do primary producers have to make sure they do not degrade soils or ground water, but because much of Australia's flora and fauna exists on freehold and leasehold land, they are also increasingly being expected to act as conservation managers to protect biodiversity. However, society has not provided the resources to allow primary producers to meet these expectations, nor the incentives for them to do so. Australian society needs to provide primary producers with certainty about what they can and can't do and the incentives to act to protect the environment.

In order to assist primary producers to farm sustainably and profitably, Australians need to incorporate into the production costs of food and fibre the hidden subsidies currently borne by the environment and pay for the provision of environmental services. Where society expects primary producers to manage their land above current levels of duty of care, then they should be paid for the provision of those services on behalf of society. In addition, a set of environmental accounts should be developed to allow all environmental assets to be measured and monitored so that funding to address environmental problems can be directed to a clearly defined set of transparent priorities with a view to preserving the amazing biodiversity of this area from further degradation.

A Peninsula of competing Priorities—Threatened and Priority One Ecosystems (TECs and PECs) on the Broome Peninsula

PRESENTER:



Louise Beames

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BIOGRAPHY:

Louise Beames co-coordinates the Kimberley Nature Project, through Environs Kimberley and is the President of the Broome Botanical Society. As an ecologist with 15 years experience, she has spent the last 8 years working with Indigenous rangers and community groups to undertake cultural, natural resource management projects throughout the Kimberley. Her collaborative scientific and cultural management work with the Bardi Jawi and Nyul Nyul ranger groups was instrumental in achieving the recognition and listing of Dampier Peninsula Monsoon Vine Thickets as Endangered under the EPBC Act (1999). Her work with Society for Indigenous Plants and Animals and Broome Botanical Society to undertake preliminary survey and description of Minyjuru (Mangarr) on relict dunes in the Broome Peninsula was pivotal in the listing of this community as a Priority 1 community. This collaborative work with Tim Willing, secretary for the Broome Botanical Society, and an independent ecological consultant, has furthered the understanding of the ecology and extent of Minyjuru and Cable Beach Ghost Gum Priority 1 Ecological Communities within the Broome Peninsula.

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Extended Abstract:

The Broome Peninsula is a wealth of diversity, ecological and cultural heritage, and a refuge for rare species. It contains three Priority 1 Ecological Communities (PECs) and one Threatened Ecological Community (TEC): Monsoon Vine Thicket. The PECs are: Minyjuru (*Sersalisia sericea*) on relict dunes, Dwarf Pindan Heath and Cable Beach Ghost Gum (*Corymbia paractia*) Community. While *C. paractia* is an extremely restricted Eucalypt species (Franklin and Preece, 2014), there is a thriving population of the Critically Endangered (EPBC Act, 1999) *Keraudrenia exastia*. The areas of PEC/TEC are limited, as is the space for urban and industrial expansion on the Broome Peninsula. A balance needs to be struck between maintaining the conservation and integrity of these ecosystems and sustainable development.

The extent, location and ecology of these PECs were poorly understood. The Minyjuru PEC was listed in 2012 from ecological data provided by Environs Kimberley (EK), Society for Kimberley Indigenous Plants and Animals and the Broome Botanical Society in 2011/12, and brief descriptions in previous reports (1988, 1990).

MVT is a comparatively well-documented ecosystem, having been listed as Endangered by the Commonwealth in 2013; additional Broome patches were mapped in 2014 by EK with Nyamba Buru Yawuru/Department of Parks and Wildlife. Small pockets remain unsurveyed. Previous work undertaken by EK, in collaboration with Bardi Jawi Rangers, Nyul Nyul Rangers and others, identified that MVT is being degraded and lost due to wildfire and weed invasion throughout its range. The loss or degradation of one MVT patch affects all the other patches, posing regional impacts upon this culturally and ecologically important vegetation community. Proximity to and clearing for inappropriate development is also a concern.

The dominant trees of Minyjuru and CBGG are valued by Yawuru people. Minyjuru is a food (Mayi), used to stimulate saliva flow during long walks (Vivian, 2013), while sugarbag, produced by the stingless native bee (*Trigona* sp.), is often found in the trunks (Blanchot & Grouset 2004, p.19–20). Cicadas (*Liyirr*) emerge from Ghost Gums—*Gunurru* to Yawuru people — whose flowering in Larja indicates the season for stingray *Birndany* and sliteye shark *Jurrawayi* (Lands and Mann 1990, p.111–2). MVT communities cover a tiny area but contain almost a quarter of the Dampier Peninsula flora species, providing Traditional fruits, medicines and materials, important water places and cultural sites.

Our understanding of the ecology, extent and location of CBGG and Minyjuru PECs has been greatly improved by surveys conducted by Tim Willing in 2013/14, and reports written with Louise Beames (EK) in 2015. Most of the work was undertaken voluntarily and supported through EK's Kimberley Nature Project. More than 90% of these PECs has now been mapped throughout the Broome Peninsula, subjected to a condition assessment and threat identification. Recommendations have been developed for each PEC community, individual patches and remnant trees.

Clearing for urban and industrial development is among the greatest threats. During the collation of the survey work and reports, both PECs experienced losses through clearing, just as unmapped Broome MVT did in 2012/3. Of the 260.1ha of CBGG community located during the survey, 8.75ha was cleared in 2014, as was 2.83ha of the 231.73ha of Minyjuru PEC within the township.

Almost 75% of the Minyjuru community within the township lies outside designated conservation reserves; almost half of the CBGG community remains exposed to development. Only 3 CBGG patches and no Minyjuru patches are fully protected. 31 of 63 CBGG patches and 8 of 19 Minyjuru patches remain unprotected.

If efforts are not made to avoid clearing PECs and TECs, development will seriously affect the extent, connectivity and ecological processes within and around the communities. Road-widening, reduced nature strips, housing redevelopment, weed infestations will also contribute to the attrition of aged remnant trees.

We recommended small changes to development zones and conservation areas to better protect these PECs, especially high-quality patches. We also recommended that the mapped remnant trees be listed on a Tree Register; local and state government, Nyamba Buru Yawuru, Landcorp etc. could cooperate to use the data and avoid unnecessary loss and damage to remnant trees.

The spread of weeds, including Neem *Azadirachta indica*, *Merremia aegyptia*, *Passiflora foetida*, Bellyache Bush *Jatropha gossypifolia* and Buffel Grass *Cenchrus ciliaris*, is the second greatest threat to each PEC. Neems spread by birds are readily establishing under shady Minyjuru/CBGG canopies, while weeds are becoming dominant in disturbed areas or where garden refuse is dumped. Arson and too-frequent late season burning continue to be major threats to Broome bushland.

Whilst we have provided maps and condition assessments to the Department to improve development planning, it is up to the Shire and developers to reduce clearing and obstruction and manage fire and weeds.

We recommended that planners and developers retain the integrity of the patches of PECs by placing a buffered protection zone around them. Development should only proceed under strict conditions, retaining aged Minyjuru/CBGG as remnant trees.

The surveys have increased our understanding of the ecology and condition of PEC and TEC areas throughout the Broome Peninsula. Had such surveys been conducted earlier, conservation zones could have been protected and unnecessary losses avoided. This knowledge must now be used to improve development and conservation planning. Areas of PEC or TEC that remain unsurveyed on the Peninsula should be thoroughly mapped and assessed.

For more information or for copies of the Minyjuru and Cable Beach Ghost Gum Reports please check our website: www.environskimberley.org.au or contact Louise or Tim Willing

References

Beames, L. (2013) *Valuable and Endangered. Working together to understand and manage threats to Monsoon Vine Thickets of the Dampier Peninsula. A summary of key findings. Environs Kimberley West Kimberley Nature Project 2011 – 2013.* Environs Kimberley, Broome.

Bellfield, A., Beames, L., Black, S. (2012) *Valuable and threatened, Monsoon Vine Thickets of the Dampier Peninsula. A Summary of Key Findings from The Broome Botanical Society.* Environs Kimberley, Broome.



The sweet purple fruit of the Minyjuru tree, *Sersalisia sericea*, is valuable *Mayi*.

Conserving South-western Australia's Rarest and Most Threatened Freshwater Fishes

PRESENTER:



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BIOGRAPHY:

Steve Beatty is currently a Senior Research Fellow at the Freshwater Fish Group, Centre for Fish and Fisheries Research (Murdoch University). He has conducted a broad range of research on the ecology and biology of fish and freshwater crayfish in Western Australia and has >140 publications in this field. His particular passion is increasing the understanding of threats facing south-western Australian species and ecosystems particularly climate change, water abstraction, salinisation, and introduced species.

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Introduction

- Rivers, streams and wetlands of southwestern Australia support populations of fish found nowhere else in the world. Many of these species are threatened and populations are declining in both abundance and distribution. In order to help understand the drivers of these declines and devise management actions to halt them, this collaborative project aimed to fill key knowledge gaps relating to the ecology of three of south-western Australia's most threatened freshwater fishes, the Western Trout Minnow, Balston's Pygmy Perch and the Little Pygmy Perch, one of Australia's 'newest' fishes.

- The key tasks were to:
 1. Determine the distribution, migration patterns, critical spawning habitats;
 2. identify critical habitats that sustain populations over the summer period;
 3. assess the risks to the ongoing sustainability of populations;
 4. recommend management actions for the protection of populations and preservation of critical habitats; and
 5. increase community awareness with regard to these threatened fishes.

Methodology

- This project represented the largest single project focussed on the ecology of southwestern Australia's endemic fishes and included three years of field-based research. Activities were undertaken throughout a large proportion of the known historical range of the target species, extending from catchments immediately south of Perth to Two Peoples Bay, just east of Albany.
- A particular focus of the project was to provide new ecological knowledge on each species which required multiple sampling events concentrated in specific catchments including the Kent, Goodga and Angove rivers for the Western Trout Minnow; Millyeannup Brook and the Blackwood River for Balston's Pygmy Perch, and; the Mitchell, Hay and Denmark rivers for the Little Pygmy Perch.
- In excess of 150 sites were sampled across the region using a combination of GIS, aerial (helicopter) mapping, and on-ground fish sampling, which included; fyke netting, seine netting, and larval light trapping.
- Movement patterns, abundances (relative and actual), current distributions, and critical habitats of all species were determined across multiple catchments.
- The first remote passive integrated transponder (PIT tagging) telemetry study for a south-western Australian freshwater fish (Western Trout Minnow) was conducted to determine fine scale movements of the species (and the Common Jollytail) through the Goodga River Fishway and to determine the population size of the threatened species.
- The first Visible Internal Elastomer (VIE) tag of south-western Australian fishes in a river environment was conducted to determine the population sizes of four species in refuge pools in the Hay River.
- The information gathered is being used to assess the threats and risks to the species and to develop management approaches to enhance their conservation.

Key Project Outcomes

Western Trout Minnow (*Galaxias truttaceus*)

- Distributional range of Western Trout Minnow increased. Distribution in the Kent River confined to tributary and mainstem habitats in the lower catchment where permanent, low salinity habitats provide refuge over the summer period. Natural barriers probably restrict upstream distribution.
- The life-cycle involves utilisation of riverine and lake habitats at different life stages. Migratory patterns of Western Trout Minnow strongly linked to a hierarchy of river flows over daily to seasonal time scales.
- Passage through a vertical-slot fishway in the Goodga River during the autumn breeding season is correlated strongly with flow pulses. Also shown to be able to 'climb' over the weir (Close *et al.* 2014).
- Spawning of Western Trout Minnow occurs over a period of months after the onset of winter rains. Spawning occurs on flushes of elevated river flow during autumn and early winter. Extensive searches and sampling for eggs failed to identify critical spawning areas. Distribution of newly hatched larvae suggest that spawning occurs in riverine habitats in the lower reaches of catchments
- Populations size (mature) of the species in the Goodga River is estimated to be ~13900. Slightly lower CPUE in the Angove River and very low abundance in the Kent River.

Balston's Pygmy Perch (*Nannatherina balstoni*)

- 31% decline documented in the area of occupancy (Morgan *et al.* 2014). The species may have been lost from at least 5 catchments from which it was previously known to occur including the Moore River, Turner Brook, Dombakup Brook, Marbelup Brook, and the King River. Two previously undetected populations were discovered in the Meerup River and Elsie.
- The species migrates into seasonally flowing tributaries in systems impacted by secondary salinisation. Examples include Millyeannup Brook in the Blackwood River and Mitchell River in the Hay system
- A critical spawning and nursery habitat for the Blackwood/Millyeannup population was discovered for the first time

during this study, comprising seasonally inundated wetlands in the headwaters of Milyeannup Brook. In the Hay/Mitchell system, the three sympatric pygmy perches displayed a seasonal partitioning of reproductive timing with *N. balstoni* spawning earliest in mid-winter, followed by *N. pygmaea* in late-winter/early spring and lastly *N. vittata* in mid/late-spring.

- Aerial and follow up on-ground surveys identified critical baseflow refuge habitats in a number of catchments that housed restricted and isolated populations of this threatened species. The most critical of these were located in the Hay River, Margaret River, Milyeannup Brook and Denmark River.
- The refuge habitats identified are threatened by various processes including inter alia, declining rainfall/flow due to climate change, alien fish species, and secondary salinisation.

Little Pygmy Perch (*Nannoperca pygmaea*)

- The Little Pygmy Perch was formally described during this study (Morgan *et al.* 2013). The known distribution prior to this study was a highly restricted section of the Hay River and adjoining Mitchell River (less than 2 stream kilometres), but new populations were discovered in the Denmark and Kent rivers and Lake Smith.
- Distribution includes middle-upper reaches of the Denmark River (~30 river km (rkm)) and middle-lower reaches of the Kent River (~50 rkm), as well as another population in Lake Smith located near the Donnelly River.
- The Hay River population was found to undertake a short breeding migration into the Mitchell River each winter when the tributary begins to flow before retreating back to permanent refuge pools in the Hay River mainstem when flows declines in the Mitchell River.
- The VIE mark-recapture program in key baseflow refuge pools in the Hay River revealed that the number of Little Pygmy Perch was ~ 90 fish in one pool compared with ~8117 Western Pygmy Perch and just ~26 Balston's Pygmy Perch.
- Extensive monthly sampling over a two-year period in the Hay/Mitchell system revealed that the critical spawning habitat for this population is located in the lower section of the Mitchell River (within ~3 km of the Mitchell/Hay confluence). The exact habitat characteristics for spawning were not identified; however, it is likely that spawning occurs amongst flooded riparian vegetation in the Mitchell. Similarly, the critical breeding/nursery habitats for the Denmark River population, appears to be restricted to a solitary tributary in the upper catchment that features extensive areas of seasonally inundated sedgeland that may provide critical spawning/nursery habitat.
- The highly restricted extent of occurrence of this species renders it susceptible to catastrophic losses from possible future perturbations such as prolonged drought, drying of critical baseflow refuges, secondary salinisation, and existing (i.e. Eastern Gambusia) and future alien species introductions.
- From the aerial and ground surveys undertaken to map refuge habitats, two artificially created pools, built to provide a water source for fire-management activities, were shown to be utilised. In fact, these artificial refuges represented ~50% of the known refuge habitat in the key spawning tributary in the Denmark catchment.
- There is good potential to mitigate the threat of population declines or losses of this species by providing additional human-created refuge habitats, using those identified in this study as a model and this is one of the key recommendations to emerge from this project.

Risk identification

The findings are being used to identify and rank risks to the population to refine management actions designed to help prevent or halt their decline. Several additional knowledge gaps have also been identified.

While the impacts, likelihood and consequence of the various impacts vary between species, key threats, their impacts and mitigation strategies that were identified are summarised as follows:

- **Flow reductions:** Caused by rainfall reductions (climate change), water abstraction (e.g. irrigation, potable), landuse changes. Impacts on migratory pathways, nursery habitat, and resource availability resulting in less recruitment (see Beatty *et al.* (2014)). Need to ensure sustainable water abstractions, landuse (impacting hydrology), and captive breeding or relocations as a back-up to mitigate extinction risk.
- **Refuge loss:** Caused by rainfall reductions (climate change), water abstraction (e.g. fire water points). Species shown to be most vulnerable during baseflow when they become concentrated in pools or small sections of rivers. Creation of new strategic waterpoints is an option along with awareness and management of existing refuge pools, and captive breeding.
- **Water quality decline:** Salinisation trajectories for certain rivers remains an ongoing threat, also future temperature increases due to climate change (along with nutrient inputs, dissolved oxygen declines). Exceeding species tolerances possible with baseflow populations most affected (e.g. salinity in main channel of Kent and Hay rivers) could reduce

the range and threaten populations. Environmental tolerances of all species should be determined to model viabilities. Ongoing actions to address salinity important in key rivers (such as was achieved in the Denmark River).

- **Introduced species:** Known to be a major stressor on native fishes and a sharp decline in introductions has occurred over recent decades in this region (Beatty and Morgan 2013; Hourston *et al.* 2014). Result in competition, predation, aggression, introduction of disease. *Gambusia holbrooki* already in main channel of several rivers. Prevention of new introductions important (through education), and monitoring for new introductions to maximise chances of elimination prior to establishment (e.g. Goldfish eradication in the Darch Brook, Margaret River).
- **Instream barriers:** Some level of impact in certain rivers for these species. In general, instream barriers prevent migration (for spawning and dispersal) and can increase mortality and reduce recruitment to populations. Fishway prioritisation and barrier removal (where feasible) can mitigate these impacts (e.g. Beatty *et al.* 2013).
- **Riparian degradation:** Riparian vegetation is important for providing food, shelter, shade and bank stability (along with nutrient uptake) that benefits fish and aquatic ecosystems generally. While considerable amounts of the remaining distribution of the target species was shown to be in State Forest or National Park, protecting remnant vegetation on private land throughout catchments remains very important (such as fencing from stock, rehabilitation where required) such as in the Goodga River.

Acknowledgements

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Provision of Photo-monitoring Services for NRM Projects

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Felicity Beswick completed her honours studies on marine macroalgae at the University of Adelaide before heading West in 2011. Felicity joined NACC in 2014, after a short stint in State Government and works as the Coastal and Marine Project Officer based in Geraldton.

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Introduction

Photo-monitoring is the process of using a series of images from the same location to record changes in the environment. Over time, these photo series become more and more valuable for recording changes such as beach erosion, vegetation regrowth and crop health. In 2013 the Northern Agricultural Catchments Council (NACC) with Coastwest assistance developed the photo-monitoring smartphone app Photomon.

Background

Photomon is a smartphone app that is available for use on both Apple and android devices. It allows for easy photo-monitoring of particular sites using automatic database upload and a standardised field of view to assist with data consistency. Photomon is currently implemented in a number of NACC's programs, the largest of which is an extensive beach monitoring program started in 2009. This program now includes over 50 volunteers who assist with monitoring over 90 coastal sites from Kalbarri to Guilderton.

Since its inception in 2013 the app and the database have undergone various improvements, one of which is the development of the photo-viewer page. The photo-viewer is directly linked to the database and allows for easy viewing of site specific photo series over time. The viewer is available to the public via the NACC website and NARvis, allowing the data collected to be accessible to all.

Photomon greatly simplifies the process of environmental monitoring and broadens the opportunities for community engagement in NRM. High demand for this service has led to further development of NACC's photo-monitoring program to include a simple back-end database that can be configured to accommodate numerous separate projects. This database is now available to third parties to establish and administer their own photo-monitoring projects.

Conclusion

Photomon is a great qualitative tool that can be used in the field with ease to photo-monitor a variety of projects that intend to capture change over time. Its simple design lends itself to citizen science programs and the most current improvement allows for numerous separate projects, each administered by their own program leader. NACC is now in the position to offer this Photomon service to external third parties, effectively allowing the establishment of individual photo-monitoring projects in a variety of fields throughout Australia.

Large Scale, Low Cost Biodiverse Reforestation Carbon Sinks

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Kent is a founding Director of Auscarbon Pty Ltd (2006) which specialises in revegetating degraded areas of the Western Australian wheatbelt with a biodiverse mix of endemic native species. As project manager, he has been responsible for successfully establishing nearly 10,000 ha on seven properties in the Mid West. Kent has lived and worked in the Mid West area as a farmer and pastoralist for over 35 years, recognising that environmental and economic values can co-exist to produce win/win outcomes. Kent is a founding Director of Auscarbon Pty Ltd and Director of Carbon Neutral Pty Ltd with a key responsibility for business development. Kent is also currently a Board member and Director of the Northern Agricultural Catchments Council (NACC), a non-profit organisation supporting people to support the natural environment. MLM Curtin Business School

Introduction

Carbon Neutral, along with its' parent company Auscarbon, has successfully developed World class direct seeding techniques using endemic native seeds across 10,000 ha of degraded farmland in the Mid West of WA.

Originally developed for carbon sequestration, this initiative has resulted in unique biodiverse environmental plantings that have enriched the local region with measurable and positive environmental, economic, social and heritage outcomes.

Carbon Neutral has also developed the Yarra Yarra Biodiversity Corridor, a long term vision for reconnecting remnant vegetation for birds and animals to transition through the landscape. All this is occurring in one of the World's 35 biodiversity hotspots, the South West of WA in areas with annual rainfall of less than 330mm.

Background

Historic over clearing in excess of 90% in some areas of wheatbelt WA has led to environmental, economic, social and heritage degradation and loss.

Lower winter rainfall, degradation through salt, water and wind erosion and the changing nature of some soil types (acidification) has led to more and more areas becoming unprofitable for normal agricultural land use.

The emerging carbon industry in the mid 2000s introduced positive economic signals to monetise revegetation activities on a larger scale than had previously been attempted through individual land owner land care initiatives.

Methodology

To establish large scale revegetation areas, a biodiversity model was chosen with up to 40 endemic species being used, rather than a monoculture. It seemed appropriate to replicate what was there originally, rather than recreate something that had not evolved over eternity.

A World class direct seeding method has been developed which has enabled thousands of plants to be successfully established per hectare (with up to 40 species). This has reduced the establishment cost per hectare substantially.

Project Outcomes/Conclusion

Carbon Neutral has successfully established large scale low cost biodiverse reforestation carbon sinks over 10,000 hectares on degraded farm land. Besides sequestering and storing carbon, numerous measurable environmental, economic, social and heritage benefits have occurred.

This has enabled Carbon Neutral to become the first company in Australia to get internationally recognised premium Gold Standard accreditation for the projects.

Small Investment Big Outcomes: Celebrating Landcare on the South Coast

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BIOGRAPHY:

David joined South Coast NRM in 2008 and works in the Albany area. He is a Regional Landcare Facilitator and is a part of the senior operations team and joint manages South Coast NRM's Regional Capacity Program with co-author Kylie Bishop. David fulfils a number of roles that includes working with the landcare community, supporting sustainable agriculture initiatives, coordinating youth in NRM and providing support to landcare groups (sustainability and capacity). David enjoys the interaction with community and other NRM professionals and covers the western area of the South Coast NRM region (Walpole to Jerramungup). His interests include sustainable agriculture, community service (Regional Development Australia Great Southern and Albany Apex Club), bush walking, travelling and a good local beer. David's efforts have been recognised in recent years. In 2011 he won the West Australian Landcare Awards Australian Government Local Landcare Facilitator. Before working for South Coast NRM, David was employed for three years as the Oyster Harbour Catchment Group's NRM officer where the group won the 2008 Landcare Group of the year.

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Introduction

How do you turn a small investment of \$19,000 into almost \$150,000? South Coast NRM did it by engaging over 990 directly into 38 projects, generating almost \$125,000 of in-kind contributions. The program has worked with 27 groups, schools and not for profits, many of whom have not previously been involved in Landcare or Natural Resource Management.

This program runs every September during National Landcare Week to promote and celebrate Landcare on the South Coast with a devolved grant scheme designed for schools, not-for-profits and the general community. Landcare Week was deliberately chosen as the period to run this program because the general community easily identifies with the brand and the values that it represents. The grants are made available for small scale projects that contribute to the region's productive agricultural and unique biodiversity. Activities have included weeding activities, tree planting, rubbish clean-ups, educational events and displays.

Background

South Coast NRM delivers a significant portion of its on-ground works program in partnership with eight community landcare groups. With much of the current investment through the Australian Government's National Landcare Programme focussed on larger strategic outcomes, many smaller scale projects can get overlooked. In addition, accessing funding through formal grant programs can be very time consuming (particularly for volunteers), and is often a significant barrier to participation. This leads to the needs of the community, that may have considerable local support and benefit, not being funded.

To address these issues, South Coast NRM's Regional Landcare Facilitators instigated the Small Grants Program. The Small Grants Program is designed to ensure the needs of the broader community are met and that they are engaged and able to participate in Landcare in a meaningful way. The Small Grants Program provides much-needed resources to many of the smaller groups that would otherwise miss out on the opportunity to participate.

The RLF Small Grants Program

Besides the provision of the small amount of seed funding, the Regional Landcare Facilitators assisted groups with the application and reporting process, participation or representation at all of the events and assisted with local media exposure. By keeping the process as simple and flexible as possible, we have encouraged and enabled many new people to participate in Landcare. This program has allowed us to work with grass roots community groups to achieve and celebrate local change.

The 7 guiding principles of the Small Grants Program:

- 1) Keep the process as simple as possible. Many applicants are not used to drawn out approval processes, funding cycles, milestone periods, complex financial requirements or detailed reporting. As projects are small scale, the amount of time invested into applications and reporting needs to be minimal.
- 2) Simple expression of interest form – The less time spent on filling in forms, the more time they have for on-ground activities. The application consists of a one page form that briefly explains what the group wants to achieve, how it connects to landcare, when, who will be involved and a budget.
- 3) Be flexible in the type of activity. If it encourages participation and contributes to the regions productive agriculture and unique biodiversity; give it equal consideration.
- 4) Be flexible in timing. If it doesn't fall exactly during landcare week, it won't fail to achieve the outcomes of the program.
- 5) Make it easy to access the funding and avoid the one payment method fits all mentality. Have multiple methods to access the funds (invoice, reimburse on receipts, pay on their behalf etc.). This also makes the lives of treasurers a lot easier as well. Try to avoid volunteers drawing down on their own accounts if at all possible.
- 6) Provide support. Try to attend each event, create opportunities for the media to get involved and encourage and support new projects.
- 7) Simple reporting. We ask the successful applicant to take at least 3 high quality pictures and return a briefing on what occurred at their event. This should be no more than half a page of detail. Again, be flexible here to keep it simple.

Conclusion

Through this Small Grant Program has worked with 27 groups to deliver over 38 projects that may not ever have occurred. The south coast community has established 4.5 ha of vegetation, cleaned 32 ha of rubbish and removed 19.6 ha of weeds. It has established investment into 10 educational infrastructure projects (including vegetable gardens, mobile green houses and frog ponds), provided materials for several events and sent students to Kids training Kids conferences. This approach and the funding to support it is critical to the ongoing success of smaller community grants and a decentralised approach through regional groups is more effective than a larger centralised approach. This initiative clearly shows that you can have maximum impact on NRM values with minimal funding and effort when you connect regionally based professional support with aspirational and inspirational local people.

Let's Talk Soil Carbon

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Introduction

Unlike carbon in the air, which is recognised universally as problematic, soil carbon is little recognised or appreciated. Yet this essential element of all fertile soils is fundamental to every form of life on, above and below the soil. Humans and all other living organisms are composed of carbon at the cellular level. The total amount of carbon on Planet earth does not change only its form and location. This carbon exists in what we call “the carbon cycle”. Plants are uniquely able to take atmospheric carbon and create simple sugars to feed themselves as well as soil living organisms. These plant modified carbon forms eventually go back into soil where they provide basic fertility. The fact that the carbon cycle and soil fertility are out of balance has prompted the United Nations to declare 2015 the International year Of Soil. This reflects looming crisis in soil degradation and loss, falling food production yields and an increasing world population. Twentieth century farming and soil management systems are depleting soil carbon and transferring it into the atmosphere.

What is soil carbon?

There are four different types of carbon:

- The living plants
- The recently dead—particulate organic carbon coming from crop residues, source of soluble nutrients and relatively quick to break down.
- The very dead—humus and related compounds, which play a role in all key soil functions. Only 10-20% of the topsoil becomes humus.
- The memory—mainly charcoal, unavailable for microbes, but can hold water and nutrients.

What is the role of soil carbon?

A healthy soil with a high level of soil organic carbon (around 5%) will:

- Sequester the carbon in the atmosphere.
- Regenerate our soils to produce food for a growing population.
- Add minor nutrients back to our food to improve its nutritional value.
- Improve farmers' profitability when there is a high presence of humus in the soil.

How can we build soil carbon?

Soil carbon will improve soil performance by impacting the water and nutrients efficiency and soil biology. It will improve soil structure and increase root growth. Soil carbon is the key to unlock soil health.

There are many ways that we can build soil carbon. These include adding composted products to the soil, retaining stubble in grain production, rolling green crops, covering the soil at all times with plants or mulch, cell grazing and crop rotation. The most important factor is to provide the soil with the right quantity and form of carbon, depending on the soil type.

Where do composted products fit into this restorative/carbon farming approach? These contribute to high humus levels in soil, this is the form of carbon that delivers real fertility. It allows moisture to move through heavy soils more effectively while assisting sandy soils to retain moisture. It can increase water holding capacity by 100% with an addition of 100 m³ per hectare. It increases the soils ability to hold onto nutrients in a plant available form, this is called the Cation Exchange Capacity. This increased CEC has massive implication in preventing wasteful fertiliser application. Currently in excess of 50% of nitrogen and phosphorus fertilisers miss their target plants resulting in unwanted side effects including nutrient pollution of waterways and aquifers. This means cost saving in the provision of fertilisers and other farm inputs. By encouraging soil biology, the health of the soil is enhanced which means that the benefits flow to all the animals including humans that consume food grown on or in it.

Conclusion

The challenge for the twenty first century is to restore balance in the carbon cycle: "Doubling of the organic content of the soil, if practised Australia wide could capture most CO₂ released in the country", Dr Martin Stapper.

We need to change our farming behaviours by putting soil back to the centre of our farming systems. Our objectives should be to improve soil health and productivity. Regenerative farming will require the agricultural industry to have a holistic approach to farming systems and develop solutions benefiting the farmers' triple bottom line.

- Economical: ensure growers' profitability with higher yields and higher quality crops.
- Environmental: protect the farmers' licence to operate.
- Social: the agricultural industry is providing jobs to a significant population in WA.

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Development of an Indigenous ‘Ranger Incubator Framework’

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BIOGRAPHY:

Spanning national and international contexts Chris has spent more than 20 years engaging land managers and communities from all walks of life for socio-economic and environmental outcomes. He has lived and worked all over the Americas and the Caribbean, including more than six years working with Amerindian communities in Central and South America. He started his career in 1990 in the semi-arid rangelands of western NSW with the then Soil Conservation Service, delivering rangelands extension services to pastoralists from Hungerford to Ivanhoe and Nyngan to Wilcannia. Between 2003 and 2013 Chris held the position of WWF-Australia’s Program Manager—Southwest Australia Land Manager Engagement. He worked to promote private land conservation that complements the National Reserve System in Southwest Australia and managed WWF’s Wheatbelt Woodlands private land conservation programs. Prior to this, he spent more than five years advising NGOs and governments in Latin America on environmental and development projects. In his spare time Chris likes to do back country hikes, sea kayaking quiet estuaries and singing songs at local farmers’ markets or around the campfire on a swag.

Introduction

Rangelands NRM, through partnership and collaborations with Central Desert Native Title Service, Kanyirninpa Jukurrpa, Pila Nguru and Greening Australia, has developed a ‘ranger incubation framework’—a step-wise tool to guide aspiring ranger groups through the phases of a ranger program.

Three phases include ‘discovering’, ‘planning’ and ‘doing’ (see Figure 1).

Rangelands NRM engages with Traditional Owners and Aboriginal land managers to identify support for land management projects throughout the rangelands regions of WA.

Background

Rangelands NRM engages with Traditional Owners and Aboriginal land managers to identify support for land management projects throughout the rangelands regions of Western Australia. One of the means for undertaking these projects can be through the establishment of ranger teams. But with seed funding thin on the ground, the support for the crucial development phase of forming a sustainable ranger group remains problematic. Rangelands NRM receive ongoing requests to assist with the establishment of ranger programs.

Methodology

With the shared experiences of those already in this space, Rangelands NRM has developed a ranger incubation framework—a step-wise tool to guide aspiring ranger groups through the ‘Discovering’ phase required before commencing the more focussed ‘Planning’ and ‘Doing’ phases of a ranger program. A ‘So, you want a Ranger Team’ poster (Figure 1) has been developed to assist the process and explains the three phases—‘Discovering’, ‘Planning’ and ‘Doing’.

Project Outcomes/Conclusion

A ranger forum in March 2014 provided the opportunity for groups to collectively look at the key lessons from those few existing ranger initiatives and how these lessons might be applied to their own ideas for developing a ranger program. Having a framework will help people to be aware of the pitfalls that invariably plagued early start ups, and ensure they consider all the components of a sustainable group formation.

Rangelands NRM and interested parties continue to explore ways to make the conversation about starting a ranger group that much more informed and supported with existing knowledge in and between the regions.

Figure 1. The ranger incubator model pathway



Working with the Community to Increase Environmental Skills and Knowledge in NRM

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Mick graduated from Curtin University's School of Environmental Biology in 2000, with a passion for ecology and burgeoning interest in why people want to look after their environment. From 2002–2013, Mick worked in the government and NGO sectors negotiating conservation covenants with private landholders to protect threatened vegetation in the heavily cleared Wheatbelt Regions of Western Australia.

Since 2013 Mick has brought his passion for working with the community and interest in WA's rich biodiversity together in his role as Environmental Friends Group Officer at the Shire of Kalamunda. Supporting more than 40 Friends Groups and their members, providing bushland management advice, monitoring planting programs and delivering skills-based training workshops are all key to the historic and ongoing success of the Shire of Kalamunda's Environmental Friends Group program.

Introduction

The Shire of Kalamunda has supported the involvement of community groups and individual volunteers in its Environmental Program for over a decade. Each year more than a hundred environmental volunteers from over 40 Friends Groups offer their time, energy, skills and knowledge towards protecting and enhancing many of the natural bushland areas in the Shire of Kalamunda.

Working closely with our volunteers and with the support of partner organisations, the Shire of Kalamunda has a unique opportunity to develop close working relationships with the local community, including working to identify training needs, skills gaps and knowledge deficiencies.

The challenge we have faced is how to organise relevant training, provide the right training to the right people and improve our volunteers knowledge of what they are doing and why it is so important.

Background

Friends Groups are most often small, unincorporated community groups made up of individuals with a passion for conservation directed at their local bushland reserve. In Kalamunda this group of volunteers contributes upwards of 1,000 person hours towards protecting and managing Shire reserves per annum.

The Shire of Kalamunda has approximately 400 bushland reserves to manage, including many small urban reserves, several long thin streams and creek reserves, a handful of large regionally significant reserves and large expanses of state forest on the outskirts of the Perth metro area. All of these reserves are important and managing them requires a strategic approach to ensure the right resources are going to the right reserve.

This is where the partnerships the Shire of Kalamunda has with its Friends Groups' really comes into its own. Without their help managing all this bushland would be a much more challenging and expensive process.

In recent years the Shire of Kalamunda has undertaken a process of identifying skills gaps in our Friends Groups, delivering targeted training workshops and measuring the resulting uptake of skills and knowledge.

This training and the subsequent on-ground outcomes have only been possible due to the commitment of each of the groups, which are supported by a close and understanding relationship between the Shire and each individual and group about what we are collectively working to achieve – i.e. better quality bushland reserves across the Shire.

Methodology

Put simply, we ask our Friends Groups what they want to do and how they want to achieve it.

Then, within the framework of our Friends Group Manual (available online) and being guided by individual Action Plans, we provide practical support to their various environmental activities. This could involve simple activities like supplying herbicide or tools to Friends Groups', more detailed tasks like applying for grants or even working with them to develop new Action Plans to guide future activities.

The Shire also runs skills workshops and informational/educational activities specifically designed to inspire and enthuse the community while providing relevant skills to the group members to help them achieve their works.

Recent skills training includes how to undertake photographic monitoring, using remote cameras to monitor wildlife, 'meet the wildlife' events, identifying macroinvertebrates in creeklines, undertaking phosphite stem injection training to fight *Phytophthora Dieback*, using Apps like the Atlas of Living Australia/OzAtlas to identify natural values or providing training workshops on how to safely apply herbicide.

A key aspect of our training workshops is how we measure skills and knowledge prior to and after each given workshop or skills session. Participants are given a simple scale to rank their skills or knowledge; 1—none, 2—a little, 3—some, 4—lots and 5—extensive.

This simple scaled scoring system allows the training recipients to measure the effectiveness of our training and identify if we are effectively filling their skills and knowledge gaps.

Project Outcomes/Conclusion

The outcome of the innovative and engaging training workshops provided by the Shire of Kalamunda is a measurable increase in our communities' skill level and knowledge of NRM issues.

Receiving training, being part of the 'bigger picture' and having a chance to incorporate social aspects into Friends Group activities has improved the groups' ability to undertake NRM activities like identifying and removing problem weeds, monitoring project progress and applying herbicides in a safe and effective manner.

By working closely with our community, listening to their needs and providing meaningful training opportunities, the Shire of Kalamunda has been able to support a large number of environmental volunteers, making our environmental programs wider reaching, more effective and more meaningful for our community.

The Shire of Kalamunda would like to thank all Environmental Friends Group members for their hard work and commitment to protecting and managing our unique natural assets. We couldn't do it without you!

Can Bird-Monitoring be Used to Assess the Ecological Outcomes of Natural Resource Management?

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Background

The assessment of ecological outcomes requires the long-term monitoring of appropriate indicators. Not surprisingly the post-treatment ecological outcomes of natural resource management (NRM) interventions are rarely assessed and are either unknown or unreported. This reduces the capacity for adaptive management and risks future political support for resourcing the NRM system.

The commitment required for long-term ecological monitoring generally precludes the continuous engagement of professional ecologists. Citizen-science models that combine the expertise of professionals (or mentors) with the observational skills of amateurs provide a potential solution to assessing long-term ecological change. However only two skilled amateur constituencies are large enough to provide that capacity, these are based on wildflowers and birds.

This paper considers how the community-based monitoring of birds might assist in assessing the long-term ecological outcomes of NRM. A monitoring system based on the 'standard search' method and functional groups analysis is being evaluated to assess the ecological outcomes of NRM in the Gondwana Link.

Bird Monitoring in the Gondwana Link

The Gondwana Link vision seeks to facilitate management actions to restore impaired ecosystems across a broad swath of south-western Australia by restoring natural linkages and flows and by mitigating ongoing threats. The Link adopts an adaptive management framework (through its Conservation Action Plans CAPs) to achieve identified conservation outcomes using a range of strategies. Adaptive management however requires the monitoring of the ecological outcomes of strategies and actions to periodically re-assess their effectiveness. A effective ecological monitoring program is required for the Gondwana Link that:

1. Provides comparable ecological outcomes measures across four bio-regions (South-West Forest, Esperance Plain, Mallee and the South-western Interzone).
2. Provides comparable ecological outcomes measures at a range of patch scales from small bush remnants, re-vegetated areas and small habitat patches to large stands of continuous native vegetation.
3. Are suitable for both surveillance and for monitoring management interventions within a experimental design framework at a variety of scales.

4. Are based on ecological indicators that relate directly to actions taken to restore impaired processes or to mitigate identified threats.
5. Generate sufficient data to provide the required statistical power.
6. Are achievable and cost-efficient.
7. Are not too limited by seasonal sampling constraints.
8. Involve indicators that can utilise the available 'citizen-science' capacity to assist in collecting and processing data.
9. Employ sampling methods that provide the data necessary to service the indicators and match the skills, capacity and motivations of both professionals and community volunteers.

Whilst a variety of plant and animal indicators (eg. various invertebrate groups) may be powerful tools for monitoring ecological processes most require knowledge and skills in sampling and identification that reside in only a few individuals, often professional experts. Other 'popular' subjects such as reptiles and mammals would require capture methodologies and permits that are mostly restricted to professionals with demonstrable experience in fauna sampling. These vertebrate groups are also unlikely to generate sufficient data to serve indicator requirements. Only two natural history interest groups emerge as having sufficient community-based knowledge and capacity to engage in ecological monitoring programs in Western Australia. These constituencies are based on the study of plants (wildflowers) and birds. Indeed the largest centrally coordinated citizen-projects around the world tend to be based on birds.

Generic measures of species richness or diversity do not usually carry much information about changes in threatening or ecological processes. One way to refine bird survey data to develop indicators might be to allocate species to functional groups that respond to specific ecological changes in a predictable way (e.g. the numbers of ground feeding / nesting resident species may provide early warning of changes in cat predation following fox baiting programs). Ultimately the functional groups could be consistent across the bio-regions even if the species composition is not directly comparable.

A critical step in developing indicators based on functional groups depends on the allocation of bird species in each bio-region. Factors that will assign bird species to functional group include foraging and nesting ecology, residency (at landscape scales) and socio-biology. Research work that may support the defensible construction of functional groups has occurred, or is in progress, in all the Gondwana Link bio-regions (e.g. South West Forests—Boyd Wykes, Fitz-Stirling—Nic Dunlop, Esperance Plain DPaW, South-West Interzone—BirdLife Australia Great Western Woodlands Project).

In the Fitz-Stirling region of the Gondwana Link a bush-bird banding project has been utilised to generate a 'residency index' which is useful in identifying the most relevant indicator species and to assign species to functional groups. Other techniques such as stable isotope analysis have provided useful insights into the way some bird species are using revegetated and remnant patches in the landscape.

The other critical step is to ensure that the survey methodology generates equivalent data across bioregions, patch-sizes and NRM treatments. It is probable that existing survey methods utilised in this region and elsewhere do not. These methods use pre-determined sample areas and sampling times and almost certainly lead to 'false negative' errors that would undermine functional group indicators. Newer methods (see Watson 2003) that allow the accumulation rate of species records to determine the sample area and sampling duration have promise in over-coming the problems, both with patch size and habitat or regional differences in bird densities. A hybrid method combining a short restricted time and area census and a standard search is being road-tested with observers from BirdLife Australia (WA Branch).

Reference

Watson, D.M. (2003). A 'standardized search': An improved way to conduct bird surveys. *Austral Ecology* 28, 515–525.

Project Dieback—Action and Opportunities for Protecting Biodiversity Assets

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I've been employed as South Coast NRM Project Dieback leader since late 2013, moving into the role after working as Dieback project officer west. I began my natural resource management career in the Perth northern metropolitan region eight years ago. Since then I've undertaken varied roles in catchment management, water quality analysis, invasive species management as well as assisting in and coordinating management strategies and planning.

Abstract

The Southwest Australia Eco-region is one of 34 global biodiversity hotspots and covers more than 300,000 sq km. Over 1 million hectares is infected with the plant disease Phytophthora Dieback. Phytophthora Dieback is a plant disease caused by *Phytophthora cinnamomi*, an introduced soil borne plant pathogen that can devastate plant communities. It affects up to 40% of native species within the south-west of Western Australia (WA). The pathogen can irreversibly alter plant communities, killing susceptible species, many of which are both iconic and fundamental to the ecosystems they support.

Project Dieback facilitated by South Coast NRM in conjunction with project partners was undertaken in response to the need for an urgent coordinated response to Phytophthora Dieback at landscape scale. Prioritising the most important areas which offer the greatest chance of successful disease control or mitigation, maximises current and future Phytophthora Dieback investment. This State NRM funded project has developed a State Phytophthora Dieback Management and Investment Framework which identifies Priority Protection Areas (PPAs) representing the most significant examples of ecosystems supporting plant species and communities vulnerable to Phytophthora Dieback within the south-west of Western Australia.

The Framework provides a logical process and operational toolkit to develop area specific management actions including on ground activity, planning, engagement, communication and structured training to prevent the further spread of Phytophthora Dieback at a landscape scale. This facilitates a standardised approach for targeted management and investment across tenure enabling collaboration between key stakeholders providing optimum return for the preservation of the state's unique biodiversity assets. The Framework and associated tools; its implementation (Priority Protection Area case study); challenges faced and; 'where to next?' will be presented.

Restoring Flora and Habitats on the Amazing Abrolhos

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Maryke Gray is the Biodiversity Conservation Projects Manager at Durack Institute of Technology's Batavia Coast Maritime Institute (BCMI). She is a passionate ecologist, with a keen interest in threatened species, biodiversity monitoring, GIS and invasive species management. Maryke studied at James Cook University and has over 20 years experience in the field of biodiversity conservation, having worked in Central and East Africa before moving to the BCMI in Geraldton, Western Australia in 2014.

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Introduction

The Abrolhos islands—a chain of 122 islands that lie approximately 70 km off the coast of Geraldton, Western Australia—are home to millions of birds including the largest colonies of Wedge-tailed Shearwaters in the eastern Indian Ocean and several rare bird species that exclusively nest on only a few of the islands. Over the decades, invasive weeds and loss of habitat have placed immense pressure on the bird species, as well as many other priority species including the Australian Sea Lion, Abrolhos Painted Button Quail, Brush Bronzewing, Abrolhos Spiny-tailed Skink, Abrolhos Dwarf Bearded Dragon and Carpet Python. The Durack Institute of Technology's Batavia Coast Maritime Institute (BCMI) in partnership with the Northern Agricultural Catchments Council (NACC) are working to restore native plant biodiversity at key sites on the islands, through strategic restoration activities including planting with local provenance native plant species and threat abatement measures.

The project seeks to implement some of the key recommendations of regional biodiversity strategies for the Abrolhos islands by implementing threat mitigation measures. Some of the key threats to the islands include invasive plant species and erosion at key sites. The project will improve native flora and habitats at the islands through implementing erosion control measures, and protecting vital seabird breeding habitat by weed control and revegetating areas that have been highly impacted by weeds and/or land use practices.

To date eight sites (encompassing 14 islands) have been selected for revegetation and threat abatement activities. Seeds and cuttings of native plant species collected from the islands are propagated and grown-out at BCMI's accredited biosecure nursery. Tube stock is later planted within restoration sites at the islands to re-establish vital habitat and food for native animals such as seabirds, reptiles and sea lions. The main weeds being controlled by the project are Weeds of National Significance, as well as State and Local priority weeds. Weed management is via hand removal and chemical control including foliar spraying and cut stump method. Different erosion control treatments: 1) coir matting and 2) coir matting with coir logs, are also being trialled at the islands to assess effectiveness.

Project Outcomes/Conclusion

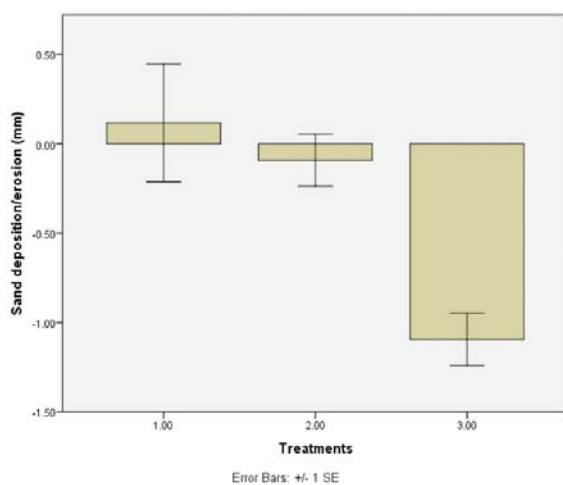
Revegetation

To date over 10,000 local provenance seedlings (20 different species) have been planted on three different islands covering an area of approximately 10 hectares. Plant survivorship one year after planting was 88% with the highest survivorship shown by *Olearia axillaris* (93%) and the lowest by *Ficinia nodosa* (80%).

Erosion Control

Sand accretion/erosion was measured in nine quadrats (10 m x 10 m) at the revegetation site on North Island and the data analysed using a one way ANOVA ($n = 9$). Results showed a significant difference between the different erosion control treatments ($F = 8.311$, $df = 2$, $p = 0.019$). There was a difference in the amount of erosion between the plots which had an erosion control treatment compared to the control plots, however, there was no significant difference in the amount of erosion between plots with coir matting and the plots with coir matting and coir logs (Figure 1). There was no significant difference in plant survivorship between the different treatments.

Figure 1. Analysis of different erosion control treatments. Treatment 1 = Coir matting and coir logs, Treatment 2 = Coir matting, Treatment 3 = Control.



Weed Management

Since the beginning of the project, priority weeds have been mapped on 18 different islands/islets. A total of 3,000 kgs of weeds have been removed from over 480 hectares via mechanical and chemical control.

Community engagement

At the heart of this project are community volunteers and students (200), who are involved in all project activities and are vital to its success. BCMI and NACC have also supported a number of project scholarships which are awarded to students enrolling in Conservation and Land Management courses at BCMI to work on the project. The Abrolhos Islands Body Corporates have shown support and assistance wherever possible, enabling the successful completion of project activities.

Conclusion

To date the project has undertaken to mitigate the threat of invasive plant species and erosion at eight sites at the Abrolhos islands with a planned expansion to an additional 12 sites by projects end. The end result will be increased biodiversity and connectivity of landscapes at the Abrolhos islands providing vital habitat for seabirds, sea lions and a range of other fauna.

Acknowledgements

This project is supported by the Durack Institute of Technology's Batavia Coast Maritime Institute, the Northern Agricultural Catchments Council, WA Department of Fisheries, WA Department of Parks and Wildlife, Employment Plus, Geraldton Senior College and the WA Museum with funding from the Australian Government.

How to Make Efficient Use of Technology in NRM Space

PRESENTER:



Piers Higgs

GAIA Resources

Abstract

Technology has the potential to deliver efficiencies, including reduced costs, to the Natural Resource Management (NRM) community. However, when poorly implemented, managed or utilised, it has the potential to instead become a burden to the organisation.

This talk will firstly provide an overview of how to select, implement and maintain technologies for organisations within the NRM community, as well as highlighting some success stories. This will include a broader review of some of the technologies in place within the NRM community.

We will also look at some of the trends in technology in the NRM space. In recent times, as funding and resources become scarce, collaboration between NRM groups has become more important, and this is no different in the technology arena. We will also discuss some other trends, such as the return to core business and the simplification of technologies in use.

This talk will provide an overview of technologies in the NRM community, insights into how to evaluate and choose the appropriate technology and the impact of the current trends in NRM upon technology choices.

NARvis: taking Natural Resource Management into the cloud

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Abstract

If a picture tells a thousand words, how much more we can achieve with interactive mapping capabilities? With this idea at the forefront and a vision to generate a highly accessible and dynamic portrayal of information, the Northern Agricultural Catchments Council (NACC) has developed a web-based, interactive NRM Strategy, NARvis. Moving away from the traditional tome that gathers dust, NACC has transformed its Strategy into a more useful tool for its members, land managers and community.

NARvis is now a portal for regional NRM information, where community can showcase the great work they are undertaking in the region and see how their projects are helping to meet regional goals. NARvis demonstrates how technology can be used to:

- Engaging community groups with maps.
- Using ArcGIS Online to promote NRM.
- Providing a portal for regional NRM information

Introduction

The foundation of NACC's work is driven by the NAR Regional NRM Strategy, originally published in 2005 and currently being updated through consultation with regional stakeholders, with funding assistance from Stream 1 of the Australian Government's NRM Planning for Climate Change Fund. The updated strategy is presented on an interactive website—NARvis.

What is NARvis:

NARvis is a regional plan created with input and support from representatives from WA State Government agencies, local councils, community groups and individual land managers. It has been designed as a tool for all stakeholders in the region to identify and prioritise NRM investment, and to promote collaboration across all levels.

The NARvis website was designed to take advantage of the web mapping capability of ArcGIS Online (AGOL). A challenge for many organisations is how to share the information that they collect as part of their daily operations—AGOL is an easy-to-use, cloud-based application that allows an organisation to create and share interactive maps (with the capacity to include photos and webpages) without any installation or set-up requirements.

AGOL can be fully integrated with existing software packages, with the ability to create maps in Microsoft Excel and insert these directly into a Powerpoint presentation.

Data and maps can be easily shared within the organisation—with both office and external field staff—along with the general community, on any device—via websites, blogs, Twitter and Facebook.

Technology drivers

All business in every sector are having to find ways to deliver core business digitally and are having to adjust practices to accommodate the shift.

NACC has been adjusting to this shift through the development of key technological innovations, such as NARvis and Photomon. Our marketing and communications activities also continue to move towards digital ‘publications’, and display an increased reliance on electronic means of communication, for example: NACC Notes weekly email newsletter and social media (Twitter and Facebook). These forms of communication have a number of benefits, including: The ability of all staff to take on roles as communicators, increased audience scope and reach, the ability to report in real-time and keep information relevant and up-to-date, enabling two-way communication, visually engaging, and reduced resource requirements.

There is an opportunity for regional NRM organisations to be at the forefront of the development of digital extension/decision-making support tools to build the internal capacity of NRM groups and community members in the region to achieve good project outcomes.

Community drivers

As a community-based NRM organisation, community and stakeholder input are key to shaping the project vision, identifying local priorities, and ultimately ensuring positive on-ground NRM outcomes. With this in mind, the success of NACC’s NRM Planning for Climate Change project depends largely on how well we can engage with the regional community and achieve stakeholder ‘buy-in’.

With approximately 63 per cent of Australia’s land mass contained in private ownerships (1993 ABS statistics¹), and less than 13 per cent² held in Terrestrial Protected Areas (2008) nationally, community participation is central to success in NRM.

Furthermore, in 2012 an estimated 4.5 million Australian adults reported they could be encouraged to become more involved in nature conservation activities—with increased information or advertising on environmental issues; more environmental events in their local area; and seeing the direct benefits of personal efforts amongst the top motivating factors³. NARvis has been designed as a tool to address these requirements, leverage community support and resources, and thus increase community participation and contribution in NRM.

The presentation explores the following topics, referencing specific case studies and social media/website analytics, where possible:

Integrating current technology-based community engagement tools, such as:

- NARvis, NACC and Inland to Ocean websites (Wordpress).
- ArcGIS Online.
- Social media (Facebook and Twitter).
- Blogs.
- Photomon app.
- Survey Monkey.
- MailChimp newsletter (NACC Notes).
- GoToMeeting
- Eventbrite

Learning outcomes—limitations, challenges and measures to combat these:

- Technical capacity of staff and community groups/members to successfully utilise new and upcoming technologies > In-house training and community assistance and extension activities.
- Target audience > Also use traditional forms of engagement.
- Keeping web-based media updated > Broken-link Plugin; Link to existing information rather than replication.
- Rural internet access > Maximise linked information and minimise uploads.
- Privacy, SPAM and moderation.

1 <http://www.abs.gov.au/ausstats/abs@.nsf/0/C4F37E44488D32591CA256B35007ACE07?opendocument>

2 <http://www.abs.gov.au/ausstats/abs@.nsf/Lookup/by%20Subject/1301.0-2012-Main%20Features-Land%20and%20biodiversity-278>

3 <http://www.abs.gov.au/ausstats/abs@.nsf/Latestproducts/4602.0.00.002Main%20Features22011-12?opendocument&tabname=Summary&prodno=4602.0.00.002&issue=2011-12&num=&view=>

The way forward:

- Search engine optimisation (SEO).
- iPads as engagement/education tools and electronic audience response systems.
- Community profiling and targeted engagement campaigns.
- Webinars.

Links:

- www.NARvis.com.au
- www.NACC.com.au
- www.InlandToOcean.com.au
- <https://www.facebook.com/northernagriculturalcatchmentscouncil>
- https://twitter.com/nacc_nrm

Incorporating Climate Change into NRM

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Emma Jackson is the GIS Coordinator at the Northern Agricultural Catchments Council (NACC) in Geraldton. She completed a Bachelor of Science and Commerce at the University of Western Australia before perusing a career in GIS and completing a Graduate Diploma in GIS at Curtin University. Working at NACC allows her to peruse her passion for the environment whilst utilising her technical skills.



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Kaylene Parker is the Climate Officer at the South Coast NRM. She completed a Bachelor of Environmental Science at Murdoch University. She has worked in the field of natural resource management for 15 years. She runs a Free Range Piggery in Albany in her spare time with over 700 pigs. This allows her with the opportunity to put sustainable farming into practice.

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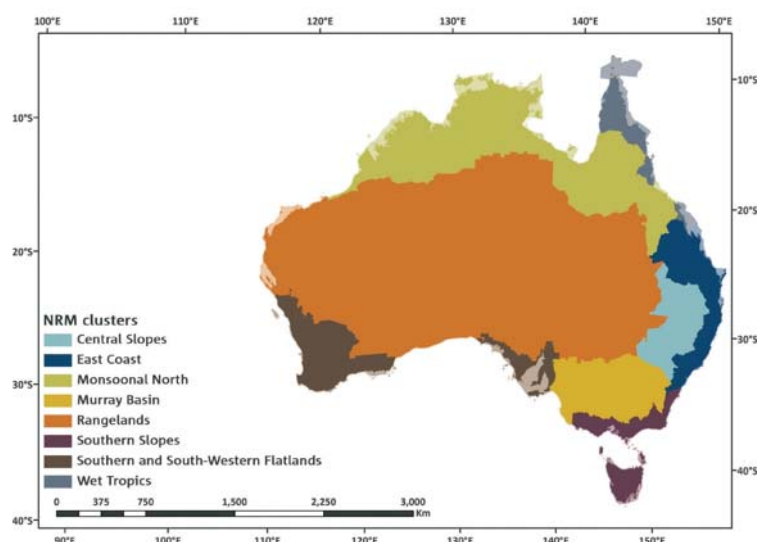
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Abstract

In 2013 the Australian Government released funding for all NRM groups across Australia to update their Regional NRM plans to incorporate climate change. As the NRM groups of the Southern and South Western Flatlands sub-cluster in Western Australia (Northern Agricultural Catchments Council, South West Catchments Council, Wheatbelt NRM, Perth NRM, South Coast NRM and Peel-Harvey Catchment Council) head towards the completion of this project we would like to share our experiences and showcase some of the valuable tools that have come out of this process.

Each of the NRM groups approached the process of incorporating climate change into their NRM Plan differently, depending on their needs and how developed their NRM plan was already. Some groups had only recently revised their strategies whereas others were significantly out of date. The greatest benefit of undertaking this journey at the same time was the collaboration that occurred between the NRM groups, both within the cluster and all over Australia. We were able to draw on each other's strengths and ultimately get better outcomes than we could have alone. Planning for climate change is now embedded in all of our Regional Plans and relationships between the NRM groups have been strengthened.

From the outset one of the major issues that had to be addressed by all the NRM groups was engaging the community so that they would participate in the planning process. Climate change was, and still is, often seen as a dirty word and in order to progress a project to set regional priorities and directions, people needed to believe in it. A variety of successful strategies were developed across the region from climate forums to just changing our language from "climate change" to "climate variability" or "the changing climate". All of the NRM groups worked to get local NRM experts involved in the strategy process from early on. These experts then championed the project to the community, giving the process credibility and valuable.

The most successful tool implemented across all the regions in our cluster was the use of the Multi-Criteria Analysis Shell for Spatial Decision Support (MCAS-S). MCAS-S has proved to be invaluable in this process, allowing community and stakeholders to have direct input into regional priorities and decision-making. Initially it was just used to identify priority areas for carbon bio-sequestration, however groups and community soon recognised the benefit of being able to undertake this very interactive and visual planning process to prioritise areas for biodiversity protection. The datasets created through this process are a legacy which will allow each of the NRMs to capitalise on this investment to support other projects for years to come.

In parallel to the regional NRM groups updating their strategies, CSIRO, BoM, the Department of Environment, NCCARF and other research institutions were funded to provide regional climate projections, undertake research and provide tools to assist NRM groups to update their plans with respect to climate change. The tools now available to NRM groups through the AdaptNRM (<http://adaptnrm.csiro.au/>) and Climate Change in Australia portals (<http://www.climatechangeinaustralia.gov.au/en/>) have given NRM groups access to quality detailed data and expertise that will continue to ensure sound decision-making now and into the future.

Midwest Pests: Invasive Aquatic Pests in Southern Pilbara Rivers



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Colin Johnson completed his studies in Tasmania before moving into a research role in the Tasmanian Atlantic Salmon industry. In 2010, he moved to Geraldton to continue with aquaculture research at The Durack Institute of Technology. Upon becoming aware of a population of noxious Tilapia in Geraldton's Chapman River he has spent the last 3 years attempting to address this issue with the support of his employer, NACC and the Federal Government.

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Keywords

Freshwater fish, freshwater turtles, freshwater ecology, biodiversity conservation, aquatic pests, invasive species

Introduction

Invasive species have the potential to markedly alter aquatic ecosystems through predation, aggressive interactions, food and space competition and habitat modification. This can lead to displacement of native species and potentially complete dominance of riverine fauna by introduced species. Complete eradication of any animal pest species has proven unachievable on mainland Australia with aquatic environments proving yet more difficult. In many cases, aquatic pest

species and associated problems are not immediately apparent due to cryptic habits or the inherent problems of viewing subsurface ecosystems. As such it is imperative to obtain accurate distributional information on aquatic pests to allow concentrated control efforts to be focussed in areas of new incursions before invasive species become firmly entrenched so as to limit their dispersal.

The Durack Institute of Technology's Batavia Coast Maritime Institute (BCMI) in partnership with the Northern Agricultural Catchments Council (NACC) and funded by the Australian Government are working to establish the current distributions of riverine invasive species in the Midwest in order to develop control strategies to inhibit further range expansion. Aquatic pest distributions in the Irwin, Greenough, Chapman and Murchison Rivers have been mapped indicating range expansions of two established pest species and detection of a new potentially invasive species introduced from the Southwest drainage.

Methods

Following a pilot study on optimal sampling methods, riverine faunal surveys have been conducted using the draft method for standardised freshwater fish sampling developed by Storer et al. (2013) using two fyke nets with five each of small and large box traps sited to target representative habitat types within the river region enclosed by the fykes. Nets and traps were deployed for 24h set times to allow coverage during peak feeding and travelling periods around dawn and dusk and to target both diurnal and nocturnal species. Fyke nets are deployed with floatation in the rear of the codend to create a breathing space for air breathers, whilst large box traps include a covered escape hatch to allow egress of turtles. Supplementary sampling has been conducted using seine nets and specifically for Tilapia, through water sampling for eDNA collection. Catches are sorted in aerated tanks upon landing with a subsample of 50 individuals of each species for each trap type given external health assessment, measured (TL) and sexed where possible before release of natives or euthanasia of pest fish species in an Aqui-S bath. Additional processing of Tilapia involved dissection for gonad staging, gut content assessment and removal of otoliths for aging.

The particularly high bycatch rates of an alien species of turtle (*Chelodina colliei*) in the Chapman River has led to the implementation of a tag-recapture population assessment of freshwater turtles commencing in May 2015. Introduced *C. colliei* and native *C. steindachneri* have been tagged with ISO FDX PIT tags placed subcutaneously in the inguinal region supplemented with temporary stick-on shellfish tags (Hallprint Pty Ltd) attached to the plastron.

Results and Conclusions

To date 199 surveys have been undertaken in 38 sites across the Irwin, Greenough, Chapman and Murchison Rivers in the Midwest representing a cross-section of aquatic habitats at different stages of invasion by aquatic pests. In the process 351 370 animals have been sampled and 273 984 pest animals removed.

Tilapia

Although present in the Chapman River Catchment since at least 1978 (Maddern *et al* 2007), *Oreochromis mossambicus* is currently restricted to the estuary and occasionally the ephemeral reaches as far upstream as a gauging weir at 28.763340°S 114.670830°E. Captured tilapia have ranged from 11–326 mm TL with all dissected specimens over 70 mm showing identifiable maturing gonads regardless of season, the smallest identifiable male was 68 mm and female at 62 mm TL.

The population shows high disease susceptibility through winter months with 55.25±7.33% of sampled tilapia showing external bacterial lesions compared to 14.33±17.55% in summer whilst other species show apparent disease incidence of <1%. Despite this apparent difficulty imposed by cold conditions, spent male Tilapia have been detected as early as August whilst brooding females have been collected in September.

Gambusia

Gambusia holbrooki is present throughout the Greenough and Chapman rivers, and is the numerically dominant fish species in these rivers during summer months. *Gambusia* populations are highly seasonally variable with catch rates 15 times higher in summer than winter. For the first time, *G. holbrooki* have been detected in the Irwin River, though far more common in tributaries where swordtails are not present.

Swordtails

Xiphophorus helleri were introduced to the Irwin River in 1982 immediately upstream of Dongara. Self-sustaining populations were first reported in 2001 extending upstream as far as the permanent waterholes at Strawberry Bridge. Surveys in this study have detected range expansion of *X. helleri* into the upstream ephemeral reaches beyond Depot Hill and Coalseam Conservation Park—approximately 45 kilometres further upstream.

Turtles

Chelodina colliei was introduced to the Chapman River (Bush *et al* 2007) and now is the dominant turtle species outnumbering the native *C. steindachneri* 266:1. This alien species appears to be the dominant animal species in the upper reaches of the river. A tag-recapture study commenced May 2015, in the Chapman River, with 155 *C. colliei* and 2 *C. steindachneri* tagged so far. Recaptures of 11 and 1 *C. colliei* and *C. steindachneri* respectively, give population estimates of between 531 and 1388 *C. colliei* and 2 *C. steindachneri* for the Chapman River estuary.

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Building Partnerships for Conservation

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Tony has worked as a conservationist for most of his 30 year career including at Perth Zoo, the Department of Parks and Wildlife, and as a director and advisor to State Government Ministers for the environment and forestry. He has also been a science teacher and, more recently, a corporate communications manager.

He has a special interest in conservation projects for endangered species such as black cockatoos.

Tony joined The Nature Conservancy in 2014 as Aridlands Project Manager, based in Perth, working with industry and local delivery partners to improve landscape scale conservation outcomes for Australia's aridlands.

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Introduction

The Nature Conservancy (TNC) is a global, not-for-profit, conservation non-government organisation. TNC is funded from a variety of sources including corporate sponsors and investors, philanthropists and donations from more than a million private members. Our mission is to 'protect the lands and waters on which all life depends', and to achieve this we collaborate with a diverse range of partners including: indigenous groups and rangers, farmers and fishermen, companies, local communities, governments, and other not-for-profit organisations.

TNC has been operating in Australia for the last decade. Early work here helped expand the National Reserve System in line with national policy. It did this through working with partner organisations (such as Bush Heritage Australia, the Australian Wildlife Conservancy and Greening Australia) to provide funds for purchase and management, and also to increase capacity of those partners in conservation planning and fundraising. With these partners and the Australian Government, TNC has directly funded the acquisition or management of 29 properties covering 3.55 million hectares, including some of Australia's largest private protected areas.

TNC has also worked to advance the establishment of Indigenous Protected Areas by helping fund Healthy Country Planning and critical land management. By leveraging funds TNC helps to achieve much bigger outcomes than would otherwise be possible.

In Australia, TNC has focused its work in five regions: Gondwana Link, Northern Australia, Great Southern Seascapes, Murray-Darling Basin and the Aridlands.

Summary of The Nature Conservancy's projects in Western Australia

Gondwana Link—Gondwana Link is a large landscape-scale connectivity project in south-western Australia. TNC provided catalyst funding for the Gondwana Link start-up in 2002. In particular support was provided for conservation planning in the Fitz-Stirling landscape and Great Western Woodlands. TNC partnered with Greening Australia and Bush Heritage Australia to acquire six conservation properties with the aim of providing better connectivity between the Stirling Range and Fitzgerald River National Parks. Over the past four years, TNC partnered with BirdLife Australia to undertake a large-scale research project into the birds in the Great Western Woodlands, looking at their distribution and abundance with the aim of informing better management of the woodlands.

Tropical savannas of northern Australia—TNC's Northern Australia program works across 130 million hectares of tropical savanna landscape including the Kimberley. Efforts here are focused on assisting Indigenous people protect their lands such as through indigenous Protected Areas such as supporting the development of 'Healthy Country Plans'.

Fire is also one of the main drivers of ecosystem health in the savannas. Early dry-season burning results in cooler, patchier fires that has benefits for biodiversity, greenhouse gas emissions and in providing income for indigenous land managers through carbon credits. TNC has supported the science necessary to develop the carbon methodologies and have these approved by the Australian Government regulator, as well as the burning to gain carbon credits.

Great Southern Seascapes—In 2014, TNC Australia launched a new marine program that aims to scale-up restoration of coastal habitats in bays and estuaries across southern Australia, with a focus on ecosystem services. TNC's 2011 *Shellfish Reefs at Risk* report found that globally we have lost over 85 percent of natural shellfish reefs worldwide (reefs made of oysters and mussels) and in Australia we have lost 99 percent making them essentially 'functionally extinct'. As a result, a large focus of TNC's work in the Great Southern Seascapes program is to use its extensive experience in this area in the US to try and restore lost shellfish reefs here.

Shellfish reefs were once abundant in Oyster Harbour in Albany. By the late 1800s a local oyster fishery had collapsed and shellfish oyster reefs have never re-established to the state they once were there. By working with local WA partners, TNC is conducting a pilot oyster reef restoration project that will hopefully see in-water trials this summer with the view to scale-up the restoration in 2017.

Aridlands—Aridlands cover 46 percent of Australia. TNC's goal in this area is to work with partners to help create the world's largest interconnected, intact aridland ecosystem to conserve nature and support Aboriginal communities in their efforts to manage country for multiple benefits. TNC's biggest aridlands project is the *Martu Living Deserts Project* in the Western Desert. This is a collaborative partnership between TNC, Kanyirninpa Jukurrpa (KJ) and BHP Billiton that assists the Martu traditional owners conserve the biodiversity and cultural values of their country. The project helps to build on the support KJ receives from other partners including the Australian Government (through its *Working on Country* program) and the WA Department of Parks and Wildlife.

Successes so far include; increased Martu engagement and employment (KJ employs 34 permanent and 293 casual Martu rangers—by far the biggest employer of Martu people); beginning to re-establish a traditional cool season mosaic burning regime; management of feral camels and cats; cleaning and monitoring waterholes; and preserving Martu culture through intergenerational knowledge transfer.

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Peron Naturaliste Partnership—Regional Coastal Adaptation Planning



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BIOGRAPHY:

Joanne's work and recreational interest all revolve around the coast. Currently, the coordinator of the Falcon Coastcare Group, she works part time as the Coastal Adaptation Coordinator for the Peron Naturaliste Partnership in South Western of Western Australia and as a Training Provider for Woolkabunning Kiaka Incorporated, contracted through the Department of Agriculture and Food Western Australia. Joanne has also recently become the new WA Convener of the Australian Coastal Society.

Joanne has over 10 years experience in working with coastal community groups, land managers, government and non government agencies and is passionate about working with past, current and future coastal managers to respond to the local and global challenges that face coastal communities.

CO-AUTHOR:

Mr Craig Perry

Peron Naturaliste Partnership

Abstract

Bunbury, Busselton, Capel, Dardanup, Harvey, Mandurah, Murray, Rockingham, Waroona are a collective group of Local Governments between Cape Peron and Cape Naturaliste in the southwest of Western Australia who recognise the potential vulnerability of this coastline due to climate change impacts.

The Peron Naturaliste Partnership (PNP) has a strategic approach to the management and implementation of coastal adaptation across the Peron Naturaliste Region of Western Australia, including:

- Adaptation Planning;
- Addressing coastal risk (i.e. legal risk, and asset management);
- Building strategic partnerships;
- Lobbying to state and federal government;
- Capacity Building (i.e. community capacity building, training and support to council staff, developing coastal monitoring standards and adaptation guidelines);
- Coastal Monitoring; and
- Knowledge management and information sharing.

In 2015 the PNP won the Australian Coastal Award for Climate Adaptation. All 9 local councils within the region have re-signed onto a current business agreement as an incorporated association.

The PNP is now working on key priority projects related to improving current coastal management efforts, monitoring standards and planning tools for Coastal Hazard and Risk Mapping and Adaptation Planning. The PNP (in its forth year) is currently working toward Incorporation and its next phase of business planning for 2015 and beyond.

Landscape Scale Projects

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BIOGRAPHY:

Gaye joined Rangelands as an employee in October 2010 but prior to that had been providing monitoring and evaluation and communications support as a consultant for a number of years. She has extensive experience in social research, evaluation and project management across a diverse range of areas. Gaye has a BA in sociology and politics and a PhD in sociology and is passionate about the 'people' side of NRM, especially finding ways that people and groups can work together to achieve more than they could on their own. She commenced the position of Chief Executive Officer in January 2014.

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BIOGRAPHY:

Ian is an environmental scientist with 15 years' experience in natural resource management in Europe, Alaska and Western Australia. Educated at Massey, Edith Cowan and Murdoch universities he holds a BBS in management, MProfAcc in accounting and an MSc in environmental science. Ian has worked as an army officer, management consultant, and in business development, bringing strong relationship building and project management skills to his role as the Pilbara Corridors Program Manager.

Introduction


Landscape scale projects are regarded to be important in making a difference in vast areas of the WA rangelands for the benefit of the people, the environment and the economy. In many instances it is the only viable option to delivering enduring land management outcomes. Landscape scale projects require multiple strategies and actions to manage assets and mitigate threats to achieve desired outcomes.

Rangelands NRM is involved in implementing landscape scale projects in the Pilbara, Wiluna region, Kalgoorlie, the Kimberley Basin and Shark Bay.



We are big

- The rangelands of WA cover 85% of the state's land mass and 75% of the coastline.
- Work undertaken in seven sub-regions
- Manage 226 million hectares
- Work across a diverse range of sectors from pastoralism, mining, conservation and tourism



Background

The Pilbara Corridors Project is a joint project between Rangelands NRM, Greening Australia and the WA Department of Parks and Wildlife, and funded through the Australian Government. It is a coordinated approach to address biodiversity threats on a landscape scale in the Pilbara. It works at a landscape scale and across management boundaries by bringing together people and organisations with environmental expertise representing government, environment, community, mining, pastoralists and Indigenous groups to deliver effective land management.

Currently, the Pilbara Corridors Project is facilitating a Conservation Action Planning (CAP) for the Pilbara—a powerful ten-step tool to guide conservation teams to develop focused strategies and measures of success. When regional priorities have been set, CAP is used to determine the plan of action for these priorities. As actions are taken and outcomes are measured, conservation action plans are revised to incorporate new knowledge.

Methodology

A Brief outline of conservation action planning and methodologies employed to collaborate and engage with stakeholders on landscape scale projects.

Project Outcomes/Conclusion

The presentation will provide insights into multiple strategies and actions to manage assets and mitigate threats to achieve desired outcomes. In particular based on the experiences and knowledge gained from the Pilbara Corridors Project.

Vegetated Floating Islands Enhance the Ability of Wetlands to Reduce Nutrients and Other Pollutants

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BIOGRAPHY:

Bernie Masters holds a science degree majoring in geology and zoology from the University of WA. He has worked as a geologist, wildlife conservation officer, member of Parliament and environmental consultant. In 2007, he co-founded FIA Technology Pty Ltd to make and install vegetated floating islands. He is a member of the board of the South West Catchments Council and a former member of the Geographe Catchment Council.

Summary

Natural and constructed wetlands have been used to improve water quality in urban, industrial and agricultural environments for more than 40 years. Initially, pollutant uptake by wetland plants was assumed to be the primary removal mechanism but research now shows that bacterial/algal biofilms growing on all solid surfaces within the water column remove more than 80% of pollutants, although plants are needed to transfer oxygen and carbon to biofilms to maximise their pollutant-removal capacity.

Vegetated floating islands designed to maximise biofilm development were commercialised in the USA in the mid-2000s. Their placement on the surface of wetlands and other waterbodies significantly increases the area of biofilm capable of removing nutrients and other pollutants, while also shading the water column, reducing water temperature and creating useful wildlife habitat. This paper summarises the science which underpins their pollutant-reduction abilities and lists the current suppliers of floating islands in Australia.

Introduction

In the 1980s, when natural or constructed wetlands were first used in Australia to improve water quality, doubts were expressed about the ability of wetlands to reduce nutrients, heavy metals and other pollutants. Since then, research on the use of wetlands for water quality improvement has been extensive, with different constructed wetland designs now available to treat different pollutants. Published literature on constructed wetlands is widely available; conferences on their use are regularly held; and regulatory authorities now accept that well-designed wetlands have an important role to play in helping to overcome some of the adverse impacts of urbanisation, industry and agriculture.

Vegetated floating islands were first used for water quality improvement in the late 1990s. The scientific understanding of the biological processes involved in their ability to remove pollutants is slowly but steadily improving but academic and regulatory acceptance of their use remains modest. This paper is designed to show that, like wetlands, the use of floating islands is on a similar pathway of understanding and acceptance.

History of Wetlands and Water Quality Improvement

Wetlands for water quality improvement appear to have been first formally used in 1971 when a large biological filtration system was constructed in Missouri, USA, to treat acidic wastewater from a lead mine and mill (Erten *et al.*, 1988). Through the 1970s and 1980s, researchers investigated the use of natural wetlands for domestic sewage wastewater treatment (e.g., Boyt *et al.* 1977, Tilton and Kadlec 1979, Deghi *et al.* 1980, Dierberg and Brezonik 1982). While bacteria, algae and periphyton were considered to be important in removing nitrogen from polluted water, quantification of their role in removing pollutants was largely absent from the scientific literature, with the focus generally placed on plants which were assumed to take up most pollutants. It wasn't until 1988 at the First International Conference on Constructed Wetlands for Wastewater Treatment held in Tennessee, USA that the science underlying the use of wetlands for water quality improvement began to be accepted by regulatory authorities and water managers (Hammer 1989).

History of Vegetated Floating Islands and Water Quality Improvement

The idea of constructing a floating platform on which plants could be grown to improve water quality was first assessed in China, Japan and Taiwan in the 1990s. Floating beds of *Canna Cana generalis* were placed on fish ponds and their biomass production was measured (Wu, *et al.* 2000). Similar soil-less floating beds planted with *Canna* were also used to improve eutrophic water quality, with coverage of 20% recommended to achieve significant improvements (Bing and Chen 2001).

A vegetated floating island made from lightweight concrete was used in Kasumigaura Lake, Japan, in 1998 to create fish and water bird habitat while improving water quality and landscape (Noriyoshi *et al.* 1999) and to reduce shoreline erosion (Keigo *et al.* 1999). Trials in the USA in 1987 using the floating plant pennywort *Hydrocotyle umbellata* improved domestic sewage water quality (DeBusk *et al.* 1989). Managers of Heathrow Airport in London, U.K., then trialed in 1994 and installed floating reed beds to remove glycol from stormwater (Revitt *et al.* 1997, Chong *et al.* 1999, Revitt *et al.* 2001, Richter *et al.* 2003).

Credit must go to Bruce Kania of Floating Island International LLC (FII)—see www.floatingislandinternational.com—for the first commercialisation of vegetated floating islands. In 2000, Kania began experimenting with different designs and construction materials for floating islands, initiating extensive laboratory research (Stewart 2005, Stewart *et al.* 2008). Commercial production started in 2005, with the company understanding the important role of microbes in nutrient removal, while also recognising that ‘microbial removal rates were three times greater in the presence of plant roots’ (Hammer 1990). FII researcher Frank Stewart (2008) concluded: ‘it appears that each square foot of floating island was about 8 times more effective than each square foot of wetland for removing nitrate.’

After extensive studies, FII’s research on their 20 cm thick floating islands gave removal rates in outdoor and laboratory test ponds of:

- ammonium—1.3 to 3.0 kg/square metre/year.
- nitrate—3.0 to 41.6 kg/square metre/year.
- phosphate—0.4 to 1.7 kg/square metre/year.
- BOD—2.2 kg/square metre/year.

In a review article, Dodkins and Mendzil (2014) concluded that vegetated floating islands have many benefits over free water surface wetlands:

1. Plant roots assist in filtering and settling processes for sediment bound P and metals.
2. Plant roots act as a large surface area for micro-organism activity in: decomposition, nitrification, and denitrification (removal of BOD and N).
3. Mild acidification of water due to release of humic acids; and a C input from senescent vegetation, assist denitrification.
4. Floating islands can adjust to varying water levels.
5. A higher retention time is possible as ponds on which islands are placed can be made deeper without submerging the vegetation.

The percentage removal of nutrients and metals from effluent is 20–40% higher in wetlands with floating islands than in conventional free surface water wetlands. 20% coverage of islands is optimal for aerobic basins. 100% cover is optimal for anaerobic basins or aerobic basins where there is artificial aeration. The design of floating islands and control of basin water chemistry are essential for optimising treatment efficiencies.

Borne (2014) compared the fate and removal performance of phosphorus (P) in two parallel stormwater retention ponds, one retrofitted with a vegetated floating island and one without any vegetation, in a field trial near Auckland, New Zealand. Results suggested that inclusion of a vegetated floating island would significantly improve P removal efficiency, showing a 27% lower Total P outlet event mean concentration than from a conventional retention pond. Inlet particulate-bound P is thought to have been associated with particulate copper on fine particles like colloidal organic matter and/or clay and to be trapped in the sticky biofilm of the roots, followed by sloughing of biofilm which then settled on the bottom of the pond. The pond with the floating island induced a more neutral pH within and higher organic release into the water column, likely promoting dissolved P sorption onto particles. Interestingly, the reduced (low redox potential) sediment observed below the floating island did not induce P release probably due to the more neutral pH conditions which allowed re-adsorption onto organics and/or clay minerals (e.g. Al-OH). This resulted in higher P sediment accumulation in the treatment pond. P uptake by plants was not thought to be a significant removal pathway. Sorption of dissolved P, physical entrapment of particulate P in roots and then its settlement onto the floor of the wetland were thought to be the main P removal pathways for ponds equipped with floating islands.

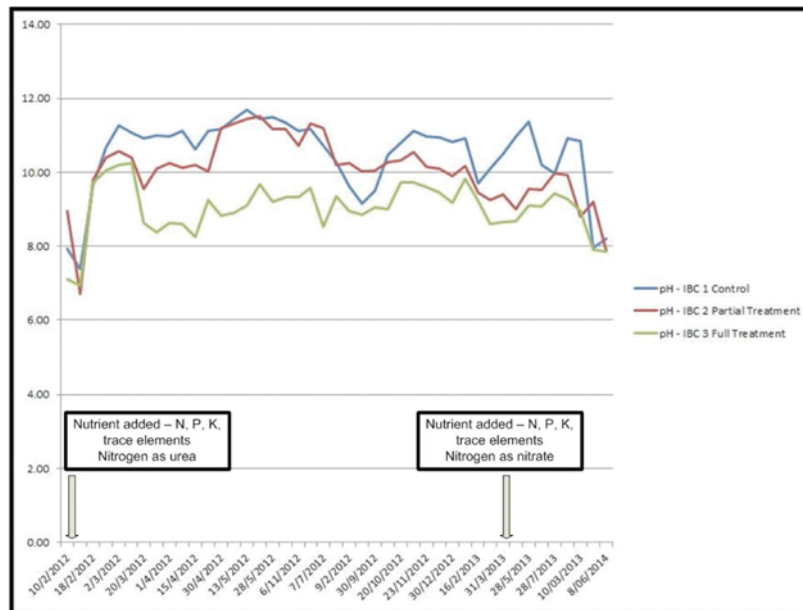
FIA Technology Pty Ltd conducted a microcosm trial using one cubic metre intermediate bulk containers (IBCs) (Masters, unpublished). Over the 30 months of this trial which began in February 2012, IBC 3 containing the vegetated floating island developed into a stable, complex ecosystem with excellent water clarity. In contrast, water in the Control and Partial

Treatment IBCs remained green with high levels of planktonic algae. Conclusions from the trial were that vegetated floating islands improve water quality in the following ways:

- Lower pH—see figure 1.
- Rapid removal of NH_4 which remains at sustained low levels—see figure 2
- Rapid removal of NO_3
- High water clarity in spite of elevated nutrient levels—see figure 3.

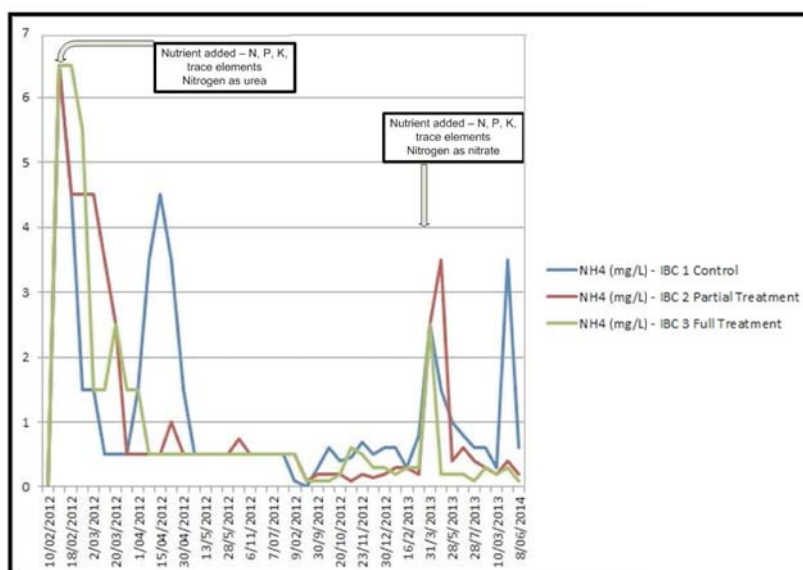
Figure 1. pH variation over 30 months in a microcosm trial involving one cubic metre international bulk containers:

- IBC 1 control—no floating island or vegetation
- IBC 2 partial treatment—an unvegetated floating island
- IBC 3 full treatment—a vegetated floating island



Research by Vázquez-Burney (2015) on vegetated floating islands in Florida, USA, used 149 m² of islands on a 1,122 m² pond (7% of pond area) over a 17 month period with a hydraulic residence time averaging 15.7 days. The islands were found to enhance pond nitrogen removal capacity by 32%. By evaluating the difference between the treatment and control periods, an incremental total nitrogen removal rate for the islands was calculated to be 4.2 kg N/m²/year.

Figure 2. NH_4 variation over 30 months of microcosm trial



The graph displays water clarity (cm) on the y-axis (0 to 120) against time on the x-axis (from 10/02/2012 to 8/06/2014). Three treatments are compared: IBC 1 Control (blue line), IBC 2 Partial Treatment (red line), and IBC 3 Full Treatment (green line). Two nutrient addition events are marked: 'Nutrient added - N, P, K, trace elements Nitrogen as urea' (around 10/02/2012) and 'Nutrient added - N, P, K, trace elements Nitrogen as nitrate' (around 16/02/2013). The IBC 3 Full Treatment shows a sharp increase in water clarity (decrease in turbidity) after the second nutrient addition, reaching a plateau near 100 cm by late February 2013.

Date	IBC 1 Control (cm)	IBC 2 Partial Treatment (cm)	IBC 3 Full Treatment (cm)
10/02/2012	12	12	12
18/02/2012	12	12	12
2/03/2012	12	12	12
20/03/2012	12	12	12
1/04/2012	12	18	38
15/04/2012	12	15	38
30/04/2012	12	15	20
13/05/2012	25	20	25
28/05/2012	20	20	25
6/11/2012	25	20	25
7/07/2012	45	25	30
9/02/2012	38	30	30
30/09/2012	18	35	25
20/10/2012	15	30	18
23/11/2012	15	45	25
30/12/2012	15	20	25
16/02/2013	10	18	50
31/03/2013	10	48	100
28/05/2013	20	40	100
28/07/2013	18	20	100
10/03/2013	38	38	100
10/03/2013	25	25	100
8/06/2014	40	50	100

For over 150 years, sewage engineers have known that “in the biological filter the purifying agencies are micro-organisms living in a gelatinous film on the filter medium” (Anon, 1987). Researchers investigating the use of natural and constructed wetlands for treatment of wastewaters found evidence in 1978 that nitrogen fixation is carried out in Western Australian wetlands by organisms related to those known to fix nitrogen in other regions (Finlayson and McComb 1978), with the presence of plant rhizomes greatly enhancing the rate of bacterial fixation, “presumably because the higher plant releases exudates which provide substrates for bacteria in the rhizosphere”.

The multi-phase involvement of bacteria in nutrient removal was recognised by Fisher in 1990: “Biological nitrification-denitrification and plant uptake are usually the two most significant nitrogen removal mechanisms in artificial wetlands. Micro-organisms which proliferate in the aerobic root zone in an artificial wetland can stabilise organics and nitrify ammonium to nitrate. As the wastewater then flows into anoxic zones within the wetland, microbially mediated denitrification can convert nitrate to nitrogen gas which is then released to the atmosphere.”

According to Bishay et al. 2005, "...it is clear that such processes (ammonia-processing stoichiometries) require oxygen, and are microbially mediated. In turn, the microbes involved are situated almost exclusively in biofilms on solid surfaces in the wetland water column".

In subsurface constructed wetlands treating wastewater, nutrient removal efficiencies in two different wetlands removed between 51.8 and 74% of phosphorous, with plants contributing between 3 and 12% of the total phosphorous removal (Yousefi and Mohseni-Bandpei 2010).

The Two Major Problems with Phosphorous

Phosphorous removal from polluted water poses two problems. First, phosphorous is usually the limiting nutrient in fresh waterbodies (Schindler 2008). If nitrogen is limiting, cyanobacteria can extract atmospheric nitrogen and produce bacterial blooms. Accordingly, phosphorous reduction should be the primary goal of wastewater treatment systems, even when inflowing or ambient phosphorous levels are very low, for example, 0.1 mg/L (Anon. 2009).

Second, in most situations, organically-bound phosphorous is removed from the water column and added to the wetland sediments. Changes in physio-chemical conditions can then allow the stored phosphorous to again become biologically available. In field situations, phosphorous “is rapidly recycled between sediments and water”, with cyanobacteria such as *Microcystis* able to consume excess phosphorous at the sediment-water interface and then rise to the water surface to form blooms (Conley *et al.* 2009).

Phosphorus accumulates in wetland sediments and plant litter which together are a major pool for phosphorous (more than 95%) in natural wetlands, with phosphorous able to be released back into the water column (Main *et al.* 2005). Adsorption of phosphorous by iron, calcium, magnesium and aluminium minerals in the sediment is considered the most significant mechanism for more permanent phosphorous removal.

A detailed ecosystem model of phosphorous dynamics in a constructed riparian wetland showed that macrophytes pumped phosphorous out of deep sediments, causing an increase in total phosphorous in the water column mostly during the non-growing season (Belmont *et al.* 2009). The use of wetland plants which senesce over winter should therefore be avoided.

A pilot-scale engineered ecosystem showed that phosphorous was not removed by the system due to the lack of regular sludge removal (Kavanagh and Keller 2007). The authors stated: “Phosphorus can be regarded as a “conserved” entity in this system since it cannot be removed atmospherically ... (this) suggests that over 90% of the influent phosphorus passes through the (system) and is discharged with the effluent as expected. The actual phosphorus removal by plant growth is clearly shown to be very small, accounting for about 6% of total incoming phosphorus.”

Even where lake sediments have high phosphorous sorption capacities, they may release phosphorous into the water column by desorption under aerobic conditions if water-column phosphorous concentrations are low enough (Belmont *et al.* 2009). Hence, reducing the phosphorous concentrations in inflowing waters may not be sufficient to prevent adverse algal and cyanobacterial blooms from developing.

Overall, many wetlands are ineffective in removing phosphorous due to unsuitable physiochemical conditions at the water/basal sediment interface. Other wetlands can remove phosphorous initially but then begin to export this nutrient. Physical removal of the materials within which phosphorous is stored within the wetland—primarily within basal organic-rich sediments—is essential if medium- to long-term phosphorous reduction from through-flowing water is to occur.

Clearly, while plants play an important role in nutrient removal from wetlands (and hence from vegetated floating islands), bacterial biofilms are far more important.

Current Suppliers Of Floating Islands

In Australia, three companies currently design, manufacture and install (as required) vegetated floating islands.

Aqua Biofilter—www.aquabiofilter.com—has floating island trials in China (Duncan 2009) together with some smaller installations in Australia. According to the company’s website, the Aqua Biofilter floating island is “an advanced Floating Wetland Treatment Technology that can be utilised within a Wetland Treatment Train either retro-fitting or designed into future wetlands. Detention basins can be designed larger and deeper, effectively providing more storage and hydraulic retention times. Wetlands can also be sized smaller as a result, bringing down costs, achieving best practice and effectively treating Total Nitrogen, Total Phosphorous, Total Suspended Solids and reducing heavy metals.”

Aqua Biofilter islands installed in China are made from low density buoyant bamboo. In Australia, sealed plastic piping provides buoyancy, with wetland plant species planted into a layer of coconut fibre matting.

Spel Environmental—see spel.com.au/products/spel-wetlands. Spel’s Floating Treatment Media are made from recycled PET as used in plastic drink bottles. This plastic is made into a non-woven, non-toxic durable matrix of fibres. Dense and porous, it is inert and has been coated in a UV-resistant resin to US EPA irradiation accelerated degradation standards. Sheets of fibre matrix are bonded together with foam to provide buoyancy. Plants are inserted into the material and grow down into the water hydroponically. The biological processes occurring within the biomass of their islands are the same as in activated sludge but have the added advantage of increased microbial activity. Microbes and bacteria adhere to the roots of the plants and within the fibrous structure of the media themselves, secreting sticky extracellular proteins. Within these biofilms, microbes and bacteria trap and digest organic matter and nutrients in wastewater, including total suspended solids, biochemical oxygen demand, nitrogen and phosphorus.

The principal of surface area is: the more underwater surface area that is available for microbes and bacteria to stick to, the cleaner the water. This surface area is called the Bio-Mediation Quotient (BMQ): Spel’s floating media and root structure

combination has a BMQ in excess of 1,000 m² per 1 m² of island which means 100 m² of planted active suspended media has more than 10 ha of surface area.

FIA Technology Pty Ltd—www.floatingislands.com.au—(Australia-wide agent is www.clearwaterlakesandponds.com.au)—has its vegetated floating islands installed in many locations throughout Australia. FIA's island design has two key features. Buoyancy and strength are provided via an external frame made from air blown recycled plastic rods having a density of about 0.7 g/cc. Air bubbles are trapped within the plastic rods during the extrusion process, ensuring that water cannot leak in. This inherent buoyancy is insurance against vandalism and protects against the possibility of leakage of water into (and air out of) sealed pipes, drums or other containers.

FIA's design maximises the development of bacterial biofilm within the bed of each island by placing shredded plastic wastes (nylon carpet, polystyrene packaging, and polyurethane mattresses) between two layers of UV-resistant shade cloth, thereby increasing the internal surface area on which biofilm can develop. Wetland plants placed onto the pocket create a dense root mat which provides further surface area for biofilm development. FIA's first floating island installation was in 2008 at the Etiwanda stormwater detention pond, Mildura, Victoria, where it has survived flood conditions unscathed.

Importance Of Plants On Floating Islands

Plants are critically important, even though they remove only a small proportion of nutrients from the water column. Plants translocate oxygen into the underlying substrate, stimulating both nitrification of ammonia and the breakdown of biological oxygen demand (Gersberg 1986). Artificial vegetated wetland filters had higher oxygen concentrations, pH, redox potential and metal retention than in systems without plants (Dunbabin 1988). Efficient nitrate removal from wetlands depends on denitrification which is supported by macrophytes which supply organic carbon (Weisner 1994) to denitrifying bacteria via plant litter. In turn, plants also offer attachment surfaces for epiphytes which produce additional organic matter.

Macrophytes have several intrinsic properties that make them an indispensable component of constructed wetlands (Brix 1994): their most important functions are their physical effects: they provide good conditions for physical filtration and provide a huge surface area for attached microbial growth. Macrophyte-mediated transfer of oxygen to the rhizosphere by leakage from roots increases aerobic degradation of organic matter and nitrification.

The major roles of macrophytes in constructed wetlands as determined by Sundaravadeivel and Vigneswaran (2001) are:

Wetland plant part	Wetland Plant Role
Aerial plant tissues	Light attenuation → reduced growth of phytoplankton Influence on microclimate → insulation during winter Reduced wind velocity → reduced risk of resuspension of solids Aesthetic appearance Nutrient storage
Plant tissue in water	Filtering effect → filter out large debris Reduced current velocity → increase rate of sedimentation, reduced risk of resuspension Surface area for attached microorganisms Excretion of photosynthetic oxygen increased → aerobic degradation Nutrient uptake
Roots and rhizomes	Stabilising the sediment surface → less soil erosion Release of oxygen increases organic degradation and nitrification Nutrient uptake Secretion of antibiotics for detoxification of root zone → pathogen removal

Macrophytes assimilate and store nutrient elements such as nitrogen and phosphorous, transport oxygen to the root zone, provide substrates for microbes and inhibit growth of algae (Chong 2003).

Vegetated floating structures have plant roots growing down into the water column while plant stems remain above water level (Hedley and Tanner 2008). The plants grow in a hydroponic manner, taking their nutrition directly from the water column in the absence of soil. Beneath the floating structure, a hanging network of roots, rhizomes and attached biofilms is formed, providing a biologically active surface area for biochemical processes as well as physical processes such as filtering and entrapment.

Conclusions

In the 1970s and 1980s, the use of natural and constructed wetlands for water quality improvement was a new field of science. Water managers were uncertain of the design parameters required to maximise pollutant removal. Researchers were uncertain of the processes responsible for pollutant removal. Regulators were uncertain of the efficiency with which wetlands removed pollutants. Yet 30 years later, tens of thousands of constructed wetlands operate around the world, with bacteria—supported by plants—responsible for most of the pollutants being removed from a multitude of different wastewaters.

Since the mid-2000s, the promotion of floating islands to improve pollutant removal efficiencies of constructed and natural wetlands has seen water managers, researchers and regulators show understandable caution in the uptake of this new natural technology. This paper shows that vegetated floating islands are a highly effective supplement to wetlands designed to improve water quality in polluted urban, agricultural and industrial environments.

The key messages are:

- Bacterial biofilms develop on all physical surfaces within a wetland and these bacteria within and beneath floating islands, supplemented by oxygen and carbon from plants, do the bulk of the pollution-reduction work.
- While nitrogen generally escapes to the atmosphere after bacterial degradation of ammonia, nitrite and nitrate compounds, phosphorous is taken up within bacterial and other organic matter, eventually falling to the bottom of the wetlands where it can become biologically available under altered physical and chemical conditions. Physical removal of this material at appropriate intervals is essential.
- Vegetated floating islands massively increase the surface area of bacterial/ algal biofilm within a wetland, enhancing the wetland's ability to reduce the levels of nutrients and other pollutants within inflowing water.

References

A list of the 42 references quoted in this paper is available on request to the author at bmasters@iinet.net.au

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Suzanne Mather has been active in bird conservation through BirdLife Australia since retiring from school teaching. During that period she has achieved a Graduate Diploma in Ornithology from Charles Sturt University, been active in various projects undertaken by BirdLife, served on several committees including three years as Chair of the WA Branch. Her current contribution to BirdLife is to ensure that the WA driven projects achieve their outcomes. This involves liaising with volunteers and the employed staff. Her specific interests are in the conservation of both shorebirds and bushbirds on Rottne and Faure Islands. She currently holds one of the vice-chair positions with the WA Branch.

Introduction

Bringing together scientists and the wider community has been central in the advancing of global knowledge over a long period of time. In Australia more than 130,000 people are active in over 90 citizen science projects, predominantly in environmental science (Peel et al. 2015). Citizen science and BirdLife Australia have had a long and fruitful association. BirdLife has morphed out of what was originally the Royal Australasian Ornithologists Union (RAOU) with a history dating from 1901. The organisation's early history demonstrates the interdependence and mutual support of private collectors and bird enthusiasts, public institutions such as museum and professional zoologists and ornithologists (Libby 2001). For example the 1920 RAOU annual congress and field excursion was held, for the first time, in Western Australia. This party of citizen scientists travelled from the eastern states by the newly commissioned Transcontinental Railway, alighting from the train en-route to survey birds in the "Desert", reporting that the country "looked well" (Barnard, 1921). So citizen science and concern for our natural habitat is not new to the organisation.

BirdLife, as the major ornithological body in Australia, has over this long period, initiated and supported conservation research in conjunction with encouraging and supporting a public interest in birds, their habitats and continued survival.

In response to the initiation of the 2008 Wentworth Group Accounting for Nature model, scientific information about the condition of the environment could be viewed and understood in an accounting framework (Cosier and Sbrocchi 2013). This is where citizen science becomes valuable because through gathering large amounts of data, using scientifically valid methods for gathering these data, a framework can be developed. That is citizen scientists, people from our community working with scientists to a common end. Through this approach can come irrefutable positions that will, for example, show population trends in a species or a particular habitat. This is comparing apples with apples or wetlands with wetlands or a species presence over time. It is an innovative and robust method for regularly reporting on birds, a natural resource and a major component of Australia's biodiversity.

BirdLife Australia has adopted this accounting framework as a means of tracking trends in the status of Australia's most threatened bird group through the Australian Bird Index (ABI). BirdLife is only able to undertake this initiative because of the contribution that citizen science has made to the Atlas of Australian Birds database with over 4500 citizen scientist's contributions, over the last 17 years. Over 427,325 standardised bird surveys were used to generate the indices. So whilst in 1920 our citizen scientists were out there observing and recording what they saw, often working with for example museum curators, now this information can be managed with a scientific rigour, important in understanding and managing our natural resources.

Citizen science is in the unique position to achieve a number of goals: it can gather data that scientists will never be funded for; it can foster community ownership of the natural environment; it can bring a higher level of scientific knowledge to the broader community. Dickinson et al.(2012) has elaborated on what professional ecologists can do with data from

citizen scientists. Some of these suggestions can be applied directly to the projects involving BirdLife's citizen scientists and professional scientists working together such as: studying ecology at a large landscape scale, showing large scale changes in the distribution, abundance and presence of birds; studying the ecology of social and working landscapes. To this list can be added the collaborative work and expertise that Western Australian citizen scientists bring to other conservation agencies.

This review will outline the role that citizen science plays in Western Australian natural resource management through the BirdLife Australia projects.

Landscape scale projects at a national and state level – used by professional ecologists

Great Western Woodlands (GWW). The GWW is 16 million hectares of a virtually intact, vast mosaic of natural ecosystems extending from the eastern edge of the Western Australian wheatbelt to the western edge of the Nullarbor. BirdLife and The Nature Conservancy, in a joint funded venture began on bird research in this area in 2011. The specific outcomes of this project included establishing long-term ongoing bird monitoring across the GWW and using the resulting datasets to better understand the temporal and spatial use of woodlands by birds, the impact of disturbances and improving conservation and management. This project also aims to raise awareness, appreciation and sense of ownership of the GWW by local communities and the wider public (GWW 2014).

To discover how such a large intact ecosystem functions, nine broad survey areas have been identified to best capture the diversity of the region. At each of these areas approximately 25 fixed survey points were established, therefore 231 individual sites where the 20minute 2 ha survey method was used. These surveys occurred in all seasons for three years and are on-going, with citizen scientists continuing this work since funding ceased. To date this represents 152 volunteers, submitting 4374 survey forms, travelling 195,000 ks and representing \$500,000 in a citizen science donation of time, effort and resources. The results show that the GWW appears to be a stable, healthy ecosystem with 182 species recorded, ten of which are listed as threatened.

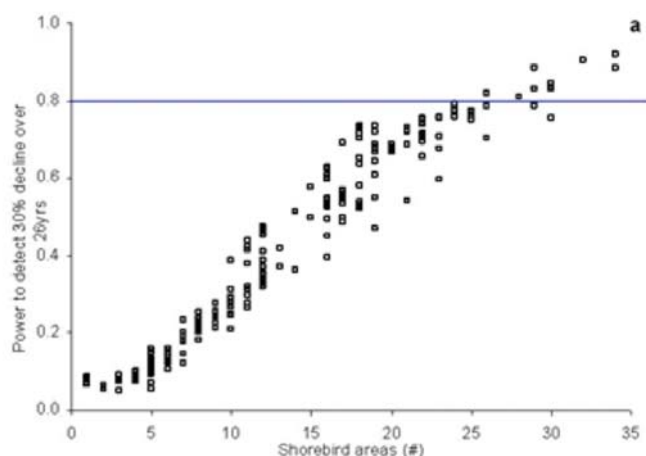
Shorebirds 2020. The national Shorebirds 2020 volunteer project evolved from monitoring this particular suite of birds since 1981. To identify statistically significant results Shorebird 2020 aims to regularly monitor 150 sites, or 35 sites for each of the 33 species found there. It has resulted in over 15,000 surveys throughout Australia, with regular counts at 29 sites. The data also helped identify shorebird areas of international importance including Ramsar sites.

Western Australian sites, are surveyed at least bi-annually with 172 citizen scientists doing this work. The results of these surveys:

- i) identify which are the most important areas for shorebirds, such as the Yalgorup system, and this leads to management and protection;
- ii) show whether species are declining, and why;
- iii) identifies threats to shorebirds and their habitat;
- iv) gauges if these population trends are driven by local factors.

The science input to this aspect of the work has occurred with data analysis where it has been shown that for national trends, while variation and abundance play a part, the power to detect population trends is driven most by the number of areas sampled (Figure 1).

Figure 1. The power to detect population trends is driven by the number of areas surveyed



The Atlas of Australian Birds. The Atlas is one of BirdLife Australia's greatest resources, tracking changes in birds across the country. Since 1998 a dedicated band of over 7000 citizen scientists have amassed over 420,000 surveys, comprising over 7.1 million bird records (<http://www.birdlife.org.au/projects/atlas-and-birddata>). These data are being used to generate indices, representing a total of more than 304,264 hours of surveying. These indices fall into Cosier and Sbrocchi's (2013) accounting framework but also Dickinson *et al.*'s. (2012) tracking species declines and movement skills, data that citizen scientists can bring to research.

Unlike most Atlases conducted around the world which collect data in grids, citizen scientists are asked to give the precise coordinates of where they undertook their survey. Knowing this information adds greatly to the value of the data and facilitates repeat surveys. With large numbers of citizen scientists collecting data, the Atlas provides a good insight into the changes in bird populations over time. Chambers *et al.* (2008) have shown how the correlation of Atlas data with climatic variables can indicate possible impacts on a species with climate change.

Western Australia has 4500 Atlassers or citizen scientists, all contributing these data which can then be used to, for example underpin a discussion on whether or not a particular area is important for a threatened species. This is the sort of information that is vital when advocating with decision makers such as local, state and federal governments. A good example of this is the case that BirdLife has been able to present to the Strategic Assessment for the Perth Peel Region (SAPPR) on the conservation of the Yalgorup system.

Projects that address social and working landscapes

It has become increasingly important to have well founded scientific data both in an urban and rural landscape so that decisions affecting the natural resources of these landscapes can be well informed.

Southwest cockatoos. BirdLife's Threatened Cockatoo Program aims to use the organisation's skills, expertise and ability to work collaboratively with a range of stakeholders, including government, non-government, industry and corporate partners to build an expanded program that will better manage and protect all three threatened cockatoos in south west Australia. These species are found both in the social urban landscape of Perth and the farming and forestry working landscapes.

The Great Cocky Count (GCC). The GCC, conducted by BirdLife WA since 2010, is a synchronized annual count of the Endangered Carnaby's Black-Cockatoo (*Calptorhynchus latirostris*). This has integrated citizen science, sound scientific methods and statistical analysis resulting in a valuable insight into roost site use and population trends. This project aimed to:

- i) train and engage the community in monitoring black-cockatoos;
- ii) to conduct roost counts and identify new roost sites of Carnaby's and Red-tailed Black-Cockatoos (*Calptorhynchus banksii naso*);
- iii) provide a maximum population count in the Greater Perth-Peel Region;
- iv) assess trends in roost counts for Carnaby's within the Perth-Peel Coastal Plain.

The 2014 survey results showed that the combined effect of fewer occupied roosts and fewer birds in each roosting flock resulted in an estimated decline in the total number of Carnaby's Black-Cockatoos of 13.0% per year. The implications of the projected declines are that, should the current trend continue, the Carnaby's Black-Cockatoo population found seasonally in the Swan Coastal District would be halved in five years, and after 15 years less than 10% of the population would remain. The result of the 2015 survey (not yet released) is similar to 2014, both surveys were funded by the Perth Region NRM.

This is the most comprehensive study of the Carnaby's population and as such is raising awareness of this endangered species at the local, state and federal government level. It is a good example of citizens, backed by sound science, informing decision making at all levels in a highly urbanised area.

This work shows that the criticisms that arise over the validity of citizen science in this project can be addressed through consistent resurveys of sites, appropriate analysis and the incorporation of additional explanatory factors such as observer effects (Williams *et al.* 2015).

Carnaby's Black-Cockatoo breeding sites project. BirdLife has over several years, identified and monitored nesting sites in the farmland, wheatbelt breeding range of this species. This work has been funded variously by Caring for our Country grants, by private donations and currently through funding from World Wildlife Fund (WWF) and the Taronga Conservation Program. The loss of nesting hollows and habitat is seen as a major contributor to this species decline (Saunders 1990, Saunders *et al.* 2003). The work with this project has concentrated on identifying breeding and nearby foraging sites. Working with landowners of properties with identified breeding sites, Voluntary Management Agreements have been brokered between landowners and BirdLife thereby securing these important sites for the future. To 2013 this has resulted in 2016 ha of fencing, 53 ha of revegetation, 207 nest hollow repairs and the installation of 28

artificial hollows. This project is on-going with citizen scientists working with BirdLife project officers and often working collaboratively with other agencies such as the Department of Parks and Wildlife and the WA Museum.

Perth Banksia Woodland Restoration. Bold Park is an important urban foraging site for Carnaby's Black-Cockatoos, particularly with its large stands of banksia species. This small project, funded through the Department of Parks and Wildlife Community Restoration Grants, involves the restoration of the degraded eastern gateway precinct of the Park through planting of banksia species, monitoring the bird presence in both this and surrounding areas. Citizen scientists both monitor the birds and assist with the planting, guided by the scientific expertise offered by Bold Park staff.

Cookies in Crisis. This two year community conservation project, funded through a Lotterywest Grant, began in mid-2015. It aims to improve the status of the endemic and declining black-cockatoos, focusing on the Baudin's Black-Cockatoo (*Calyptorhynchus baudinii*) and Forest Red-tailed Black-Cockatoo (*Calyptorhynchus banksii naso*). A broad range of actions will be undertaken generating achievements that will set up a long-term community-driven conservation project. Specifically this project is identifying key habitats, running citizen scientist workshops, creating a survey manual, working in the urban and rural communities where these threatened birds are found.

Australasian Bittern (*Botaurus poiciloptilus*) project. The Endangered Australasian Bittern study from 2007 to 2012 concentrated on the specific wetland habitat of this waterbird. Originally a volunteer study then funded through Lotterywest and the Department of Parks and Wildlife, this work aimed to:

- i) determine the current range, population and wetlands inhabited by the species in Western Australia;
- ii) to document wetland characteristics to determine specific habitat requirements including drought refuges to document threatening processes;
- iii) to increase awareness of the species and the importance of wetland conservation.

This placed BirdLife in the position to make recommendations, based on data gathered by citizen scientists, for Australasian Bittern conservation and the wetlands that support populations of the species.

The study consisted of 513 surveys by 130 citizen scientists at 105 wetlands and resulted in 132 records of Australasian Bittern and 88 records of Australian Little Bittern (*Ixobrychus minutus*) (Pickering 2013). The estimate process was also used to estimate the population present in WA during the 1980s and this indicated the species had declined by 24 to 51% since the 1980s. The species is thought to still be declining in Western Australia.

Awareness raising, education and community engagement has been a key part of the work undertaken. An important outcome has been the development of a technical advisory group and a draft Interim Recovery Plan for the species in Western Australia. The project has also played a critically important role in collating existing and new knowledge, and actively bringing together key stakeholders.

Perth Biodiversity Project. Between 2002 and 2006 the Perth Biodiversity Project undertook an inventory of the bird species in 117 reserves, vested in the Perth region local government. This work, involving 275 BirdLife citizen scientists, aimed to link bird survey information with management and conservation strategies in this urban area. Based on data from these community surveys, scientists were able to report that at least 83 % of 65 landbirds were found to be dependent, in some way, on the presence of native vegetation (Davis *et al.* 2012). For three groups of species defined by specific patterns of habitat use (bushland birds), there were sufficient data to show that species occurrences declined as the landscape changed from variegated to fragmented to relictual, according to the percentage of vegetation cover remaining. In order to maximise the chances of retaining bird diversity, it was recommended that management actions should concentrate on maintaining the integrity and quality of remnant native vegetation, one of our natural resources.

Hooded Plover Project (*Thinornis rubricollis tregellasi*). The annual Hooded Plover survey aims to quantify the Western Australian Hooded Plover population including the recruitment of juveniles and their distribution. These data have been collected for the last 20 years, the surveys covering the known habitat of this species and are stored in a database. For example the database for the Cape to Cape region holds around 1100 records. The results from a long term database such as this result in confidence in the estimated stability of the population in this area (Singor, 2014).

Collaborative work with other agencies

BirdLife has found that working collaboratively with other agencies often results in better outcomes for natural resource management. The organisation is able to offer expertise specifically relating to birds such as which habitats are most important for particular groups of birds or species.

Peel Harvey Catchment Council. BirdLife collaborated with PHCC in the Rivers 2 Ramsar project where the environmental issues affecting the riparian and bushland area of the Peel Harvey Catchment, an area that extends from the west coast inland to the wheatbelt, are addressed. BirdLife conducts community based workshops on the conservation issues facing the threatened black-cockatoos that are part of the natural resources of the area.

The Australian Wildlife Conservancy (AWC). BirdLife WA collaborates with AWC in surveying annually their four southwest sanctuaries, Karakamia, Paruna, Mt Gibson and Faure Island. The data, gathered by citizen scientists, resulting from this work contributes to the on-ground conservation programs of each of these sanctuaries. Specific survey work at Mt Gibson is recording the bird species both in and outside the 6,000 ha, feral-proofed high conservation valued woodland.

Rottneest Island Authority. Rottneest Island is recognised internationally as an Important Bird Area on the basis of the breeding colony of the threatened Fairy Tern (*Sternula nereis nereis*) and the population of Banded Stilt (*Cladorhynchus leucocephalus*). BirdLife has surveyed both the shorebirds and bushbirds on the island for many years resulting in scientific data that underpins the environmental decisions on protecting this island's unique values. An example of this was the consultation prior to the re-construction of a new boardwalk at Cape Vlamingh, an established Wedge-tailed Shearwater (*Ardenna pacifica*) colony.

There have been a number of smaller collaborative agreements between BirdLife and other agencies but Table 1 summarises the number of citizens scientists involved in this work, the broad natural resource areas where this has impacted and the type of data that is gathered and can inform decision makers.

Table 1: BirdLife citizen science projects that underpin natural resource management.

Project	# CS	Area	Data	Date
Shorebirds 2020	1500	WA coast and wetlands	Species present, abundance, location, population trends	ongoing
Atlas	4500	WA	Species present, location	ongoing
Australian Bird Indices		Australia	Indices of bird groups	ongoing
GCC	600	293 sites in Perth metropolitan	Abundance, population trends, roost site locations	April 2014
GCC Breeding sites	18	Wheatbelt	Nest site locations	ongoing
Australasian Bittern	130	Southwest wetlands	Abundance, location.	2010 ongoing
Perth Biodiversity Project	275	117 local government reserves in the Perth metropolitan area	Species present, abundance, location, flora structure	2002-2006
Hooded Plover	80 (2015)	South and south west beaches, inlets	Abundance, breeding records, locations	1995-ongoing

Conclusion

The future looks bright for the collaboration of citizen scientists and professional scientists. The expanding public engagement in the emerging technologies brings skills and enthusiasm that can influence the scientific research process by streamlining data collection, improving data management and communication (Newman *et al.* 2012). BirdLife is already working on this, factoring new technology into the project implementation plans for south west cockatoo projects. Using mobile phones to enter a BirdLife portal with immediate data, confirmed by photographic images, will attract a new and diverse suite of citizen scientists. However good data management capabilities need to be integral to the design of any projects using such an approach. Some of the criticisms of the value of citizen science data (Tulloch and Szabo 2012) will be addressed by gathering more data with temporal and spatial data automatically recorded. Using new technology will give scientists data that would be unaffordable in the amount of data that can be gathered and the range it can cover. Citizen scientists are everywhere, in the most remote areas as well as the heavily urbanised places.

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Act Local; Think Global—The Importance of Sharing Local Species Project Data for Global Conservation Impact

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Richard McLellan is the Chief Executive Officer of the Northern Agricultural Catchments Council—in role in which he is charged with progressing the organization’s mission to catalyse and support the community’s contribution towards environmental stewardship in his region.

An environmental scientist by training, Richard joined NACC (in February) after 15 years with WWF, the global conservation organisation, with which he first became involved with WA NRM groups through his work as a field ecologist on a private lands protected area conservation program across the WA Wheatbelt. He has since worked across WA and Australia, Southeast Asia and, for the last seven years, in Switzerland—a long way from his childhood days of growing-up on a broad-acre farm at Kellerberrin in the central Wheatbelt. His final role with WWF was as the global director of the organisation’s Ecological Footprint program, and editor-in-chief of the Living Planet Report.

With a long-standing interest in community-based conservation, Richard is committed to a future in which people live in harmony with nature—through connecting, conserving and contributing to our natural environment.

Introduction

Working in the fields of conservation and natural resource management/stewardship is frequently daunting—especially when local practitioners are confronted by both the scale of some of the challenges and the alarming global statistics that accompany them—such as regarding pollution, climate change, overfishing, soil erosion and desertification, and similar seemingly-insurmountable impacts. Reports on these global-scale impacts regularly appear in academic journals, summit and conference proceeding, research reports ... and ultimately mainstream media.

The Living Planet Report

Adding to this overwhelming picture is the *Living Planet Report*—the world’s longest-running “State of the Planet” report—published by WWF, the global conservation organisation. First published in 1998, *The Living Planet Report* recently passed its tenth edition milestone – with the publication of its latest edition in October 2014. Alarming, the *Living Planet Index* (LPI)—the report’s principal “state of the world’s biodiversity” index, produced by the Zoological Society of London—revealed a massive 52% decline in species’ populations all around the world.

This a complex and concerning statistic that masks the true plight of many species’ populations. For although the LPI draws on data from more than 10,000 populations of more than 3,000 species, it is too broad a measure to highlight what is happening to species’ populations in specific biomes and geographic realms. Fortunately, the LPR does “drill-down” and provide information on these, which reveals some good news in some parts of the world, but even worse news (than minus 52 per cent) in others. Species’ populations in the Freshwater biome, and the Latin America and Indo-Pacific realms are showing near catastrophic rates of decline.

Missing links

Further adding to the complexity of understanding the implications of this global index is the fact that so little data exists for so many species, especially in the global south and east. Surprisingly, relatively there is relatively little data in the LPI from Australia, and Western Australia—where trends from just 17 species’ population are represented in the database.

To have any chance of reversing the global declining trend of the LPI, every effort must be made to protect and monitor as many species’ populations as possible, which, while “thinking global”, can only be done by practitioners at the local and regional scale.

Act local, think global

Much of this work is being done, however the data is stashed-away in private (and public) researchers' notebooks and folders, laptops and computer hard-drives. The challenge being put here is for us to find and share that data, to lodge it online via the LPI portal, to help paint a more accurate picture of the "state of the planet", and to use this information to guide better conservation planning, policy and action. This is not the biggest challenge, or highest priority, faced by the conservation community, but it's an important one ... and only solvable by local practitioners "acting local, and thinking global".

The LPI research team at the Zoological Society of London would welcome outreach from anyone on-the-ground or in-the-field who has records of species' populations in Australia, and particularly Western Australia.

Data can be lodged directly online via the LPI portal at: <http://www.livingplanetindex.org/home/index>

Conclusion

Field staff and environmental conservation practitioners are encouraged to:

- Share your species' research data.
- Publish it, Post it, Tweet it ...
- Go digital—add it to the LPI.
- Encourage your peers to share their data.
- Draw on "private" resources—Citizen Science
- Promote and contribute to science communications #SciComm

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The *Living Planet Report* can be downloaded from here: http://wwf.panda.org/about_our_earth/all_publications/living_planet_report/

#DoMoreGood: Using @Twitter to Increase your #NRM Group Impact – by @Richard McLellan

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Introduction

Everyone who works for a regional Natural Resource Management (NRM) group is a communicator. Every one of these individuals communicates about their organisation every day—some via formal communications channels and others by their conversations, their behaviour and the snippets of information they post on social media. All of this has the potential to impact an organisation’s profile and reputation; and all, if done well, have the potential to “do more good” for the organisation, its work, and the outcomes it is trying to achieve.

Social media platforms are all different and all have their advantages and limitations. Twitter is one that can easily be adopted by any (and all) staff, providing multiple benefits to the individuals and the organisation.

Moving with the times

No organisation in this day and age can afford to remain static and carry-on doing things the way they always have. The goal posts, the game, and actually the entire “playing field” is constantly changing. Keeping abreast of these changes is not quite a matter of “life or death” for a regional NRM group, but it does make a difference to a group’s performance, efficiency, reputation and impact.

The playing field is changing in many ways, including these five that were highlighted in an interesting article in The Huffington Post in September 2014 under the heading: Five trends shaping the future of work. These were:

1. Ever-changing technology—Big data, the Internet of things, robots, automation.
2. Globalisation—Operating in “markets” with diminishing boundaries.
3. New behaviours—Living more public lives; More sharing & collaborating; Social media.
4. The millennials—50% of the workforce by 2020; 75% by 2025. A generation of “digital natives”—with new values, ideas, expectations about work.
5. Mobility—We can stay connected anytime, anywhere, any device.

All of these relate, in one way or another, to communication. One could argue that if you work in NRM, then, at one time or another, you're a communicator. Whether you like it or not, you're probably a "jack of all trades"—at different times a practitioner, a fundraiser, and a communicator.

Communicating NRM

There are multiple ways in which we formally communicate NRM and the work of our organisations, and we are all familiar with the following list of examples: media releases, website, brochures, displays, newsletters, publications, posters, blogs, and social media—Facebook, LinkedIn, #Twitter.

Of the latter, Twitter can be much more than "social media". And it can be done by all staff, especially program staff, and not just the nominated communications lead. It has considerable professional potential—for both the individual, and the organisation—if "done right". The key benefits to be gained from NRM program staff using Twitter include the following:

- Source of professional reading.
- Source of news and current affairs.
- Staying abreast of key topics and issues.
- Connecting / Networking.
- "Filing" key documents, graphics, statements, reports, etc.
- Intellectually stimulating, inspiring.
- Virtual conferencing.

Twitter @ Work

A few tips for getting started as a program Twitter exponent:

- Make your account professional / work-related (not social).
- Make your bio and the photo you post work-relevant.
- Be topic-focussed—Tweet limited / specific subject area(s).
- Tweet mostly work-related material (but show you have another life from time to time), but still professional (nothing offensive).
- Follow people whose work matters to you—key stakeholders, organisations and individuals.
- Be regular—Treat it as "twerking"—Tweet regularly—at start and end of day.
- Demonstrate that you have a life (beyond work).

Some advice for professional Twitter success

- Learn before you start. Do an internet search for "Twitter for beginners" (or similar). There are lots of tips out there on how to get the most out of Twitter.
- Give yourself an objective—Such as: Twitter competency: to engage particular stakeholders (potential partners); for professional development; to get something actionable that can help your work.
- #DoMoreGood—make it a positive space.
- Maintain high standards—words, images, ethics.
- Be prepared to stand-by what you say.
- Retweet and comment / mention.
- Acknowledge RTs (use the favourite star).
- Ignore #trolls.
- Search relevant topics (e.g., NRM, Landcare, coastal erosion, etc.—use to guide who to follow; what to retweet).
- Tweet from conferences.
- Follow-back courteously & judiciously.

Some Take-home tips for top tweets

- Don't begin with @
- Shorter is better
- Use headlines - Stay on safe ground. Catch attention.
- Use "Quotes"
- 87% of people on Twitter like #statistics

- Include a link to the source article/website for more information
- Add a graphic / image
- Use #hashtags
- Use @mentions
- Acknowledge @sources
- Retweet praise
- Ask for a RT (if it's important)
- Promote your blogs, website, Facebook page, newsletter, etc.

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Pilbara freshwater fishes: field guide and documentary

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BIOGRAPHY:

David Morgan grew up in the Perth southern suburb of Rossmoyne, where he developed a passion for aquatic environments though chasing prawns, crabs and cobbler with his parents Robert and Faye. He has since specialised on threatened, introduced and native freshwater fishes throughout Western Australia. Over the last 24 years at the Freshwater Fish Group at Murdoch University he amassed more than 200 publications on Western Australian fishes in the south-west, Pilbara and Kimberley. He has developed an unparalleled knowledge of the distribution of inland fishes in Western Australia and his research has helped to shine a light on freshwater fishes in Western Australia and aided in their conservation and management. He has a passion for collaborating with Traditional Owners in his research such as developing the long running Team Sawfish project in the Kimberley. David has three children, Naomi, Charlie and Renee, and is currently the Acting Director of the Centre for Fish & Fisheries Research at Murdoch University. Away from fish research he enjoys fishing, crabbing, and coaching the Y5 Whites at the Jandakot Jet Junior Football Club in Atwell.

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Introduction

Covering nearly one-third of the Australian continent, Western Australia comprises five of Australia's 10 ichthyological (fish) provinces and this includes the Southwestern, Pilbara, and Kimberley provinces, all of which are wholly contained within Western Australia, whereas the western edge of the Northern Province and the western portion of the Paleo Province also occur in Western Australia (see Unmack 2013, Morgan *et al.* 2014a, b).

The study focuses on the fish fauna of the Pilbara Province, and was a joint initiative of the Rangelands NRM Coordinating Group and the Western Australian Government's State NRM Program and co-funded by the Australian and State Governments.

The Pilbara Province encompasses the Mid-west, Gascoyne and Pilbara regions of Western Australian and covers an area of over 500,000 km². Almost 10% of the Australian continent is drained by the rivers of the region, and despite its aridity, the Pilbara Province hosts Western Australia's longest river, the Gascoyne, which has a catchment of almost 80,000 km² and is over 860 km in length. Other notable river systems include the Murchison, Ashburton, Fortescue and De Grey rivers.

The Pilbara Province includes all river basins from the Irwin River in the south to the De Grey River in the north (Morgan & Gill 2004) and the northern boundary abuts the Great Sandy Desert, which has largely isolated this Province from other parts of northern Australia. Consequently, the freshwater fishes in this province are either local endemics (6 species) or have extensive distributions across much of northern Australia (4 species). There are no shared freshwater fish species with the Southwestern Province, although some estuarine species are shared, such as Black Bream and Blue-spot Goby. Distinct patterns in the distribution of fish species in the Pilbara Province resulted in the recognition of three sub-provinces, namely the Southern Pilbara, Northern Pilbara, and North West Cape (Morgan & Gill 2004).

The most unusual endemic fishes of the Pilbara are found in the subterranean waters in North West Cape Sub-province. Two species of cave gudgeon occur in the region. The Blind Gudgeon occurs on the mainland at Cape Range Peninsula while the newly described Barrow Cave Gudgeon is restricted to Barrow Island (Humphreys & Adams 1991, Larson *et al.* 2013). Both species share their habitat with the Blind Cave Eel, although it is likely that the eels on Barrow Island also represent an additional endemic species given the isolation of the two blind gudgeon species.

The surface dwelling freshwater fish fauna is dominated by a relatively small number of species that can survive in the extreme environments of the Pilbara where rivers experience massive flooding following cyclones and limited water availability during dry times. The fauna consists of three fishes endemic to the province; Deep Hardyhead and Golden Gudgeon are primarily restricted to southern rivers, but with the former having a disjunct northern population in the De Grey River. The Fortescue Grunter is restricted to a few Northern Sub-province rivers (Morgan and Gill 2004). A possible new species of eel-tailed catfish from the Robe River may also be endemic although it has not been captured for a number of years and the Robe River is predicted to have the highest freshwater fish extinction rate on the planet under future climate change scenarios (Tedesco *et al.* 2013).

The remaining freshwater species are all widespread across northern Australia, although Pilbara populations tend to be distinct genetically, with some differences sufficiently large to suggest they represent distinct (and thus endemic) species (Unmack 2013). For example, Pilbara populations of Bony Bream and Hyrtl's Tandan, two of Australia's most widespread freshwater fishes, both appear to be new species (Unmack 2013; Morgan *et al.* 2014a, b), and warrant closer morphological examination. Pilbara populations Western Rainbowfish are also genetically distinct to populations elsewhere in northern Australia (Unmack *et al.* 2013).

In contrast to the Southwestern Province, there are more estuarine and marine vagrants occurring in the non-tidal waters of the Pilbara Province with at least 13 of these species found in fresh waters of the Province, and in some habitats they have been recorded to comprise between 5 and 10% of the total fish numbers. Diadromous fishes (fish that migrate between the sea and freshwater) of the Pilbara Province include Mangrove Jack, Tarpon, Bull Shark and Freshwater Sawfish. Catadromous species (fish which live in freshwater but breed in the sea) include the Indian Short-finned Eel, while Barramundi is considered to be semi-catadromous as it breeds within estuaries or may remain in the estuarine or marine environment.

Future impacts to the habitats and fishes of the region are likely to result from the impacts of climate change and from dewatering of habitats during mining and through water abstraction (Tedesco *et al.* 2013). As an example, Tedesco *et al.* (2013) predicted that freshwater fish extinction rates within river basins within the Northern Pilbara Sub-province will be amongst the highest on the globe. Incredibly, the authors predicted that six of the rivers within the Northern Pilbara Sub-province will be in the top 12 rivers globally to suffer the highest extinction rates due to water availability shrinkage from climate change. Furthermore, the impacts of introduced species are outlined within the field guide and documentary, and are an ever increasing threat to this unique fauna.

The field guide produced during this study, together with the associated documentary and additional publications, summarises the fishes in the inland waters of the Pilbara, and each represents a timely review of this often forgotten fauna.

Methodology

To further determine the distribution of fishes in the Pilbara Province, as well as to capture fish on film for the field guide and documentary, a number of field trips to most of the rivers of the Pilbara Province were conducted during 2013 and 2014. A review of all existing literature on the fishes of the Pilbara was performed in order to complete the field guide and for the narration of the documentary. ENVfusion Films completed the documentary at the end of 2014, at which time it was placed in the public arena (on youtube). The field guide was printed in December 2014.

Project Outcomes/Conclusion

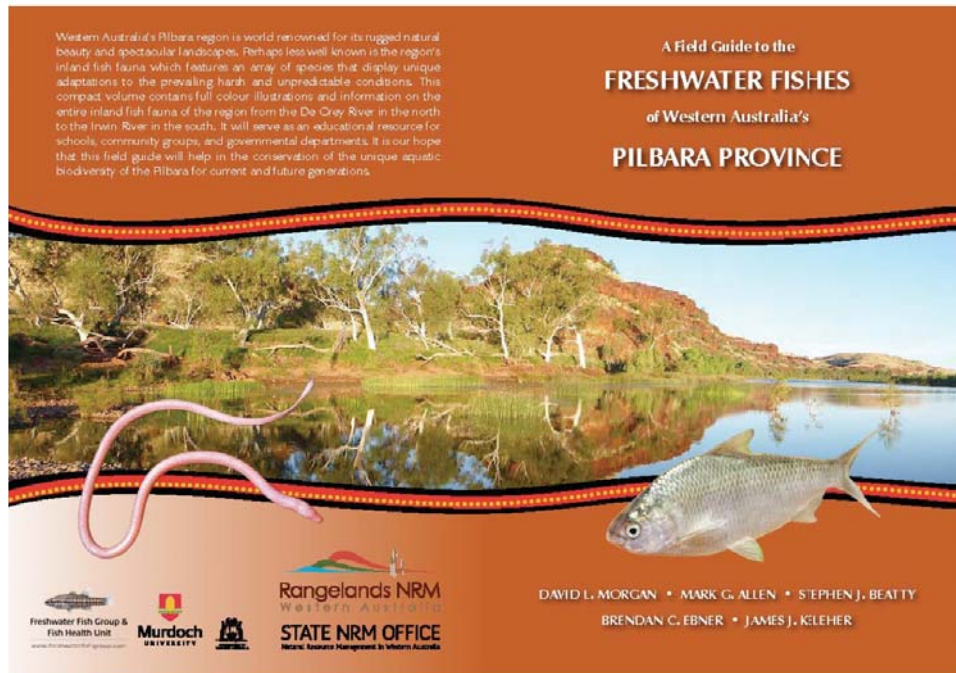
The main outcomes of the project were the completion of a field guide and documentary on the fishes of the Pilbara Province. There was also considerable public involvement in the project.

The documentary can be viewed at:

https://www.youtube.com/watch?v=d9v5DMzm_1o

A total of 1000 copies of the field guide (Morgan et al. 2014a) were printed, and copies are available from:

fish@murdoch.edu.au



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Growing Community Capacity and Banking with Kimberley Seeds

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Louise Beames co-coordinates the Kimberley Nature Project, through Environs Kimberley and is the President of the Broome Botanical Society. As an ecologist with 15 years experience, she has spent the last 8 years working with Indigenous rangers and community groups to undertake cultural, natural resource management projects throughout the Kimberley. Her collaborative scientific and cultural management work with the Bardi Jawi and Nyul Nyul ranger groups was instrumental in achieving the recognition and listing of Dampier Peninsula Monsoon Vine Thickets as Endangered under the EPBC Act (1999). Her work with Society for Indigenous Plants and Animals and Broome Botanical Society to undertake preliminary survey and description of Minyjuru (Mangarr) on relict dunes in the Broome Peninsula was pivotal in the listing of this community as a Priority 1 community. This collaborative work with Tim Willing, secretary for the Broome Botanical Society, and an independent ecological consultant, has furthered the understanding of the ecology and extent of Minyjuru and Cable Beach Ghost Gum Priority 1 Ecological Communities within the Broome Peninsula.

Abstract

The establishment of a Kimberley regional not-for profit seedbank co-operative and outreach service has the potential to promote improved revegetation practices, support conservation and management activities, supply horticultural enterprise and provide economic returns to local collectors.

The Kimberley region is a biodiversity ark for Northern Australia, yet is under threat from weeds, land clearing and frequent wild fires. Revegetation work in the region by Indigenous Ranger groups, companies and government departments is inadequate due to the scarcity of viable indigenous and provenance seed. At present, the lack of a regional seedbank leads to unmet seed demand, poor outcomes from revegetation contractors and an underrepresentation of Kimberley seed in National Botanical Garden Seedbanks. As one example, the Department of Parks and Wildlife Threatened Flora Seedbank has no seed of threatened Kimberley plants.

In 2015, Environs Kimberley will initiate the Kimberley Regional Seedbank Cooperative. The project is initially funded through the State NRM and will be conducted in collaboration with the Kimberley Training Institute (KTI) and Indigenous ranger groups facilitated through the Kimberley Land Council. Other community groups and individuals are encouraged to participate.

The seedbank, coordinated by Ayesha Moss, will provide support, training and information for Indigenous people and community groups in how to collect, store, clean and propagate viable native seed. Collected seed will be catalogued and placed on consignment within a temperature- and humidity-controlled facility. The seedbank will operate as a not-for-profit, connect buyers and sellers of seed and create a micro-market for seeds and other plant products, including nursery and floristry supplies. We will also partner with the Bardi Jawi Oorany Rangers' nursery to germinate seedlings and support further enterprise development with this Indigenous group.

Outreach support for Indigenous Rangers and community groups will ensure the sustainable collection of viable, diverse-provenance seed, reliable seed supply and successful propagation. By running workshops and producing materials, we will work to broaden community awareness of biodiversity threats, restoration practices and the role of seedbanks. Seed

collection and propagation knowledge will be collated within a booklet and an online resource, and provide the platform for further engagement with Indigenous groups to culturally adapt booklets to include language names and Traditional Ecological Knowledge.

By increasing awareness and holding collection activities, we will encourage licensed collectors to gather rare and threatened plant seeds in a sustainable manner and provide them to National/State botanic gardens. In collaboration with KTI and Society for Kimberley Indigenous Plants and Animals (SKIPPA), the seedbank project will work to grow and maintain these plants as living specimens in the Balu Buru arboretum as a local seed source.

Initially the seedbank coordinator will develop consignment agreements with collectors, as well as pricing, supply and payment structures, quality assessment tools and agreements on the uses of stored seed. Developing the market for collected seeds will be aided by good quality-assessment of supplied seed, a well-managed store and database, invoice and payment capacity and direct promotion to end users/buyers of seed.

As a social enterprise, the seedbank will support Indigenous ranger and other community groups, facilitate seed sales, provide ongoing operational costs for the seedbank and profits to the collector. It is intended that, after the initial setup phase, we will explore additional markets and move toward the seedbank becoming a self-sufficient community cooperative that enables people to participate in the Kimberley's emerging conservation economy.



Collecting Goolmi *Grewia breviflora*, a delicious bushfruit and an important species within the Endangered Monsoon Vine Thickets of the Dampier Peninsula.

Implications of Climate Change on the Aestivating Salamanderfish, *Lepidogalaxias salamandroides* Mees and Black-stripe Minnow, *Galaxiella nigrostriata* Shipway

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Garry Ogston has completed his Bachelor of Science with First Class Honours and currently works as an Environmental Advisor (Zoologist) within the Perth metropolitan and the Pilbara. For his achievements during his undergraduate degree, Garry was presented with the Student Medal by the Royal Society of Western Australia. Following on from his Honours research Garry is now hoping to pursue a PhD focussing on the use of environmental flows to buffer the impacts of climate change on the freshwater fishes of south-western Australia.

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Introduction

This study considers the impact of climate change on two aestivating species, Salamanderfish, *Lepidogalaxias salamandroides* Mees and Black-stripe Minnow, *Galaxiella nigrostriata* Shipway, from a drying region, Australia's Southwestern Province. *Lepidogalaxias salamandroides* is unique in that it is the sole member of the family Lepidogalaxiidae basally placed as the sister taxon of all Euteleosteiomorpha (Li *et al.*, 2010). Both *L. salamandroides* and *G. nigrostriata* are highly restricted in distribution to the ephemeral, acidic wetlands in the extreme south-western corner of the region (Berra & Allen, 1989a, b; Morgan *et al.* 1998), and are small bodied, have relatively short life cycles and annually aestivate underground (Pusey, 1989).

This study aimed to quantify any changes in their geographical range and losses of populations, identify the factors that best explain their current distributions, and assess the overall threats to the viability of remnant populations. We hypothesised that: (i) there has been a decline in the distribution of both species since previous surveys, and (ii) the environmental drivers of this distributional decline will be directly linked to climate change.

Background

Although freshwater environments comprise <1% of global water, these ecosystems are experiencing declines in biodiversity much greater than those seen in either terrestrial or marine ecosystems (Dudgeon et al., 2006). Several anthropogenic stressors have been identified as the causal factors of these declines, including water pollution, flow modification, degradation and loss of habitat, damage to riparian vegetation, the introduction of invasive species and climate change (Morrongiello et al., 2011; Comte et al., 2013). Climate change is predicted to severely impact freshwater systems around the globe, through increased water temperature and altered flow regimes (Tisseuil et al., 2012). Changes in water availability are predicted to push numerous species of freshwater fishes towards extinction by 2070 (Kingsford, 2011), which will in turn impact on the functional diversity of freshwater ecosystems globally (Buisson et al., 2013).

Despite aestivation occurring in a considerable range of fauna, it is relatively rare in fishes, and those that do aestivate have unique adaptations to cope with challenges such as water retention and water loss during annual dry periods, metabolic waste production and excretion, and energy storage and utilisation. Given their relatively unusual life-cycles and habitat requirements, aestivating fishes have been identified as particularly vulnerable to several of the major stressors facing freshwater systems, including that of climate change (Saddler et al., 2010).

Project Outcomes/Conclusion

Reductions in the extent of occurrence (EOO) and area of occupancy (AOO) was found to be 79% and 70% for *L. salamandroides*, and 12% and 58% for *G. nigrostriata*, for EOO and AOO, respectively. Depth of water in winter and length of the annual dry period were identified as variables of significance for the presence of *L. salamandroides*, with connectivity among sites most important for the presence of *G. nigrostriata*. Those factors are strongly influenced by rainfall and it is likely that climate change has been the major driver of the observed population losses. Given the Global Climatic Model (GCM) projections of continued large rainfall reductions within the species' distributional ranges and water table decreases by up to 4 m by 2030, further population losses are anticipated. This research has considerable implications for understanding how aestivating fishes will be impacted by climatically driven hydrological change.

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Planting with Machines: Using Mature Vegetative Divisions for Ready-made Wetland Habitat

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Introduction

Now in its second year, the Blackwood Basin Group's (BBG) Priority Bittern and Waterbird Biodiversity Enhancement Project has both success and learnings to share. The Project aims to create a wetland haven from historic mining dams in Greenbushes, south-west Western Australia, to provide vital habitat for endangered waterbird and migratory species. Run in partnership with Talison Lithium Pty Ltd and supported by Department of Parks and Wildlife, the project is funded by the Australian Government's Biodiversity Fund Program. The focus species for the **rehabilitation** is the **endangered Australasian Bittern** (*Botaurus poiciloptilus*), **Little Bittern** (*Ixobrychus minutus*), and **Black Bittern** (*Ixobrychus flavicollis*). These species require tall, dense reedy habitat in emergent freshwater, hence revegetation forms a major part of the project along with large-scale feral animal and weed control; dam modification; flora and fauna surveys; and community engagement activities.

Options for reed bed planting

The BBG has trialed a number of methods to revegetate seasonally inundated areas for waterbird habitat, some with more success than others. The jointed twig rush, *Baumea articulata*, is the primary species being used, with mature clumps being divided from a large reed bed source nearby using both manual and machinery methods. In wetlands with variable water levels, using machinery to relocate mature clumps offers many advantages over manual handling methods or seedlings. We found that once the winter rains arrive, water levels increase rapidly to inundate approximately 3ha of beds that are exposed during low water level. This is unfavourable for seedlings as they can easily be flooded and drowned if planted before the rains, or left exposed and vulnerable to drying out and predation by herbivores in the summer. Manually planting mature clumps led to damage of the stems during the unloading stage which resulted in some being flooded and dying completely, while in others growth was hindered as new shoots only emerged once water levels reduced.

Use of machinery

Using expert and precise excavator drivers to remove, load, unload, and plant mature clumps reduced handling and subsequent damage, and allowed for larger clumps to be planted. These are much less likely to be predated by herbivores and, with less damage and more of the stems standing upright, are unlikely to drown. A technique of tying bunches at the loading stage also assisted more clumps to stand upright. Using mature vegetative divisions with machinery-assisted planting keeps the root system intact, complete with a microbial ecosystem that will allow the plant to thrive, grow and provide a ready-made wetland for the protection of threatened waterbird species.

This project is supported by The Blackwood Basin Group, through funding from the Australian Government.

For more information on this project, please go to the website www.blackwoodbasingroup.com.au

Control of *Opuntia Elatior* on Wydgee Station

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BIOGRAPHY:

Andrew Reeves grew up on Oudabunna Station at Paynes Find where he was a neighbour to the property where the cactus work controlling *Opuntia elatior* has been undertaken.

He has worked with many Rangeland community groups controlling pest species and is now a policy and planning officer with DAFWA.

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Introduction/Background

Outlier populations of Weeds of National Significance (WoNS) weeds exist within the rangelands that can be controlled by a strategic treatment before they become widespread and established.

Florabase records show the only large infestation of *Opuntia elatior* in Western Australia is located at Wydgee Station in the Murchison region of the Southern rangelands. The infestation at Wydgee is prominently located on a creek line near the Station homestead and crosses the Great Northern Highway. The infestation is regularly reported to Main Roads WA and DAFWA by passing tourists, landholders and prospectors.

The infestation extends over 2,000 hectares and poses significant impediments to the movement of humans, livestock and native animals. The largest plants are up to 4 meters tall with a diameter of over 7 meters. Severe injury and subsequent infestation from the spines of the plants is highly likely. The infestation is slowly spreading along the creek-line and onto adjacent land.

Control of the infestation of *Opuntia elatior* on Wydgee station started in 2014 when the Rangeland Fibre and Produce Association (RFPA) was successful in obtaining a \$40,000 grant from State NRM with \$19,874 in kind from DAFWA and \$10,000 in kind from the RFPA. In 2015 State NRM provided a further \$30,000 with \$21,850 in kind from DAFWA and the RFPA.

Treatment occurred in 2014 using chemical treatment of 3% Triclopyr and 2% spray oil with the infested area divided into 7 areas and control occurred over 3 months from May to July with all plants being treated twice during the chemical application period. The outcome was 100% control of all plants less than 2m tall with 60% control of plants that were 3m tall.

Two small scale projects were initiated that recorded the number of areoles dropped by *Opuntia elatior* for plants that were 1–2m tall and a second trial that recorded the survivability of areoles after they had been released. The trials determined that the areoles have a high survivability when partially or completely buried.

A small scale chemical trial determined that the chemical treatment was effective but did not penetrate the core of the plant. Application of the same herbicide using diesel as the carrier provided 100% control and killed the inner core of *Opuntia elatior*.

Lessons learnt in 2014 led to adaptations in 2015 and the volume of spray oil increased from 2% to 5% that increased the control of larger plants from 60% to 80%. Final control of the core will need to be conducted using a chainsaw and direct application of herbicide using the cut stump technique.

The *Opuntia* control has been a measurable outcome, however greatest value of this project is that funding provided by State NRM has rejuvenated a community group that was struggling for membership and this project has provided a focus for the community to deliver an environmental outcome that has benefited the people of the region and highlighted the importance of cactus control to the community.

Methodology

The on-ground control was undertaken by the landholder of Wydgee Station utilising the assistance of backpackers who were working on the property to maintain the Stations horticulture enterprise that includes a peach, apricot and water melon orchard.

Additional support was provided by the members of the RFPA at field days and DAFWA staff undertook the small scale experiments on *Opuntia elatior* biology and established photo monitoring points.

Results

2014 Control

The control of *Opuntia elatior* on Wydgee Station commenced in 2014, approximately 45 years after the first plants were planted in the Station garden and 35 years after the plants had spread to the adjacent creek.

In 2006 DAFWA attempted to release the *Cactoblastis* biological control agent however the grub was not able to survive on this host and control was not successful.

From 1980 to 2014 water movement along the creek line spread the infestation over 2000 ha with a core infestation of approximately 400 ha that includes individual plants that are 4 m tall with a diameter of 7 m+ that has formed a “wall” of cactus 300 m in length.

Observations of the *Opuntia* at Wydgee Station determined that the plants could be classified into four categories.

Table1. Rating system used to assess the *Opuntia elatior* infestation at Wydgee Station

Rating	Description	Comment
0	No plants	–
1	Small plant	1 m tall, 1–2 m diameter, usually, a single stem
2	Medium plant	2 m tall, 3–4 m diameter, multi-stemmed plant
3	Large plant	3 m–4 m tall, 4–6 m diameter, multi-stemmed plants
4	Largest plants	4 m+ tall, 7 m+ diameter, large number of auxiliary stems

No plants of Rating 4 were present in the 2014 treatment area.

The funding provided by State NRM in 2014 was used to control the outlier infestations on 1600 ha by surveying the area to locate the last cactus before commencing control. The area was divided into seven treatment areas and control was started in May and concluded in July with each area being treated twice. The second treatment was applied 4 weeks after the first application to identify any plants that were missed in the first treatment.

Because of the dispersed nature of the infestation the most economical way to treat *Opuntia elatior* of Wydgee station was to use two 4 wheel motorbikes with 100 L spray tanks with 30 m chemical hose using 2 volt pumps.

Treatment was conducted using 100% coverage to ensure that all leaves receive herbicide application. Control was undertaken using 3% Grando® (600 g/L Triclopyr) + 2% wetting agent (Uptake) in 100 L water. Control of the area took a total of 361 hours using 340 L of herbicide and 280 L of spray oil.

The benefit of the second application was that any plants or individual leaves that were missed could be re-treated to ensure total coverage.

Table 2. Percentage infestation and control of *Opuntia elatior* infestation across 1600ha at Wydgee Station in 2014

Rating	Description	% Infestation	% Control
0	No plants	–	–
1	Small plant (1 m tall)	40%	100%
2	Medium plant (2 m tall)	40%	100%
3	Large plant (3–4 m tall)	20%	60%
4	Largest plants (4 m+ tall)	n/a	n/a

All of the *Opuntia* plants in treatment in areas 1 to 7 received at least one application of herbicide and the small to medium plants all had 100% control and were killed.

The large plants that are 3 m–4 m tall all had the outer areoles and auxiliary stems killed and this resulted in 60% of the plants that were treated were killed. However, 40% of the *Opuntia* treated did not have the herbicide penetrate the entire plant and were reduced to a single “core” stem with no auxiliary stems.

Opuntia elatior small scale trials

As part of the control activities two small scale trials were undertaken that aimed to determine the spread biology of *Opuntia* on Wydgee station. Observations of the area identified that spread by water was the primary dispersal mechanism as areoles from existing plants were washed along the creekline during flood events and established roots in soil further downstream.

The first trail aimed to determine the number of areoles that were released from a parent plant.

Observations over a seven month period from May to November 2014 recorded the number of *Opuntia* plants that released areoles.

Table 3. Small scale trail monitoring areole drop of *Opuntia elatior*

Number of areoles dropped by <i>Opuntia elatior</i>	Rating 1 (1m plants)	Rating 2 (2 m plants)
Areoles that were alive and had established roots	1 (20%)	19 (17%)
Areoles that were alive but had not established roots	1 (20%)	16 (15%)
Areoles that had died	3 (60%)	73 (68%)
Total	5	108

Opuntia elatior that were 3m tall or greater had so many juvenile plants established at their base that determining the number of released areoles over the seven month period was not possible.

It is not possible to draw conclusions from this initial observation however the number of areoles that are released from the parent plant appears to increased greatly as the plants become larger.

The second trail aimed to determine the survivability of areoles after release from *Opuntia elatior*.

Areoles from untreated plants were removed in May 2014 and were graded on size and weight. Fifty areoles were then planted in three groups, the first were placed on the ground, the second were 50% covered in soil, and the third were 100% covered in soil. The areoles were not watered or cared for in any way.

Observations over a seven month period from May to November 2014 examined the survivability of *Opuntia* areoles.

Table 4. Small scale trail monitoring leaf drop of *Opuntia elatior*

Description	Not buried	50% buried	100% buried
Dead	1 (2%)	0	5 (10%)
Alive but no root establishment	22 (44%)	–	–
Alive with root establishment	27 (54%)	50 (100%)*	45 (90%)*

*Regeneration was 50–100 mm

Opuntia elatior areoles that were 50% buried after release showed 100% survival, the regeneration of plants that were 50% and 100% buried was both the same at 50–100 mm.

Opuntia elatior chemical control trial

A third trial was undertaken to look at application techniques and alternative herbicide formulations that could be used to treat *Opuntia elatior*. Six trials were established to demonstrate the effectiveness of the control activities.

Table 5. Trial sites to assess herbicide effectiveness

Trial	Treatment	% control	Observation
Trial 1	Nil	0%	New growth of 100mm and plants flowering.
Trial 2	3% Grando® (600 g/L Triclopyr) + 2% wetting agent (Uptake) in 100L water	100%	Inner core alive
Trial 3	3% Grando® (600 g/L Triclopyr) + 2% wetting agent (Uptake) in 100L diesel	100%	Inner core dead
Trial 4	2% Grazon Extra™ + 2% wetting agent (Uptake) in 100L water	80%	Inner core alive
Trial 5	1.5% Grando® (600 g/L Triclopyr) + 1% wetting agent (Uptake) in 100L water	90%	Inner core alive
Trial 6	Splatter gun using 3% Grando® (600 g/L Triclopyr) + 2% wetting agent (Uptake) in 100L water	25%	Inner core alive

The site was established on the 13th May 2014 and was assessed on the 22nd November 2014.

The trial determined that the 3% Grando solution with 2% wetting agent was the most effective at treating *Opuntia elatior*. Where water is used as the carrier for the herbicide the penetration of the chemical into the core of the plant can be limited in larger plants leaving the core of the plant alive.

When diesel is used as the carrier for the herbicide the chemical penetrates directly into the core of the plant and the inner core is killed.

2015 control

Control in 2015 concentrated upon the core infestation of 400 ha and treatment to reduce the bulk of the largest *Opuntia* plants to a level where control was achievable across the infestation.

The lessons learnt from the 2014 treatments were that the entire *Opuntia* plant needed to be treated to achieve 100% control and that the herbicide was not able to successfully penetrate the core of the largest plants. To overcome the penetration issue the spray oil content was increased from 3% to 5% with control undertaken using 3% Grando® (600 g/L Triclopyr) + 5% wetting agent (Uptake) in 100 L water.

The 2014 control involved treating *Opuntia* across 1600 ha with plants varying in size from 1 m to 3 m with a few isolated plants to 4 m tall. The treatment area in 2015 is a core infestation of 400 ha that had the majority of plants that were 3 m–4 m tall with a 4 m–7 m diameter.

The smaller area and larger plants meant that the amount of time required to treat the infested area and apply the herbicide was greatly reduced as the spray unit could occupy a stationary position and the herbicide applied without the need to move the equipment.

Control of the area took a total of 218 hours using 210 L of herbicide and 220 L of spray oil. The increased use of spray oil has resulted as the treatment has increased from 2% spray oil to 5%

Table 6: Percentage infestation and control of *Opuntia elatior* infestation across 400 ha at Wydgee Station in 2015

Rating	Description	% Infestation	% Control 2014	% Control 2015
0	No plants	–	–	–
1	Small plant (1 m tall)	10%	100%	100%
2	Medium plant (2 m tall)	10%	100%	100%
3	Large plant (3–4 m tall)	20%	60%	80%
4	Largest plants (4 m+ tall)	60%	–	60%

The results of the treatment are that the small and medium sized plants continued to be treated at 100% control and the increase in the spray oil from 3% to 5% did not affect the control of these plants.

There was an increase in the control of large plants from 60% in 2014 with 3% spray oil to 80% control when the spray oil was increased to 5%.

No 4 m+ tall plants were present in the treated areas in 2014 however 60% of the largest plants were killed by the treatment. Of the 40% of the largest plants that were not killed the 5% spray oil did not penetrate the entire plant however the plant was reduced to a single “core” stem with no auxiliary stems.

This has significantly reduced the bulk of the infestation and has allowed access to the 400 ha area as the *Opuntia* that has been controlled has died and the areoles and auxiliary stems that died have degenerated.

Future Control (2016)

No funding has been secured to treat the core stems of the 3 m–4 m+ tall plants that were not killed by the 2015 treatment. These plants have been reduced to a single stem however application of additional herbicide using spray techniques may not be successful in treating these plants.

The landowner at Wydgee Station has continued to explore control options and has determined that the most appropriate control is to use a chainsaw to cut down any surviving *Opuntia* plants and immediately after the stem is removed to paint the stump using a concentrated application of 50% diesel as the carrier and 50% FallowBoss™ Tordon™ that contains the active ingredient 75 g/L Picloram, 300 g/L 2,4-D and 7.5 g/L of aminopyralid.

The cut stump approach using a chainsaw and the targeted application of herbicide directly onto the stem is an innovative approach to third year control of an *Opuntia* infestation that has seen the landholder adapt his control techniques in response to the treatments that have been applied.

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Here Comes the Bride... Again: The Necessity of Ongoing Bridal Creeper Control

PRESENTER:

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Andrea Salmond has been with Katanning Landcare for two years. She works with farmers to undertake soil health and biodiversity projects, and is passionate about bringing sustainable living education to the community.

Abstract

Bridal Creeper is a resilient and persistent weed that requires repeated treatments to manage and eventually kill. Due to its excellent reproductive habit and cormal energy stores, it has spread prolifically through the Great Southern region.

Because this Weed of National Significance (WoNS) was so prevalent and wide-spread, a collaborative, broad-scale approach was needed to make any kind of noticeable impact.

Five shires and relevant local Landcare groups, DAFWA, DPaW and other stakeholders created a two pronged plan to apply for funding for professional spraying of roadside reserves within the boundaries of the five shires and to engage the community in localised control and education opportunities.

Over six years of regular roadside spraying and awareness campaigns has led to a marked decrease in plant infestation density, and a significant amount of awareness and concern about the plant and its management.

The flow-on benefits of this program has included:

- Increased commitments from the local Shires for additional spraying outside the scope of the program;
- community members who manage Bridal Creeper in their own properties, and in areas not reached by the program;
- increased commitments from Main Roads for Bridal Creeper spraying beyond the boundaries of the existing program; and
- the addition of three new Shires to begin participating in the program in the coming year.

The Living Lakes of Gondwana Link – Tapping into Google Earth and Other Digital Resources for Networking and Promotion

PRESENTERS:



Basil Schur

Green Skills



Louise Duxbury

Green Skills

Keith Bradby

Green Skills

Abstract

The Living Lakes of Gondwana Link program aims to utilise internet/digital interactivity to promote networking, promotion and support of wetland work across Gondwana Link (www.gondwanalink.org). The program aims to build on the achievements of the South Coast Wetland Conservation Program which commenced in the early 1990s. The presentation will introduce the type of wetland conservation work carried across the lower south west in recent years, highlight the opportunities now available in utilising Google Earth and other digital platforms to promote networking and promotion. At this early stage, further input and ideas are being welcomed into the program.

The presentation will present:

1. an example of the value of Google Earth in an applied eco restoration project installing Wallaby gates;
2. show an excerpt from a Green Skills'YouTube video about Gondwana Link (<https://www.youtube.com/watch?v=hrIguLdEIwY>); and
3. display an excerpt from a Google Earth YouTube presentation of the Pilbara based Ngarluma Ngurra project see which uses Google Earth community based digital mapping and story telling. (<http://www.form.net.au/project/ngarluma-ngurra/>).

The Living Lakes of Gondwana Link program aims to capture and build on 20 years of wetland conservation, planning, and documentation by Green Skills and partner organisations by inviting new collaborations with artists, indigenous leaders, scientists, educational institutions and others. Links to on line tutorials and assistance will be provided for people interested in applying Google Earth and related digital platforms in supporting their own NRM work.

Aquila Project—Detecting Target Weeds Using Crowdsourced Volunteers to Search Ultra-High-Resolution Aerial Imagery Over the Internet

PRESENTER:



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BIOGRAPHY:

Born Bunbury Western Australia—1956.

Completed B. Psych., and Dip. Ed., University of Western Australia 1978.

School Psychologist 1979–2007, Education Department of Western Australia.

Started own Fishing Tackle Distribution Business 2005–Present.

Patented and brought to market several consumer products.

Appeared on ABC The New Inventors as inventor of a marine rescue device.

Volunteer, rubber vine eradication at Willare, West Kimberley, 2006–2010.

Project Manager—West Kimberley Rubber Vine Eradication Program, 2011–present date.

Restores vintage Italian lever coffee machines.

Introduction

Rubber Vine, *cryptostegia grandiflora*, is a Weed of National Significance and Australia's worst. During the eradication program at Willare in the West Kimberley Region of North Western Australia, the author has developed many innovative eradication processes, the *Aquila Project* being just one. Eradicating rubber vine as quickly as possible reduces the damage caused to the environment and maximizes the chance of success and minimizes costs. One major way to achieve this is to improve the detection rates of target species, whether searching on the ground or from the air, or in the case of '*Aquila*', over the Internet. Once eradication is "deemed" to have occurred, *Aquila* provides a monitoring tool to ensure eradication has indeed occurred and provides an early warning of the contrary. *Aquila* is both an eradication detection strategy and a cost effective wide-area monitoring tool.

Background

Over the last four years the *Aquila* methodology has developed using ultra-high-resolution aerial imagery for the detection of rubber vine. Commissioning the capture of 2 cm pixel images, and creating software to search those images over the desktop revealed 2 cm imagery was on the borderline of the resolution required to reliably detect the tell tale white flowers of rubber vine. This resulted in the current methodology of capturing, sub 2 cm pixel images during the annual helicopter survey and serving those images to conservation volunteers over the Internet. These images are of the entire 26,500-hectare infestation area and are captured at minimal cost.

Partnering with AMC Converget IT, feature detection software was developed to reduce the extremely large number of images and present those to Internet volunteers who could then mark images as 'containing', 'possibly containing' or 'not containing' rubber vine. These marked images were then geo-referenced and ground truthed to control any vines confirmed.

Methodology

1. Wide-angle 12 megapixel images are captured and stored to hard drives in a NAS in RAID1 with the NAS becoming the server.
2. While flying at low level and approximately 50 km/hr over nearly 60 hours of aerial search, images are captured at a rate of 100 images a minute or one image every nine metres for a total of 350,000 images.
3. Images are processed using feature detection software created by Dr Stefan Bird, an artificial intelligence expert and analyst from IT company AMC Convergent IT.
4. Each 12 megapixel image is segmented into 12 parts allowing the image segment to be presented on a standard 13 inch computer screen at the correct zoom level with no need to zoom or scroll to see the entire image. Four million image segments were created.
5. From four million segments, only 4% or 137,000 images remained after processing. These images were served over the Internet via a Search Portal to members of '*Team Aquila*', and these Virtual Rubber Vine Chopper Spotters completed a short, practical training session over the Internet to "qualify" for a Virtual Chopper Observer Licence.
6. Only those who completed the training and registered on the project website, friendofthefitzroy.com.au, became part of Team Aquila and have access to the Aquila Image Search Portal.
7. Immediately an image is marked either 'vine present' or 'not present', the following image is automatically served to the searcher to enable the search to proceed as a one-click system designed to process a large number of images quickly. The Search Portal also includes a "review" button, which returns a searcher, uncertain of their previous choice, to the previously marked image for reconsideration.
8. Part way through the Aquila Search, a 'self-learning' tool was introduced, where a searcher could "skip" an image if they felt it was too difficult for their skill level. These skipped images tend to be automatically served to those more skilled in the art of detecting.
9. Search progress data was available to Team Aquila enabling them to track the progress of the search and compare their own marking results with the norm.
10. Once the primary search of all 137,000 images was completed, several other passes of the "marked images" were made by Team Aquila before in-house staff completed the final analysis of images to be ground truthed.

Project Outcomes/Conclusion

From 350,000/12 megapixel images, four million image segments were reduced by software to 137,000 and searched by volunteers over the Internet to specifically identify those images containing rubber vine. Four million images were reduced to just 47 to be ground truthed by *Team Rubber Vine*, the ground search and control team. From four million images, seven vines were confirmed. During the end game of an eradication program, these vines are 'gold'.

The Aquila Methodology works! It is a wide-area cost effective monitoring tool having application to other weed and feral animal species, with the potential to save even this program \$50,000 in aerial costs annually. In this application, Virtual Chopper Observers provided a higher Probability of Detection than very experienced real chopper observers.

Due to the success of Aquila, the Department of Parks and Wildlife is supporting a second generation of the methodology. Aquila Mark 2, will feature a new 29-megapixel camera system and Neural Network or artificial intelligence feature detection software. These two features will enable easier marking of images and a more enjoyable image experience for the searchers. It will enable fewer images to be presented multiple times to searchers for fewer missed vines and more certain true positives.

Aquila has brought together people from all over Australia and the World. Team Aquila successfully detected our target plant species remotely from the comfort of their home. Aquila enabled those environmentally committed citizens, unable to contribute physically on the ground, to engage in a meaningful and social way, helping each become more skilled, and together experiencing the satisfaction of a very real contribution to environmental protection in a novel and enjoyable way. The contributors were also rewarded when the collective goals were achieved.

I personally thank every one of them from the bottom of my heart.

Changes in the NRM/Landcare Officer Role and Finding the Balance—Past, Present and Future

PRESENTER:

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BIOGRAPHY:

Rodger works as an NRM Officer with the Northern Agricultural Catchments Council (NACC) and he is based at Jurien Bay. His role puts him on the ground, working closely with the community on a variety of environmental issues and projects. Previous to the role the author worked for Ravensthorpe Agricultural Initiative Network (R.A.I.N) in the South Coast NRM region from 2004 to 2013 in a variety of NRMO/Grower group roles. He enjoys the challenge of the NRMO role and is keen to share some insights to the position looking past, present and future.

Introduction

The demands and resourcing of the NRM/Landcare Officer role have changed significantly over the past 10–20 years. In the current climate of downsized budgets and the drive for efficiency gains across every sector, there should be better questioning and understanding of the implications of this change and what it means to the way we do our role and its effectiveness.

The NRM/Landcare Officer role is one of the most diverse role of the NRM sector, heavily influenced by the locational setting, and involves a significant field component and community interaction.

The role has gone through considerable changes over the decades, including the name, but the core goals of the position still remain the same, i.e.:

- To support community groups and individuals to achieve enhance environmental outcomes.
- To monitor, report and identify environmental issues for community, private and government agencies to be aware of and possibly address.

However, population is rising, the NRM sector is downsizing, and all the while NRM issues continue to appear and evolve across our land and seas. The illusion of universal solutions, increasing on-ground funding at the expense of capacity-building and expertise still populates the hearts and minds of those unfamiliar with the NRM industry and on-ground roles. The NRM funding model has been incredibly lean and efficient as is, (although better than many a federal or state government agency), yet how much further can cuts be maintained before the delivery becomes unsustainable and fragmented.

Often overlooked is that knowledge and understanding drives efficiency, but job efficiency now means less time for knowledge and understanding in the role. Are we losing the links to grass-roots landcare as our in-house reporting demands increase?

Importantly how do we as NRM/Landcare Officers at the front line, and our NRM groups manage this change?

Issues, Conclusions and Recommendations

Time, technical expertise and support

- Declining levels of field officer numbers and agency support poses important implications to local and regional NRM outcomes
- Less support staff and increased workloads mean less time on the ground and reduced field presence. (Is this efficiency or deficiency?)
- Increased reliance on the community to be our eyes and ears.
- Less support staff/agencies often means up-skilling, multi-skilling and cross-skilling. Are we in balance or have we spread our skills too thinly?
- Agencies and NRM groups need to factor in staff departures, and allocate enough time to enable knowledge sharing, understanding and in-field advice to remaining staff and landcare partners.

Technology and Monitoring

- Technology continues to revolutionised the NRM/Landcare Officer role and opportunities to understand on-ground changes
- If we are to continue to inform and empower the community at large then we need continued collation of new biological resource information into relevant regional and local publications and online resources easily available to the public.
- We need to ensure office environments and IT support are up to date for field officers in order to take advantage of new technology.
- Limited resources mean one site visit a year is the new norm.
- Capturing, understanding and communicating a site's diversity and condition accurately is harder than most outsiders would think. Furthermore NRM and agency staff are often concentrated in locations away from biodiverse areas which limits understanding of our most valuable areas of our land.
- Let's not let satellite imagery replace feet on the ground and "hands-free" prevent "hands-on".
- Biosecurity (the hidden iceberg)—monitoring and technical expertise is crucial for surveillance and eradication. Are we expecting too much from the community under the new government model? Have we paid the price of relaxed regulation efforts in the past? Why does local government not have a front and centre role? If regulation and compliance becomes voluntary and watered down what does that say about our society and its relationship to the environment?

Community—Part of the NRM core

- Community interaction and feedback continues to support the effectiveness of the role but how much responsibility should the community shoulder.
- Land-use and production systems are becoming more diversified in rural areas hence the need for the field officer to be abreast of industry innovations in multiple fields is becoming a major challenge.
- When a field officer's on-ground support and attendance for meetings and field days with willing groups is limited, be prepared for the implications of being left out of the conversation, the disconnect in information sharing, community member criticism and possibly not being invited to the next event.
- Transparency in up-to date NRM information is critical—from NRM groups to field officers and community groups.
- Community meetings are declining in frequency and numbers present, hence information needs more than ever to be up to date and relevant to those involved, to enable better informed decisions and discussions to be made.
- Knowledge transition needs to be diverse to reflect age demographics and learning mediums of our population. Let's not lose track of the valued old ways of communication in our rush to embrace new mediums. Not everyone learns the same way and not always digitally.

Symbiosis: developing mutually beneficial relationships between research and practitioners

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BIOGRAPHY:

Dr Adams has been involved in feral and pest species research for over ten years, with a particular focus on applied ecological studies of vertebrate pests with the aim of improving current conservation and pest management strategies. However, applied research is a two way street, and as such he uses conservation and/or management issues of concern identified by industry and government to help guide his research.



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BIOGRAPHY:

Sue Metcalf has been around the traps for around twenty years. Not only feral traps but local government and state agency policy development and involved in landcare activities since the 1999. Mrs Metcalf was the chairperson of the Swan Region Natural Resource Management group during development of the Strategy and is now an officer with the Chittering Landcare Centre.

Introduction

Research is often seen by on ground practitioners as being remote from day to day activities in the management of feral and pest animals. This paper seeks to showcase an alliance which has formed between researchers and a landcare group which benefits both groups and helps achieve better outcomes for feral animal control.

Background

Feral pig management is a challenging undertaking, made even more so when set in a peri-urban landscape. Many of the control methods used in farmland and forest habitats are not available or appropriate for use in closely settled areas. Therefore, it is vitally important that as new information becomes available with regard to a feral or pest species of interest, that an assessment of the suitability or application of this knowledge for use by management agencies be conducted quickly.

By having close relationships with researchers the Chittering Landcare Centre has been able to disseminate information to on-ground operators as soon as new methods and information become available. Conversely researchers are able to discuss with operators the effectiveness of the new methods and “ground truth” technologies, whilst also receiving guidance to help direct research initiatives.

In essence, a symbiotic relationship develops.

Fire leadership, management and collaboration in the WA rangelands

PRESENTER:

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Biography:

John has spent most of his life in regional WA. He currently lives in Broome, is from Derby and has lived in Carnarvon, Karratha, Dowerin and Perth. John went to Murdoch University as a mature age student and started his career working as the Dowering/Goomalling Community Landcare Co-ordinator. He then moved to Karratha as the Pilbara/Kimberley Regional Coastal Facilitator, then moved back to his hometown of Derby working in Regional Development. John enjoys the interdisciplinary nature of NRM and joined Rangelands NRM in 2006. In his current role of Operations Manager, John likes to 'keep it real' by ensuring Rangelands NRM remains relevant and well placed to facilitate good environmental, social and economic outcomes. The enormous size of the WA rangelands inspires social and environmental diversity, hence many NRM projects are at the landscape scale and in collaboration with numerous funding and delivery partners. In his spare time John is an avid gardener and goes 'glamping' with the family which includes two teenage daughters. He enjoys beach swimming, four-wheel driving and socialising with friends.

Introduction

The inaugural Rangelands Fire Forum in 2014 was based on a need for cross regional collaboration, shared learning and strong evidence demonstrating the need for proactive fire management to combat the destructive nature of hot, late-dry season wildfires.

The Kimberley EcoFire project (NHT/CfoC) and the Western Desert Fire Projects (CfoC) were actively managing large landscapes by integrating cool season patchy/mosaic fire patterns with the aim of various vegetation ages and protecting places of high environmental and cultural significance, infrastructure and other assets. Burning techniques encompassed both on ground hand burning and aerial incendiary and were tenure blind.

The Rangelands Fire Forum is a cross sectoral and seeks input from pastoral, conservation, Indigenous and State Government agencies to have a shared vision and eventually hopes to simplify co-ordinated training opportunities for Indigenous ranger groups.

Two key outcomes of the 2014 Fire Forum were to develop a guiding principles document endorsed by the various stakeholder sectors, as well as develop a Fire Leadership Group to advance fire management in the WA Rangelands.

Support to the Leadership Group is provided by Rangelands NRM, in partnership with the WA Department of Parks and Wildlife (DPaW), Department of Fire and Emergency Services, Kanyirninpa Jukurrpa (KJ) and the Pastoral and Graziers Association of WA. The vision of the Leadership Group is to develop an integrated fire management regime which:

- Is proactively planned and co-ordinated.
- Recognises local/regional circumstances.
- Delivers cultural, economic and ecological benefits.

Background

The rangelands cover some 2.26 million km² (~85%) of WA, a vast area of cultural, social, environmental and economic significance—with industries such as mining, pastoralism and tourism being important to the state and national economy. All stakeholders in the rangelands are concerned about the protection of lives, property, livelihoods, cultural assets and environmental services from the harmful effects of inappropriate fire regimes.

The Fire Management Guidelines for the WA rangelands document provides a broad framework and high level knowledge-based principles to guide fire management.

The extent of fire knowledge is very variable across the rangelands; hence application of the guidelines should be in an adaptive management framework, so that in addition to structured research programs, practitioners learn by doing.

A common interest and a desire to work collaboratively for the greater good saw a number of cross sectoral and passionate individuals come together to form the Fire Leadership group. A primary purpose of the Leadership Group is to plan, mobilise support for and coordinate the following strategic objectives:

2014

- Develop a regional strategy.
- Improve and streamline legislation.
- Develop Sustainable funding model.
- Coordinate future fire forums.

2015

- Develop sustainable funding model.
- Extend use of NAFI across the whole WA rangelands (www.firenorth.org.au).
- Enhance communications.
- Develop and share inventory of skills, experience and tools.

Project Outcomes/Conclusion

The findings from consecutive Regional Fire Forums in 2014 and 2015 complimented one another and found broad sector support for the vision statement and a consistent belief about fire management from all sectors—conservation, pastoral, Indigenous, and government. The rangelands needs proactive fire management, fire is the primary land management tool. Different pyro (bush) fire regions have differing needs in terms of land management. Fire is the main driver influencing change, with differing sectors undertaking prescribed burning according to their values (e.g. species habitat vs perennial grasses for stock feed). Our aim is for collaborative processes to complement one another with smaller, more frequent fires incorporated into the rangelands landscape.

Special thanks to Gareth Catt (KJ) for initiating the fire forum idea and to Neil Burrows (DPaW) for leading the development of the *Guiding Principles* document. The following people also made helpful comments on early drafts of the Guiding Principles document: Sarah Legge (Australian Wildlife Conservancy), Fiona Walsh (CSIRO), Steven Van Leeuwen (DPaW), Ed Hatherley (DPaW), Lachie McCaw (DPaW), Ryan Butler (DPaW) and Gareth Catt (KJ). The Fire Leadership Group also acknowledges traditional fire knowledge from a variety of Aboriginal communities across the rangelands which has been incorporated into the guidelines.

Figure 1.

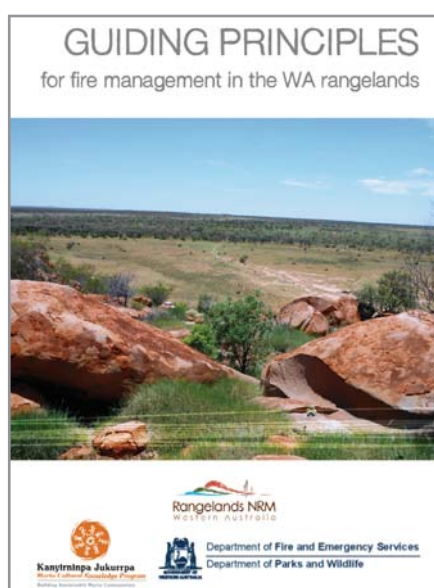


Figure 2. Bushfire regions in the WA rangeland

