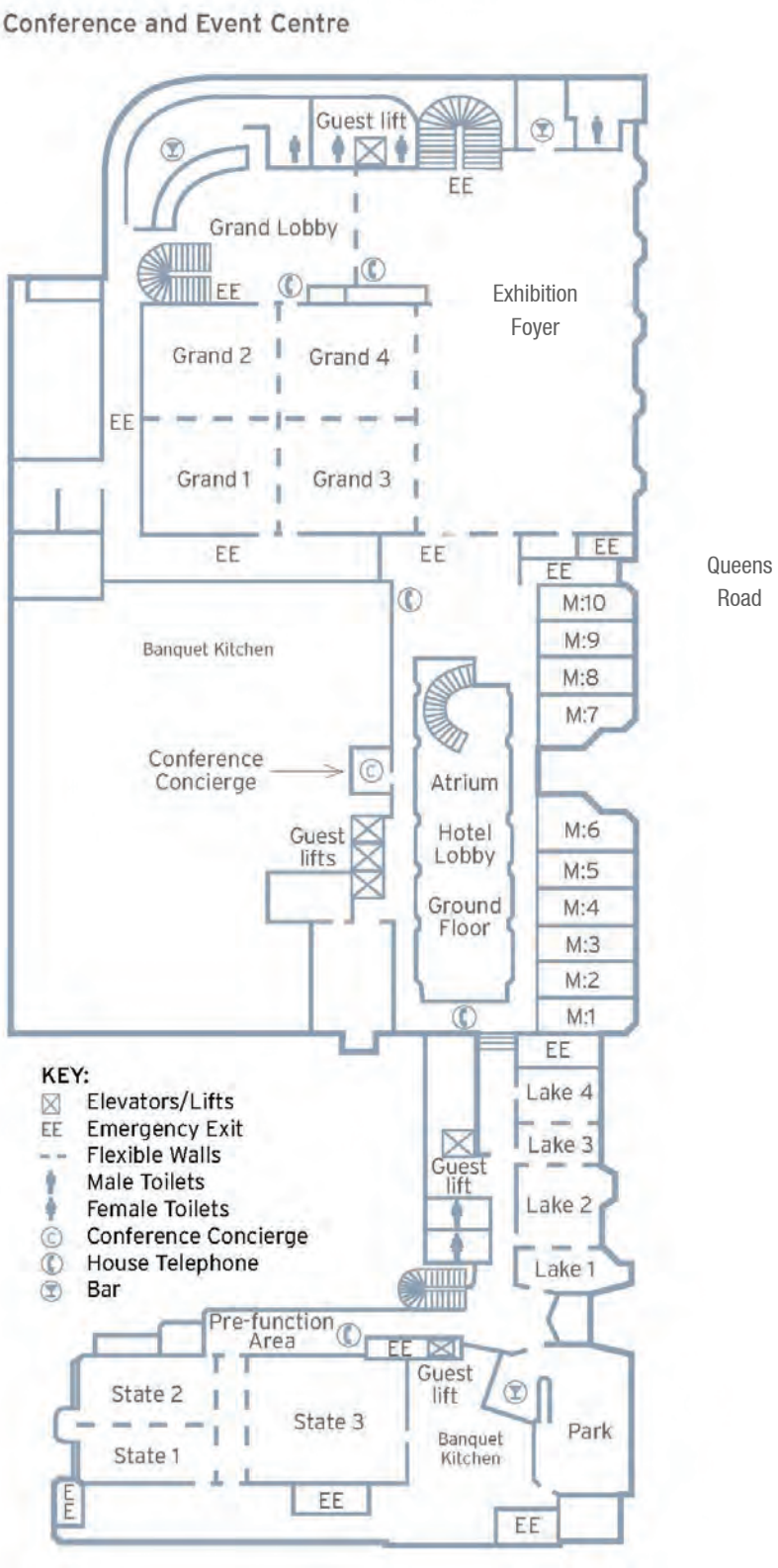
ECOLOGICAL SOCIETY OF AUSTRALIA

ESA 2012 Annual Conference

Ecology: Fundamental Science of the Biosphere

Contents

Venue map


Conference and Event Centre
Guest lift
EE
Grand Lobby
EE
Exhibition
Foyer
Grand 2
Grand 4
EE
Grand 1
Grand 3
EE
EE
EE
EE
Queens
Road
M:10
M:9
M:8
M:7
Banquet Kitchen
Conference
Concierge
Atrium
Hotel
Lobby
Ground
Floor
Guest
lifts
M:6
M:5
M:4
M:3
M:2
M:1
EE
Lake 4
Lake 3
Lake 2
Lake 1
KEY:
Elevators/Lifts
EE Emergency Exit
Flexible Walls
Male Toilets
Female Toilets
Conference Concierge
House Telephone
Bar
Guest
lift
Pre-function
Area
EE
Guest
lift
State 2
State 3
State 1
Banquet
Kitchen
Park
EE
EE
EE

Welcome

Welcome to the Annual Conference of the Ecological Society of Australia. Melbourne last hosted the conference in the year 2000 and we are excited that you've joined us for what will be a fascinating update on ecological science as it is currently undertaken in Australia.

We have encouraged ecologists working in all natural systems—from terrestrial, freshwater and marine—and from the molecular to the ecosystem level, to attend the conference this year. Several excellent plenary speakers will deliver presentations on a wide range of topics. We feel it is important that the sub-disciplines of ecology meet and share what are, fundamentally, similar ecological processes. This year, you will notice the conference program is arranged according to ecological themes, regardless of organism or study area, to highlight the basic principles of ecological theory and practice. Hence, the broad objectives of the conference theme—*Ecology: Fundamental Science of the Biosphere*.

With poster sessions and mixers every evening of the week, you will have ample opportunity to mingle with ecologists from around the country, as well as enjoy the cultural offerings of inner-city Melbourne, only a short tram ride from The Sebel, Albert Park. This year the conference dinner will be held at Zinc at Federation Square, Melbourne's contemporary art hub, right on the banks of the Yarra River. There will be several fieldtrips to some of Victoria's wonderful national parks and special locations led by local experts and opportunities to participate in workshops too.

The ESA Annual Conference is an opportunity to network, catch up with old friends, and present your recent work. We hope your stay in Melbourne allows you to do all these things, and much more.

John Morgan
on behalf of the ESA 2012 Local Organising Committee

Local Organising Committee

- John Morgan, Conference chair
- Jane Catford
- Roger Cousens
- Barbara Downes
- Georgia Garrard
- Heloise Gibb
- Peter Green
- Andrew Hamer
- Marie Keatley
- Jill Lancaster
- Josephine MacHunter
- Libby Rumpff
- Susanna Venn
- Peter Vesk
- Nick Williams
- John Wright

Conference Secretariat

Conference Logistics
PO Box 6150
Kingston ACT 2604

Tel: +61 2 6281 6624
Fax: +61 2 6285 1336

Email: esa@conlog.com.au
Web: www.esa2012.org.au

CONFERENCE LOGISTICS

2012 Award winners

ESA is proud to announce our 2012 award winners:

AERA lecture

Chris Johnson

The AERA Lecture recognises excellence in research in Australian ecology, for a specific body of recent work by a mid-career researcher, and is delivered annually as a Plenary at the conference of the Ecological Society of Australia.

The 2012 AERA recognises Professor Chris Johnson's substantial contributions in understanding the causes of mammal declines and extinctions in Australia.

As Australia has already witnessed record losses of mammal species, this work is of direct and on-going significance for the conservation of mammal biodiversity in Australia.

The AERA Lecture will be delivered at ESA2012 on **Tuesday 4 December at 0945**.

Gold Medal Award

Michael Keogh

The ESA Gold Medal is presented in recognition of an ecologist who has made a substantial contribution to the study of ecology in Australia over the course of their career.

The 2012 Gold Medal recognises Professor Michael Keogh's substantial contribution to marine ecology in Australia, particularly his work on larval behaviour and on expanding understanding of environmental impacts. We also acknowledge his contribution to the development of statistics and experimental design within ecology and congratulate him on an extensive and highly productive career.

Michael will deliver the Gold Medal address at ESA2012 on **Thursday 6 December at 0900**.

ESA Member's Service Prize

Sue Murray-Jones

Congratulations to Dr Sue Murray-Jones who is the 2012 Ecological Society of Australia Members' Prize recipient. The service prize is awarded in recognition of Sue's contribution as the Bulletin Editor which has provided the society with an important communication tool for many years. The society appreciates the diligence and expertise that she has contributed to the bulletin and to an extensive range of other activities during her time on Council.

Sue will receive her Members' Service Prize at ESA2012 on **Thursday 6 December at 1600**.

Jill Landsberg Trust Fund Award

Amanda Edworthy (ANU) and Kate Stevens (Deakin University)


The Jill Landsberg Trust Fund funds an ongoing postgraduate scholarship in the field of Applied Ecology. The winner receives a grant of **$6000** to support the field based research of a postgraduate student and travel, accommodation and registration costs to attend the ESA conference to receive their award and present the following year.

In 2012 the Trustee's were very pleased to be able to offer two scholarships to Amanda Edworthy and Kate Stevens. Amanda's research topic is 'Ecology and conservation of endangered forty spotted pardalotes' and Kate is investigating the 'Ecology and Biology of the Grey-crowned Babbler (*Pomatostomus temporalis*)'. Our 2011 winner, Dejan Stojanovic, will also be attending presenting the 2012 Jill Landsberg Trust Fund address.

JLTF Presentations will be made at the ESA2012 awards session on **Thursday 6 December at 1600**.

The Nature Conservancy Applied Conservation Award

Matthew Rees, CDU

The Nature Conservancy and The Ecological Society of Australia have established this award to fund a postgraduate scholarship in applied conservation science. The winner receives a grant of **$6000** to support research directed towards practical conservation and travel, accommodation and registration costs to attend the ESA conference to receive their award and present the following year. Matthew's research topic is 'Developing seascape models for pelagic and demersal fish assemblages'.

Matthew will receive his award and 2011 winner Gill Ainsworth will present the 2012 'The Nature Conservancy address' at the ESA awards session on **Thursday 24 November at 1400**.

Indigenous Travel Grants

ESA, in partnership with the Myer Foundation, The Nature Conservancy, and NTNRM was pleased to again offer eligible applicants funds to support the sharing of knowledge and Indigenous participation in the Indigenous ecology symposium, **'Back to fundamentals: linking Indigenous and Western ecologies'** at ESA2012. The Indigenous Travel Grant Program is aimed at supporting the sharing of knowledge and Indigenous participation in Western science.

The symposium will be held on **Wednesday 5 December**.

We welcome Eric Abbott, Ray Ahmat, Clive Aitken, Simon Booth, Oliver Costello, Terrah Guymala, Annette Kogolo, Emmanuel Namarnyilk, Rebecca Phillips, Ian Ross, Gerry Turpin, Thomas Tjilya and Doug Williams.

NT Student Travel Award

Le Bai, CDU

Congratulations to Le Bai, winner of the 2012 NT Student Travel Award. Le will present his abstract 'The colour of mud: blue carbon storage in Darwin Harbour mangrove communities' at ESA2012. The award is an NT regional initiative, specifically aimed at student members. The aim of the award is to support and encourage ecologists working in the NT, and promote their engagement with other NT members of ESA and the wider ESA community. The award provides financial assistance for the successful applicant to attend the Society's annual conference.

Congratulations to all our 2012 winners—ESA is proud to be associated with these innovative researchers. More information on all awards and recipients is available at www.ecolsoc.org.au.

Keynote speakers

Emma Johnston

Associate Professor Emma Johnston is an Australian Research Fellow at the University of New South Wales and inaugural Director of the Sydney Harbour Research Program at the Sydney Institute of Marine Science. She investigates the ecology of human impacts in marine systems. She combines the disciplines of ecology, ecotoxicology and invasion biology in an exciting research program that expands our fundamental understanding and provides recommendations for management. Her research is conducted in such diverse field environments as Antarctica, the Great Barrier Reef and temperate Australian estuaries. Her work has met the highest standards of international research, as evidenced by keynote presentations, editorial positions with international journals and more than 60 peer-reviewed publications. She contributes expert opinion to government agencies and consults with industry through the development and implementation of impact assessment programs.

Hanna Kokko

Professor Hanna Kokko is a professor of animal ecology and a Laureate Fellow at the ANU. Her work intertwines ecology and evolution. She is particularly interested in eco-evolutionary feedbacks where the evolution of a trait cannot be understood without taking into consideration that an evolutionary change prompts ecological changes (e.g., population density, adult sex ratio, intensity of competition). In this context she has also been interested in the phenomenon that natural selection does not necessarily optimise population performance: for example, resource use can evolve to be more 'greedy' than would be ideal for persistence.

Ian Lunt

Ian Lunt is Associate Professor in vegetation ecology and management at Charles Sturt University. His research focuses on how human management and disturbances affect the structure, composition and functioning of Australian ecosystems, especially fragmented and endangered grasslands and woodlands. Ian's work incorporates historical ecology, disturbance ecology and restoration ecology, to provide a holistic understanding of long- and short-term ecosystem dynamics and the ecological mechanisms that underpin these dynamics. Through his research and input to management agencies, Ian's work has helped to improve ecological understanding and on-ground management of Australia's most endangered ecosystems.

Angus McIntosh

Focusing on freshwater ecosystems, Professor McIntosh has combined investigation of food webs with spatial analysis to reveal how environmental context affects population and community characteristics. This has involved investigation of habitat size effects on food-web stability and the influence of network configuration on invader impacts and management. Through his position as Mackenzie Foundation Chair in Freshwater Ecology at the University of Canterbury he is currently applying this approach to improve measures to protect rivers from land-use intensification. His is also a member of the Academy of Ako Aoteatroa, New Zealand's national centre for tertiary teaching excellence.

Ben Phillips

Dr Ben Phillips is a QEII Research Fellow at the Centre for Tropical Biodiversity and Climate Change at James Cook University, Australia. His work focuses on contemporary evolution: how it plays out in space, and how it interacts with ecology. He has worked extensively in Australia's tropics, most recently spending five years chasing cane toads around northern Australia. In doing so he has become fascinated by range edges and how evolution might affect whether, and how fast, range edges will shift under climate change.

Keynote speakers gifts sponsored by Andrew Isles Books

Australian Ecology Research Award 2013

Nominations Now Open

Closing 30th April 2013

Nominations are online and should include the following:

1. Name of nominated person
2. General area of research
3. A statement describing the nature of the research and its importance to ecology.

Nominations are invited for the 2013 *Australian Ecology Research Award (AERA) Lecture*. This award recognizes excellence in recent research in Australian ecology and supports an annual Ecological Society of Australia invited research lecture.

Professor Lesley Hughes
2011 AERA lecture

Professor Chris Johnson
2012 AERA lecture

The recipient of the award will present a lecture, based on this research, at the annual ESA conference of that year. This year's recipient will present at the ESA13, Auckland, New Zealand, 2013. The candidate's travel, registration and accommodation will be paid or reimbursed.

For more information concerning the 2011 awards visit http://ecolsoc.org.au/prizes.html

Student conference awards

ECOLOGICAL SOCIETY OF AUSTRALIA

All student members can nominate for a range of conference presentation prizes if they present a poster or paper at the ESA 2012 Annual Conference.

To be eligible for prizes you needed to indicate your student status when submitting your abstract. If you have not done this and still want to be considered see Gail at the ESA booth BEFORE your talk or poster presentation and we'll add you to the list where possible! For details on judging criteria see www.esa2012.org.au

Prizes in 2012 include:

- ESA Marilyn Fox Award for best inaugural presentation at a conference
- ESA Wiley-Blackwell Student prizes for Outstanding spoken presentations (3 awards)
- ESA Wiley-Blackwell Student prizes for Outstanding poster presentations (2 awards)
- Wiley-Blackwell/EMR prize for a spoken presentation on management or restoration
- Wiley-Blackwell/EMR prize for a poster presentation on management or restoration
- Society for Conservation Biology Prize for a spoken paper on conservation
- Australian Flora Foundation Prizes for best spoken and poster presentations on the biology or cultivation of Australian native plants

WILEY-BLACKWELL | Society for Conservation Biology | AUSTRALIAN FLORA FOUNDATION

2012 ESA Photographic Competition
Ecology in Action

ESA

First Prize $500

Second Prize $300 Third Prize $100

as well as prizes for highly comm
and People's Choice categ

Entries close midnig ***ober 10th***

Winners announced Tuesday December 4 during the Poster Session. Be there!!

CATEGORIES

e Field": Ecologists in Action

ple studying or applying ecology in the field or lab

And NEW in 2012!

Ecology in Action:

"Niches & Hollows: Adaptive Behaviour + Biodiversity" or

"Beneath Southern Skies: Unique Australian landscapes"

Photos of biota and landscapes with their ecological story

Winners will be announced and exhibited at ESA12 and posted online
For more information, including entry forms and conditions, see
www.ecolsoc.org.au

Photo competition prizes provided by Australian GEOGRAPHIC

Program information

Pre-conference workshops

Postgraduate Workshop

Date: Sunday 2 December 2012
Time: 0900–1700
Cost: $30 (incl. GST)
Venue: School of Botany, Melbourne University
Inclusions: Lunch, morning and afternoon tea

An introduction to using R for population and landscape genetics with a focus on microsatellite data

Convenor: Aaron Adamack
Date: Sunday 2 December
Time: 1300–1700
Cost: $55 delegate, $80 non-delegate (incl. GST)
Venue: Lake Room 3, The Sebel Albert Park
Inclusions: Afternoon tea

This workshop will provide participants with an interactive introduction to using R to analyse their microsatellite data, with a focus towards population and landscape genetics approaches. Participants will learn how to import their raw data into R, and carry out basic analyses of their data (e.g. allele frequencies, alleles per locus, HWE, HE, FST, etc.) using a newly developed package that simplifies this routine.

Additionally, we will demonstrate how to use R for advanced landscape genetic approaches, starting with producing customised maps and simple tests for isolation by distance and will work towards least-cost-path-analysis based on partial mantel tests.

Post-conference workshops

Wild grasses of south-eastern Australia—identification and ecology

Convenor: Graeme Lorimer
Date: Friday 7 December
Time: 0930–1700
Cost: $198 (incl. GST)
Venue: Mitcham (participants will need to make their own way there)
Inclusions: Morning tea, handouts

This is a one-day training session for people who have a basic knowledge of grasses in south-eastern Australia (e.g. able to recognise wallaby-grasses as a group but not the species) and want to improve their identification skills and ecological insight. It will be conducted by Dr Graeme Lorimer, who has specialised in teaching about grasses for 25 years and will be held at Mitcham, a suburb of Melbourne.

Smarter workflows for ecologists: what are they?

Convenor: Alison Specht
Date: Friday 7 December
Time: 0900–1130
Cost: Free for delegates, $45 non-delegate (incl. GST)
Venue: Lake Room 2, The Sebel Albert Park
Inclusions: Morning tea

Data science is transforming ecology with more and more data available, but it's not always easily accessible, usable or interpretable. The data environment is dynamic and requires evidence-based decision making about practice and governance. This creates many challenges for the modern ecologist, and in this harsh world it might seem that the one who does this best will succeed. Good data drives cutting-edge science: sharing and re-use of data maximises its value as new science, comparisons and refinements are made to provide new knowledge useful to society.

This workshop is generously sponsored by ACEAS TERN.

Understanding and influencing the Commonwealth policy environment

Convenor: Jacquie Shannon
Date: Friday 7 December
Time: 0900–1230
Cost: $30 delegate, $45 non-delegates (incl. GST)
Venue: Lake Room 3, The Sebel Albert Park
Inclusions: Morning tea

Be introduced to the policy formulation and advice process being employed in the Australian Public Service; the key timeframes for advising on policy and influencing Cabinet; and the means by which to optimise Parliamentary support. Time will be allocated for exploring how this information can be used to optimise the policy agendas of participants.

Living and working with stress

Convenor: Jacquie Shannon
Date: Friday 7 December
Time: 1300–1545
Cost: $30 delegate, $45 non-delegate (incl. GST)
Venue: Lake Room 3, The Sebel Albert Park
Inclusions: Afternoon tea

The participants will be introduced to contemporary knowledge about the energising and de-energising aspects of stress; the neuroscience of resilience and insight; and the practices of mindfulness.

Writing clearly and succinctly

Convenor: Marina Hurley
Date: Friday 7 December
Time: 1300–1730
Cost: $115 delegate, $150 non-delegate (incl. GST)
Venue: Lake Room 2, The Sebel Albert Park
Inclusions: Afternoon tea

For science to be understood, assimilated and further developed, it needs to be accessible through clear and concise writing. 'Writing Clearly and Succinctly' takes you through three stages to help you improve the clarity of your writing. Firstly we discuss the writing process and recommend techniques to improve efficiency. Secondly we review sentence structure without introducing complicated grammar rules and teach you how to improve the flow of your writing. Lastly we demonstrate how to make your writing more concise. The workshop begins with a short discussion and group exercise, and is then followed with rotations of short lectures, exercises and discussion sessions. Participants are encouraged to work on a sample of their own writing during the workshop.

Pre-conference field trip

Wilson's Promontory and Mt Baw Baw [Pre-conference field trip]

Date: Thursday 29 November to Saturday 1 December
Cost: $375 (incl. GST)
Inclusions: Transport, accommodation one night Tidal River, one night Mt Baw Baw; all meals except dinner on the second night; entry to the parks
Departing: The Sebel Albert Park at 8am on Thursday 29 November.

Drive through South Gippsland to Wilson Promontory National Park. At Wilsons Promontory Jim Whelan and John will present a half hour on history, flora, fauna, fire, floods, vegetation and threatened species management issues. A short site visit will be made to inspect monitoring sites and old photo locations to appreciate the marked historic vegetation change.

Sponsored by GHD.

Post-conference field trip

Central Highlands—long-term monitoring of the mountain ash

Date: Friday 7 December
Time: 0700–1730
Cost: $60 (incl. GST)
Inclusions: Transport, snack for bus (will need to provide/buy own lunch)
Departing: The Sebel Albert Park at 0700.

Professor David Lindenmayer from the Fenner School of Environment and Society at the Australian National University has been running a Long Term Monitoring (LTM) program in the Mountain Ash forests of the Central Highlands since the early 1980s. This field trip will be a tour of the LTM guided by David's two Senior Research Officers, Lachie Mcburney and David Blair, who have a decade of combined experience running this Victorian section of Professor Lindenmayer's research. The tour will travel to a variety of sites, detailing the set-up of the study, the methodology behind the research and the major findings to date.

The LTM program surveys birds, vegetation and arboreal marsupials. There are over 160 sites covering different forest age classes (old growth, regrowth forest etc), land tenures (state forest, water catchment, etc) and geographic locations (Marysville, Toolangi, Powelltown, etc). The tour will visit a sample of these sites to give an overall picture of the LTM program.

Black Saturday bushfires: refuges and recovery

Date: Friday 7 December
Time: 0800–1700
Cost: $130 (incl. GST)
Inclusions: Transport, snack and lunch
Departing: The Sebel Albert Park at 0800

The Black Saturday bushfires of February 2009 provided a dramatic example of how large, intense fires shape the landscape of south eastern Australia. This field trip will provide participants with insights into the ecology of these fires and the opportunity to explore the recovering landscape. The trip will lead by members of the Faunal Refuges Project team from Deakin and La Trobe Universities. The highlight of the trip will be a 5km walk through a section of Kinglake National Park that was affected by the fires.

Re-establishing grasslands—the Moolapio experience

Date: Friday 7 December
Time: 0900–1330
Cost: $160 (incl. GST)
Inclusions: Transport, printed materials, laminated species field identification card, catering
Departing: The Sebel Albert Park at 0900

Plains Grassy Woodland (EVC) are among Australia's most threatened vegetation communities. Once widespread throughout the south east of Victoria, these quintessentially Australian ecosystems have been cleared or severely modified due to their suitability for agriculture. Weed invasion, increased nutrient levels and altered fire regimes have reduced native plant diversity in remaining pockets of this vegetation type. The magnitude of decline is recognised as a critical biodiversity issue at both state and federal levels.

Greening Australia Victoria is working hard to restore a diverse range of native groundcover species at sites across Victoria. At Alcoa of Australia's Point Henry property (near Geelong) the joint partnership project between Alcoa and Greening Australia has successful re-established over 10 hectares of species rich complex grassland using groundbreaking techniques and knowledge gained through scientific research.

This field-trip generously sponsored by Greening Australia.

The ESA invites you to attend the Society's

Annual General Meeting

on Tuesday during the lunchbreak

ECOLOGICAL SOCIETY OF AUSTRALIA

Notice of Meeting

37th Annual General Meeting

To be held in Grand Ballroom, Sebel Albert Park, Melbourne

1.00–2.00pm

Tuesday 4 December, 2012

Bring your lunch with you!

Agenda Papers and Proxy voting forms are available at the ESA booth.

"Back to fundamentals: linking Indigenous and Western ecologies"

Post-Symposium Informal Mixer

The Indigenous ecology symposium "Back to fundamentals: linking Indigenous and Western ecologies" will be held on Wednesday December 5, and at the end of the day we would like to invite all those who attended the presentations, and any delegates who have an interest in finding out more about the work being done on Country, to join us at a post-symposium mixer and take the opportunity to share stories with the presenters or find out more about the Indigenous Travel Grants.

Wednesday 5 December
5.30-6.30pm

Light refreshments available
All welcome

Social program

'Happy Hour' Welcome Drinks

Date: Sunday 2 December 2012
Time: 1730–1830
Venue: Exhibition Foyer, The Sebel Albert Park Conference Centre
Dress: Smart casual
Cost: Conference delegates—included in full registration fee
Additional ticket—$25 (incl. GST)

Barbara Rice Memorial Poster Session 1

(Presenters of even number posters)

Date: Monday 3 December 2012
Time: 1730–1900
Venue: Exhibition Foyer, The Sebel Albert Park Conference Centre
Dress: Smart casual
Cost: Conference delegates—included in full registration fee
Additional ticket—$35 (incl. GST)

Barbara Rice Memorial Poster Session 2

(Presenters of odd number posters)

Date: Tuesday 4 December 2012
Time: 1730–1900
Venue: Exhibition Foyer, The Sebel Albert Park Conference Centre
Dress: Smart casual
Cost: Conference delegates—included in full registration fee
Additional ticket—$35 (incl. GST)

The Barbara Rice Memorial Poster Sessions will be held on Monday, 3 December 2012 (with presenters of even number posters to be in attendance) and on Tuesday, 4 December 2012 (with presenters of odd number posters to be in attendance). Both sessions are included in full registration fees. The session will operate on the ESA 'sticky dot reward system'.

About Barbara Rice

Barbara Louise Rice (1944–2009) was a key member of the Macquarie University Ecology Group for nearly 25 years and an elder sister and field mentor to several research students and postdocs. At least 50 publications and dissertations express thanks for her help in the field and with identifications. She participated consistently in the research conferences of the Ecological Society of Australia from 1975 to 2008 and was especially fond of the poster sessions since she did not enjoy giving talks herself.

Postgraduate Evening Mixer

Date: Wednesday 5 December 2012
Time: 1900–2200
Venue: Middle Park Bowling Club

Quantitative & Applied Ecology Group

Step away from your computers people, it's time to meet with your peers! The postgraduate mixer is a registered free event for students. Please join us for a light casual dinner, a beverage or two, a spot of lawn bowls and some fine company. The event is fully subscribed, so don't forget your tickets!

Kindly sponsored by the Quantitative and Applied Ecology Group at the University of Melbourne

Conference Dinner

Date: Thursday 6 December 2012
Time: 1830–2300
Venue: Zinc, Federation Square, Melbourne
Dress: Smart casual
Cost: Delegate—$100 per person (incl. GST)
Student delegate—$70 (incl. GST)
Non-delegate—$120 (incl. GST)

The annual ESA Conference Dinner is a fantastic opportunity to relax, let your hair down and just have fun. The venue is Zinc at Federation Square, which gives you a good taste of the unique Melbourne atmosphere with its outlook on the Yarra River. This stand-up function will give you the chance to enjoy the company of your friends and colleagues while tempting your tastebuds with the beautifully crafted seasonal dishes. The best part of all is that there is no early morning start to the Conference the next day which means you have plenty of time to network with likeminded delegates, unwind in the beautiful Melbourne ambience or party all night.

Program at a glance

Sunday 2 December

0900–1700	Postgraduate Workshop	School of Botany, The University of Melbourne
1300–1700	Workshop—An introduction to using R	Lake Room 3
	ESA Planning day	Park Room
1500–1900	Conference registration	Exhibition Foyer
1730–1830	WELCOME DRINKS	Exhibition Foyer

Monday 3 December

0730–1900	Registration open	Exhibition Foyer
0900–1100	**PLENARY SESSION 1**	Grand Ballroom 1–4
0900	Welcome and opening	
0915	President's Message, Kris French	
0930	KEYNOTE PRESENTATION: **Fact, theory or fiction? Understanding long-term changes in woody cover in semi-arid and temperate woodlands**—Ian Lunt	
1015	KEYNOTE PRESENTATION: **Stress ecology and why everybody's doing it**—Emma Johnston	
1100–1130	MORNING TEA	Exhibition Foyer
1130–1300	**CONCURRENT SESSION 1**	
1300–1400	LUNCH	Exhibition Foyer
1300–1400	Austral Ecology board meeting	Park Room
1400–1530	**CONCURRENT SESSION 2**	
1530–1600	AFTERNOON TEA	Exhibition Foyer
1600–1715	**SPEED TALKS**	
1745–1930	POSTER SESSION 1—BARBARA RICE MEMORIAL POSTER SESSION (even numbered posters)	Exhibition Foyer

Tuesday 4 December

0730–1900	Registration open	Exhibition Foyer
0900–1030	**PLENARY SESSION 2**	Grand Ballroom 1–4
0900	KEYNOTE PRESENTATION: **The overwhelming importance of habitat size for food webs**—Angus McIntosh	
0945	AERA LECTURE: **Mammal extinctions and ecological cascades**—Chris Johnson	
1030–1100	MORNING TEA	Exhibition Foyer
1100–1300	**CONCURRENT SESSION 3**	
1300–1400	LUNCH	Exhibition Foyer
1300–1400	ESA AGM	Grand Ballroom 1–2
1400–1530	**CONCURRENT SESSION 4**	
1530–1600	AFTERNOON TEA	Exhibition Foyer
1600–1730	**CONCURRENT SESSION 5**	
1745–1930	POSTER SESSION 2—BARBARA RICE MEMORIAL POSTER SESSION (odd numbered posters) plus Ecology in Action Photo Competition winners announced	Exhibition Foyer

Wednesday 5 December

0730–1900	Registration open	Exhibition Foyer
0900–1030	**PLENARY SESSION 3**	Grand Ballroom 1–4
0900	KEYNOTE PRESENTATION: **Species' range edges and the evolution of dispersal**—Ben Phillips	
0945	KEYNOTE PRESENTATION: **Males exist. Does it matter?**—Hanna Kokko	
1030–1100	MORNING TEA	Exhibition Foyer
1100–1300	**CONCURRENT SESSION 6**	
1300–1400	LUNCH	Exhibition Foyer
1300–1400	Ecological Restoration and Management Editorial Board Meeting (Ecological Restoration and Management)	Park Room
1400–1530	**CONCURRENT SESSION 7**	
1530–1600	AFTERNOON TEA	Exhibition Foyer
1600–1730	**CONCURRENT SESSION 8**	
1730–1930	Research Chapter meetings	Grand 1–2 and Grand 3–4
1730–1930	Invasive Species Research Chapter meeting	Lake 1–2
1730–1930	Indigenous Forum informal mixer	Park Room
1930–2200	Postgraduate mixer	Middle Park Bowling Club

Thursday 6 December

0730–1700	Registration open	Exhibition Foyer
0900–1000	**PLENARY SESSION 4**	Grand Ballroom 1–4
0900	Introduction to the ESA Gold Medal Award	
0915	Gold Medal Presentation: **How much starter is too much?**—Michael Keogh	
1000–1045	MORNING TEA	Exhibition Foyer
1045–1245	**CONCURRENT SESSION 9**	
1245–1400	LUNCH	Exhibition Foyer
1400–1530	**CONCURRENT SESSION 10**	
1530–1600	AFTERNOON TEA	Exhibition Foyer
1600–1715	**PLENARY SESSION 5**	Grand Ballroom 1–4
1600	Awards Jill Landsberg Trust Fund Award TNC Applied Conservation Award ESA Members Service Prize Student Prizes	
1700	Launch of ESA 2013, and Conference close	
1830–2300	CONFERENCE DINNER	Zinc at Federation Square

Friday 7 December

WORKSHOPS		
0900–1130	Smarter workflows for ecologists	Lake 1–2
0900–1230	Understanding the Commonwealth policy environment	Lake 3–4
1330–1545	Living and working with stress	Lake 3–4
1330–1730	Writing clearly and succinctly	Lake 1–2
0930–1700	Wild grasses of south-eastern Australia—identification and ecology (offsite)	Mitcham, Victoria
FIELD TRIPS		
0700–1730	Central Highlands—Long-term monitoring of the mountain ash	
0800–1700	Black Saturday Bushfires—Refuges and recovery	
7–12 Dec	Riverina remnant landscapes—Trust for nature	

Invasive Species Research Chapter

Ecological management of invasive species: Bridging theory and practice

An interactive 'Q&A' forum for academics and practitioners

5.30-7.30 PM, Wednesday December 5th 2012 (Lake Rooms 1-2)

Ecological Society of Australia Annual Conference, The Sebel, Albert Park, Melbourne

Co-facilitated by the **Invasive Species Research Chapter** & **Council of Australasian Weed Societies**

Australia's unique ecosystems are increasingly under threat from invasive alien species. Despite extensive social and financial investment in invasive species management, the effectiveness of interventions at rehabilitating native communities remains poorly understood.

In collaboration with practitioners and Australia's leading invasive species ecologists, the ISRC invites you to participate in an exciting new 'Q&A' research forum to discuss the ecological effects of managing invasive species across natural Australian landscapes.


Louisa Armstrong 2012

This Research Chapter forum aims to:

- Discuss novel research into ecological effects of invasive species management.
- Extend scientist-practitioner dialogues to inform invasive species research priorities.


Kristian Bell, 2011

The discussion will focus on some important, yet rarely considered questions including:

- Are the current methods for management of invaded landscapes effective at restoring native communities and ecosystem functions?
- How are research outcomes best communicated to managers?
- What type of ecological research is needed in the future to help managers make better decisions?

This forum will span the full spectrum of biological invasions, from weeds to vertebrate, fungal and insect invaders of terrestrial, marine and freshwater ecosystems.

Light refreshments will be provided, and there will be an opportunity to meet with the panellists and other members of the ISRC after the forum.

Further information
Ben Gooden (ISRC Convenor)
Ph: (02) 4252 8993
Email: bengooden@gmail.com
or
Hillary Cherry (CAWS representative)
Ph: (02) 9585 6587
Email: hillary.cherry@environment.nsw.gov.au

Full program

Sunday 2 December

0900–1700	Postgraduate Workshop	School of Botany, The University of Melbourne
1300–1700	Workshop—An introduction to using R	Lake Room 3
	ESA Planning day	Park Room
1500–1900	Conference registration	Grand Lobby
1730–1830	WELCOME DRINKS	Grand Lobby

Monday 3 December

0730–1900	Registration open					Exhibition Foyer
0900–1100	**PLENARY SESSION 1** Chairs: Georgia Garrard, Jane Catford					Grand Ballroom 1–4
0900	Welcome and opening—John Morgan Welcome to Country					
0915	President's Message, Kris French					
0930	KEYNOTE PRESENTATION: **Fact, theory or fiction? Understanding long-term changes in woody cover in semi-arid and temperate woodlands** **Ian Lunt**, Institute for Land, Water and Society, Charles Sturt University					
1015	KEYNOTE PRESENTATION: **Stress ecology and why everybody's doing it** **Emma Johnston**, University of New South Wales and the Sydney Institute of Marine Science					
1100–1130	MORNING TEA					Exhibition Foyer
1130–1300	**CONCURRENT SESSION 1**					
	1A **Symposium: Ecological fire management**	**1B** **Animal behaviour**	**1C** **Symposium: Plant adaptations to drought**	**1D** **Symposium: Plant pollination and mate choice**	**1E** **Changing distribution patterns and range sizes**	**1F** **Ecosystem dynamics**
ROOM	Grand 1–2	State 3	State 1–2	Park	Lake 1–4	Grand 3–4
CHAIR	Josephine Machunter	Stephanie Godfrey	Stefan Arndt, David Tissue	Susan Hoebee	Damien Fordham	Melvin Varughese
1130	**Laurence Berry** Bird response to the spatial dynamics of small unburnt patches in a post-fire Mallee landscape	**Kimberley Christie** Home range size and overlap of northern quoll (*Dasyurus hallucatus*) on Koolan Island, Western Australia	**Patrick Mitchell** Vulnerability of trees to drought-induced mortality is defined by a common climatic threshold	**Laura Vary** The impact of exotic pollinators on native plant-pollinator networks	**John Martin** Flying-fox relocation from the Royal Botanic Garden, Sydney: gone for now, but challenges ahead	**Charles Krebs** Resilience: the concept and its measurement
1145	**Natasha Robinson** Faunal refuges in fire-prone landscapes: does prescribed fire moderate wildfire impacts on bird assemblages?	**Josh Griffiths** Development of a novel tracking technique for platypuses using acoustic telemetry		**Trevor Edwards** Aiming for a blues revival: mimicry in blue *Thelymitra* (Orchidaceae) species	**Chris Malam** Past is key to future: modelling historical distribution to guide brush-tailed rock-wallaby (*Petrogale penicillata*) reintroduction	**Melvin Varughese** Statistical inference for a multivariate diffusion model of an ecological time series
1200	**Diana Virkki** Burning questions: investigating the relationship between fire mosaics and reptile communities in dry sclerophyll forests	**Jessica Roberts** A continent-wide analysis of the shade requirements of red and western grey kangaroos	**Libby Pinkard** The role of defoliating pests in drought mortality	**Andrew Young** Incest or abstinence: reproductive tradeoffs between mate limitation and progeny fitness in a self-incompatible invasive plant	**Dan Lunney** Revealing the cryptic distribution of wild deer in New South Wales	**Samantha Travers** Three years of litter fall in a semi-arid mallee woodland: a focus on reproductive structures

Monday 3 December (cont)

	1A	1B	1C	1D	1E	1F
ROOM	Grand 1–2	State 3	State 1–2	Park	Lake 1–4	Grand 3–4
1215	**Greg Holland** Experimental planned burns result in the loss of key forest structural elements	**Mathew Crowther** Climate-mediated habitat selection in koalas in a fragmented rural landscape	**Brendan Choat** Vulnerability of woody vegetation to drought-induced mortality	**Tony Popic** Robust sampling yields new discoveries and informs pollination and mate choice of Simpson Desert plants	**Samuel Nicol** Prioritising investment to prevent sea level rise in the East Asia – Australasia flyway	**Shaun Cunningham** Carbon sequestration of environmental plantings on degraded agricultural lands
1230	**Fiona Christie** Conserving biodiversity in fire-prone landscapes: testing the relationship between species richness and environmental heterogeneity	**Francesca van den Berg** Intraspecific competition for suitable retreat sites in stressful thermal environments by the spider, *Morebilus plagusius*	**Chris Blackman** Variation in leaf hydraulic vulnerability and leaf venation across a strong aridity gradient in eastern Australia	**Philippa Griffin** Quantitative genetics of flower shape in selfing and outcrossing *Arabidopsis lyrata* populations	**Damien Fordham** Managing marine species under climate change: the importance of modelling demographic, spatial and ecological processes	**Kristin Hulvey** Using diverse tree plantings to restore multiple ecosystem functions in carbon projects
1245	**Richard Loyn** Fauna and fire regimes: effects of the 2009 Victorian bushfires and previous fire histories	**Stephanie Godfrey** The response of a sleepy lizard social network to altered ecological conditions	**Mark Olson** The adaptive causes of drought resistance via vessel diameter and plant size: stem size, not environment, predicts vessel diameter worldwide	**Jason Sexton** Breeding across environmental gradients and at range limits: a case study in Californian monkeyflowers		**Penny Watson** Litter fuel in Australian forests: effects of climate across forest types in a changing world
1300–1400	LUNCH					Exhibition Foyer
1300–1400	Austral Ecology board meeting					Park Room
1400–1530	**CONCURRENT SESSION 2**					
	2A **Symposium: Ecological fire management**	**2B** **Animal behaviour**	**2C** **Symposium: Plant adaptations to drought**	**2D** **Symposium: Plant pollination and mate choice**	**2E** **Changing distribution patterns and range sizes**	**2F** **Ecosystem dynamics**
ROOM	Grand 1–2	State 3	State 1–2	Park	Lake 1–4	Grand 3–4
CHAIR	Don Driscoll	Sophie Golding	Stefan Arndt, David Tissue	Laura Vary	Madeleine Barton	Sally Hladyz
1400	**Sebastian Buckingham** Fire severity effects on invertebrate detritivores and their functional importance in leaf litter breakdown	**Mathew Berg** Behavioural and ecological maintenance of a circular overlapping species complex: assortative mating in *Platycercus elegans*	**Guomin Huang** Plastic and adaptive responses of NSW waratah populations to future climatic scenarios	**Cairo Forrest** Do pollinators or pollen quality determine the reproductive success of arid zone acacias?	**Daisy Englert Duursma** Naturalised plants: the next wave of invaders under climate change?	**Emma Steggles** Effects of biological soil crust on seedling emergence in an *Acacia papyrocarpa* open woodland
1415	**Evelyn Chia** Fire severity, history or landscape context: optimal attributes of refuges for mammal recovery post wildfire	**Sophie Golding** Procreation or mastication: the behaviour of male grey-headed flying-foxes	**Remko Duursma** Separating fact from artefact in drought experiments using a process-based model	**Margaret Byrne** Patterns of pollination in woody plants in fragmented landscapes of south-west Western Australia	**Phillippa Bricher** Mapping sub-Antarctic cushion plants: random forest classification of very high resolution terrain and spectral data	**Sally Hladyz** Can changes in flow regime alter community structure and ecosystem process in managed rivers?

Monday 3 December (cont)

	2A	2B	2C	2D	2E	2F
ROOM	Grand 1–2	State 3	State 1–2	Park	Lake 1–4	Grand 3–4
1430	**Sarah Avitabile** Measuring outcomes for fire management: how well do surrogates represent biodiversity?	**Matthew Malishev** New approaches to managing invasive species: agent-based modelling of foraging behaviour under environmental change	**Honglang Duan** Elevated [CO_2] and warming effects on eucalypt response to drought	**David Coates** Pollination and mating system variation in two sister triggerplant species, *Stylidium affine* and *Stylidium maritimum*	**Nick Schultz** Seasonal and interannual variability in vegetation data: implications for survey design	**Aaron Greenville** Extreme climatic events drive mammal irruptions: 100-year trends in desert rainfall and temperature
1445	**Angie Haslem** Inter-fire interval estimates: what insights do they provide for fire management?	**Jennifer Anson** Behavioural response of native prey to disparate predators: naivete and predator recognition	**Mark Tjoelker** Climate warming and precipitation modify tree-grass interactions and accelerate woody thickening in a warm-temperate savanna	**Yvonne Davila** Does less mean more? A review of pollinator diversity and pollen limitation of angiosperm reproduction	**Adrienne Nicotra** Local differentiation in growth and plasticity in an Australian Alpine herb	**Rachel Blakey** Bats across biomes: comparing the value of wetland and dryland habitats within the Murray-Darling Basin
1500	Discussion	**Andre Chiaradia** Individual foraging strategies of inshore little penguins and their response to changes in sea-surface temperature	**Pieter Poot** Contrasting water relations are associated with species distribution and crown decline in four common sympatric eucalypt species in south-western Australia	**Alastair Robertson** When mates run out: declining pollination service threatens cryptic recruitment failure in New Zealand trees	**Claire Runge** Unravelling the mysteries of nomadic species: refugia versus resource tracking	**Simon Verdon** Mammalian ecosystem engineers can limit plant recruitment and alter plant composition in the arid zone
1515	Discussion	Discussion	**Shuangxi Zhou** Modelling diverse plant water use strategies: a meta-analysis of stomatal and non-stomatal responses to water stress	**Paul Rymer** Remnant *Pachira quinata* pasture trees have greater opportunities to self and suffer reduced reproductive success due to inbreeding depression	**Madeleine Barton** Predicting the response of a broadly distributed butterfly to environmental change: incorporating behaviour, flight and dispersal capacity	**Leonie Valentine** Foraging activity by the southern brown bandicoot as a mechanism for ecosystem services
1530–1600	AFTERNOON TEA					Exhibition Foyer
1600–1715	**SPEED TALKS**					

	A From physiology and behaviour to populations	B Dispersal and distribution patterns	C Disturbance and ecosystem dynamics
ROOM	Grand 1–2	Grand 3–4	State 3
CHAIR	Roger Cousens	Susanna Venn	Pete Green
1600	**Andrew Denham** Can times of plenty save palatable seedlings from herbivory?	**John Morgan** Performance of woodland annuals at 'home' and 'away': how important are soils versus climate?	**Rodrigo Estevez** The clarification of values, attitudes and risk perceptions to help resolve (or avoid) conflicts in invasive species management
1605	**Gregor Sanders** Ecophysiological adaptation of savanna trees across an aridity gradient in northern Australia	**Erin Waller** Influence of habitat loss and fragmentation on koalas in a peri-urban landscape of south-east Queensland	**Mark Hall** At the crossroads: does the configuration of roadside vegetation affect woodland birds?

Monday 3 December (cont)

	A	B	C
ROOM	Grand 1–2	Grand 3–4	State 3
1610	**Vuong Nguyen** Potential risks of excluding the seed bank from plant population models	**Brandy Ream** Mapping koala and eucalypt habitats in south-west Queensland using satellite imagery and field data	**Greg Cranston** Cumbungi response to flooding at Lindsay-Mulcra-Wallpolla Islands in the Murray River system, north-west Victoria
1615	**Heidi Zimmer** Recruitment in the rare Australian endemic conifer *Wollemia nobilis*	**Reid Tingley** Halting the spread of cane toads in Western Australia	**Megan Good** Floodplain woodland dynamics and the dense regeneration phenomenon
1620	**Myralyn Abasolo** Flowering asynchrony between planted and native spotted gums is a barrier to gene flow	**John Porter** Long-term monitoring of fauna in the NSW conservation reserve system: filling the gaps	**Tony Auld** Temperature effects on seed bank persistence influence extinction risk
1625	**Gaye Bourke** Protective attributes of artificial refuges mediate the risk of predation in Boulenger's skink (*Morethia boulengeri*)	**Mohsen Mesgaran** A new tool for detecting areas of extrapolation in species distribution modelling	**Pawel Waryszak** Soil seed bank ecology and its role in *Banksia* woodland restoration, Western Australia
1630	**Stephen Griffiths** Microbats produce echolocation buzz calls while drinking on the wing	**Gwenllian Iacona** Predicted invadedness of protected areas varies across species but is independent of treatment funding	**Michelle Bassett** Logs in fire-prone landscapes: fire history and landscape attributes influence resource availability following wildfire
1635	**Tanja Straka** Local and landscape features of water bodies and their importance for insectivorous bats and insects in an urban environment	**Lee Belbin** The Atlas of Living Australia: an educational resource for ecology	**Janet Cohn** Mosaic burning, heterogeneity and plant diversity
1640	**Adam Cardilini** Surviving urbanisation: masked lapwing, *Vanellus miles*, experience greater reproductive success in suburban than agricultural environments	Discussion	Discussion
1645	**Alissa Monk** Contribution of mercury contamination to deaths in a newly discovered dolphin species		
1650–1715	Discussion		
1745–1930	**POSTER SESSION 1—BARBARA RICE MEMORIAL POSTER SESSION** (Presenters of even number posters to be in attendance)		Exhibition Foyer

Tuesday 4 December

0730–1900	Registration open					Exhibition Foyer
0900–1030	**PLENARY SESSION 2** Chair: Barbara Downes					Grand Ballroom 1–4
0900	KEYNOTE PRESENTATION: **The overwhelming importance of habitat size for food webs** **Angus McIntosh**, School of Biological Sciences, University of Canterbury, New Zealand					
0945	AERA LECTURE: **Mammal extinctions and ecological cascades**—**Chris Johnson**					
1030–1100	MORNING TEA					Exhibition Foyer
1100–1300	**CONCURRENT SESSION 3**					
	3A **Disturbance, recovery and resilience**	**3B** **Symposium: Restoration of ecosystem functions**	**3C** **Plant ecophysiology**	**3D** **Complex species interactions**	**3E** **Biogeography and macroecology**	**3F** **Community assembly, diversity and dynamics**
ROOM	Grand 1–2	Grand 3–4	Park	State 1–2	Lake 1–4	State 3
CHAIR	Tricia Wevill	Claire Farrell	Christopher Szota	David Watson	Erik Wapstra	Daniel Laughlin
1100	**Lyndsey Vivian** Understanding the hydrological responses of wetland plants for restoring wetlands degraded by altered flood regimes	**Richard Hobbs** Maintaining and restoring critical green infrastructure in urban areas: what matters most?	**Jacqueline England** Dieback of floodplain forest is associated with groundwater depth during drought	**David Watson** The effects of mistletoe on insectivore occurrence: insights from a removal experiment	**Mark Westoby** Proteaceae are the world's most important clade for ecology	**Daniel Laughlin** A new solution to a perennial problem: predicting species abundances using intraspecific trait variation
1115	**Joanne Ocock** How much food on the floodplain? The contribution of frogs to wetland productivity alters with flood size	**Jeremy Lundholm** Stormwater runoff and biodiversity benefits of green roofs	**Gerald Page** Linking branch hydraulics with leaf level adaptations to water stress in arid environments	**Sarah Garnick** Inter- and intraspecific body size affects microhabitat use in a macropod community	**Riin Tamme** The relationship between small-scale environmental heterogeneity and plant species diversity: a macroecological approach	**Jian Yen** Is there an ecological basis for species-abundance distributions?
1130	**Sarah Kelly** The impact of spring burning on the home range of breeding scarlet robins	**Robyn Simcock** Living roofs restore hydrology but need more moisture to restore native plants and invertebrates	**Christopher Szota** Finding drought tolerance in high water users: balancing conflicting aims in green roof plant selection	**Laura Russo** Predicting the impact of invaders on mutualistic networks	**Marianne Tindall** Are species at low latitudes more likely to be spinescent: a two-pronged approach	**Gary Luck** Functional diversity across multiple land uses: interpretations of redundancy depend on functional group identity
1145	**Tim Curran** Trait shifts across rainfall contrasts in tropical and subtropical rainforests indicate plant adaptations to drought	**Claire Farrell** Ecological templates for selecting green roof plant species to improve ecosystem function	**Rachel Argus** Characterising waterlogging stress in mature eucalypt trees in the Pilbara, north-west Western Australia	**Aleks Terauds** Invasive species interactions over multiple trophic levels: rabbit grazing impacts soil fauna in the sub-Antarctic	**David Gillieson** Woody thickening of savanna ecosystems in northern Australia	**François Teste** Mycorrhizal fungal communities along a soil age gradient in a plant biodiversity hotspot
1200	**Ben Gooden** Alien turfgrass impacts on coastal seed banks: implications for community resilience	**Mardie Townsend** The influence of green infrastructure on human health and wellbeing	**Cate Macinnis-Ng** Thirsty plants in NZ? Water stress in six species native to New Zealand	**James Camac** Biotic interactions matter under climate change: evidence from an alpine heathland	**Natalie Briscoe** Variation in body size and insulation in koalas—how does it relate to climate?	**Belinda Cooke** Spatial scales of variation in sandy beach meiofauna in south-east Australia: implications for impact assessmen

Tuesday 4 December (cont)

	3A	3B	3C	3D	3E	3F
ROOM	Grand 1–2	Grand 3–4	Park	State 1–2	Lake 1–4	State 3
1215	**Paul Carnell** Resilience of temperate reefs: response of *Ecklonia radiata* (common kelp) to disturbance, herbivory and nutrients	**Emily Payne** Interactions between plant species and nitrogen cycling dynamics within stormwater biofilters	**Martin Bader** Drought stress physiology of sclerophyllous broad-leaved trees assessed with the non-invasive magnetic turgor pressure probe	**Justine Shaw** Managing invasive plants on remote oceanic islands with complex species interactions	**Richard FitzJohn** Does size matter? Species selection and mammalian body size evolution	**Andrew Letten** Too much of a good thing? Temperature variability and species richness in woodland plant communities
1230	**Cassia Read** Using biological soil crusts to assess condition of semi-arid ecosystems	**Tim Fletcher** Restoring catchment-scale water balance using stormwater retention and passive irrigation systems	**Christine Allen** Back from the brink of extinction: improving success of endangered plant translocations in south-western Australia	**Emma Carlos** Wildlife in weeds: impacts and their implications	**Marlee Tucker** Home range and body mass patterns: are all mammals equal?	**Jiajia Liu** Climate change management of conservation areas using functional traits
1245	**Tricia Wevill** An audit of riparian restoration: following a restoration trajectory or meandering through a changed landscape	**Fatemah Poodat** Gap detection in habitat networks: locating restoration areas in Greater Melbourne	**Victoria Marchesini** Spectral detection of stress-related pigments in samphires of Western Australia		**Hannah Cliff** Biogeography in glaciated landscapes: the historical context of ecological and evolutionary divergence in the spotted snow skink (*Niveoscincus occelatus*) across Tasmania	
1300–1400	LUNCH					Exhibition Foyer
1300–1400	ESA AGM					Grand Ballroom 1–2
1400–1530	**CONCURRENT SESSION 4**					
	4A **Disturbance, recovery and resilience**	**4B** **Symposium: Identifying refugia for biodiversity**	**4C** **Plant ecophysiology**	**4D** **Food webs and trophic networks**	**4E** **Dispersal and habitat connectivity**	**4F** **Community assembly, diversity and dynamics**
ROOM	Grand 1–2	Grand 3–4	Park	State 1–2	Lake 1–4	State 3
CHAIR	Liza Smith	April Reside	Julieta Rosell	Paula Sardina	Tim Jessop	Michael Nash
1400	**Mark Antos** What's happening in the long grass? Impacts of biomass accumulation on native grassland faunal communities	**Cassandra James** Identifying refugia for freshwater biodiversity across Australia	**Marina Scalon** Photosynthetic trait relationships in mistletoes compared to hosts: the hidden costs of cheating	**Scott Johnson** Downstairs drivers: how root herbivores shape multi-trophic communities aboveground	**Tim Jessop** Dispersal inertia renders Komodo dragons unresponsive to environmental change	**Michael Nash** Conservation of Carabidae in productive landscapes: understanding fine scale spatial dynamics
1415		**Grant Wardell-Johnson** Identifying refugia in a warming, drying global biodiversity hotspot	**Aimee Bourne** Coordination of leaf gas exchange and stem hydraulic traits in *Eucalyptus* species from contrasting climates	**Chris Gordon** Rodent granivory as a process limiting shrub encroachment in arid Australia: an indirect dingo affect	**Raoul Ribot** Nomadic movements of black swans (*Cygnus atratus*) in arid Australia following La Nina floods	**Matthew Binns** Predicting the effect of climate change on community structure and function: an assessment using grassland Thysanoptera

Tuesday 4 December (cont)

	4A	4B	4C	4D	4E	4F
ROOM	Grand 1–2	Grand 3–4	Park	State 1–2	Lake 1–4	State 3
1430	**Justine Smith** Differential responses of two native marsupials to a planned burn	**Nick Bond** Incorporating climate change into conservation planning: an example using freshwater fish	**Rachael Nolan** Effect of the Black Saturday fires on forest water use: from leaf to stand	**Melissa Klamt** Trophic relationships of the platypus: insights from stable isotopes and cheek pouch dietary analysis	**John McEvoy** From farm-duck to desert nomad: how waterfowl respond to rapidly changing environments	**Beth Crase** Environmental drivers of spatial patterning in mangrove tree species dominance
1445	**Carolina Galindez Silva** Planned burning and swamp wallabies: do they bounce back?	**Sylvia Hay** Aquatic invertebrate refugia: the importance of persistent pools as stable patches under climate change	**Julieta Rosell** Insights into bark trait ecology based on 90 species from dry scrub to rainforest	**Ross Thompson** Reassembling food webs in climate-changed landscapes: an experimental study	**Inka Veltheim** Can habitat suitability modelling explain seasonal movements of brolgas in south-western Victoria?	**Brad Farmilo** Microclimate and plant species density is altered in small forest fragments: not how you may expect
1500	**Louise Pastro** Fire type and hemisphere determine fire effects on vertebrate diversity: a global meta-analysis	**Tom Harwood** In search of topographically mediated refugia under climate change	**Kasia Zieminska** Wood density and its anatomical components	**Ryan Woodland** Assimilation of diazotrophic nitrogen into pelagic food webs	**Peter Menkhorst** Is a fuelbreak a barrier to movement for smoky mice?	**Sabine Nooten** Potential impacts of climate change on insect communities: a transplant experiment
1515	**Liza Smith** Comparisons between native and exotic liana biomass in eastern Australian rainforests	**John Gollan** A method to identify microrefugia and an acid test using plant and invertebrate community distributions	**E Charles Morris** Seed coat dormancy in Grevillea: test of the mechanical constraint model	**Paula Sardina** Means and extremes in climate-impacted freshwater ecosystems: an experimental approach	**Don Driscoll** The matrix in fragmented landscapes: conceptual model and empirical challenge using a 14-year dataset	**James Schlunke** Integrating ants into the ecological community: does conserving plant communities adequately conserve invertebrates?
1530–1600	AFTERNOON TEA					Exhibition Foyer
1600–1730	**CONCURRENT SESSION 5**					
	5A **Attitudes and perception of landscapes and ecology**	**5B** **Symposium: Identifying refugia for biodiversity**	**5C** **Environmental stressors**	**5D** **Predation and predator–prey interactions**	**5E** **Dispersal and habitat connectivity**	**5F** **Temporal patterns in community assembly**
ROOM	Park	Grand 3–4	Grand 1–2	State 1–2	Lake 1–4	State 3
CHAIR	Christopher Ives	Cassandra James	Sally Power	Euan Ritchie	Mark Ooi	David Keith
1600	**Dieter Hochuli** Nature's classroom: blending citizen science and education to bring ecological research to primary students	**Robert Puschendorf** Environmental refuges from disease-driven amphibian extinctions: patterns and processes protecting frogs from extermination in the periphery of their distribution	**Anita Smyth** Chronically ill sleepy lizards *Tiliqua rugosa* in Australia's cereal cropping landscapes	**Andrew Hamer** Predation modifies larval amphibian communities in urban ponds	**Pia Lentini** The effect of planning for connectivity on a network of roadside reserves	**Graeme Clark** Intrinsic time-dependence in the diversity-invasibility relationship

Tuesday 4 December (cont)

	5A	5B	5C	5D	5E	5F
ROOM	Park	Grand 3–4	Grand 1–2	State 1–2	Lake 1–4	State 3
1615	**Charlotte Taylor** The role of public education initiatives in changing attitudes and behaviours associated with urban habitat and biodiversity loss	**April Reside** Identifying refugia for terrestrial biodiversity across Australia	**Camilla Ridoutt** Persistent organic pollutants in Australian white ibis (*Threskiornis molucca*) eggs of eastern Australia	**Anke Frank** The role of feral cats in small mammal declines in northern Australia: experimental evidence	**Kylie Soanes** Evaluating the effectiveness of road crossing structures for arboreal mammals: is use evidence for effectiveness?	**Tanya Mason** Arrival order of native functional groups does not affect invasibility of planted dune communities
1630		**Jenny Davis** Evolutionary refugia and ecological refuges: key concepts for conserving arid zone freshwater biodiversity under climate change	**Allyson O'Brien** Detecting ecological consequences of pollution in marine environments	**Valentina Mella** Perceived predation risk by brushtail possums (*Trichosurus vulpecula*): the use of direct and indirect cues	**Clarissa Barbosa** From metapopulations to meta-food-webs: spacial community ecology in the arid zone	**Joanne Bennett** Changes in bird assemblages and their habitats in response to a changing climate
1645	**Christopher Ives** The values and preferences of city residents for peri-urban landscapes: implications for biodiversity conservation	**Dan Rosauer** Does late Pleistocene climate stability predict within-species diversity for herpetofauna in Australia's eastern mesic arc?	**Elizabeth Martin** Stormwater limits distribution of platypus in an urban landscape	**Euan Ritchie** Conservation with bite: understanding and applying predators' ecological functions	**Katrien Geurts** Patching up the divide: population dynamics of rainforest mammals in a fragmented landscape	**Miriam Goosem** Effects of successional age on community composition and above-ground biomass in tropical Australia
1700		**Dale Nimmo** Collapse and recovery of an avifauna: have south-eastern Australia's bird communities recovered from a decade of drought?	**Meenu Vitarana** Lichen *Usnea inermis* as a biomonitor of atmospheric heavy-metals in the Collie coal basin, south-western Australia		**Claire Coulson** Factors influencing the dispersal of tree species in a fragmented landscape: are roadside environments useful?	**David Keith** Long-term studies: detecting and understanding trends in biodiversity
1715		**Louise Gilfedder** Do refugia provide the key to resilient landscapes?	**Sally Power** Changing rainfall patterns affect the composition and functioning of a temperate grassland ecosystem		**Mark Ooi** Seed banks of physically dormant species: season- versus fire-related dynamics and climate change	
1745–1930	**POSTER SESSION 2—BARBARA RICE MEMORIAL POSTER SESSION** Exhibition Foyer (Presenters of odd number posters to be in attendance) Plus Ecology in Action Photo Competition winners announced'					

Wednesday 5 December

0730–1900	Registration open					Exhibition Foyer
0900–1030	**PLENARY SESSION 3** Chair: Jill Lancaster					Grand Ballroom 1–4
0900	KEYNOTE PRESENTATION: **Species' range edges and the evolution of dispersal** **Ben Phillips**, Centre for Tropical Biodiversity and Climate Change, James Cook University					
0945	KEYNOTE PRESENTATION: **Males exist. Does it matter?** **Hanna Kokko**, Research School of Biology, Australian National University					
1030–1100	MORNING TEA					Exhibition Foyer
1100–1300	**CONCURRENT SESSION 6**					
	6A **Symposium: Forest transition in a changing climate**	**6B** **Symposium: Linking Indigenous and Western ecology**	**6C** **Ecological genetics**	**6D** **Extremes of interactions: parasitism to mutualism**	**6E** **Spatial processes: causes and consequences**	**6F** **Conservation planning and management**
ROOM	State 1–2	Lake 1–4	State 3	Park	Grand 3–4	Grand 1–2
CHAIR	Niels Brouwers	Christine Schlesinger	Christina Richards	Victor Resco de Dios	Alexandra Bowman	Jim Thomson
1100	**Sarah Boulter** Australia's forests and climate change: from impact assessment to adaptation	**Rebecca Phillips** Can modern science be akin to TEK? Case studies: linking cultural knowledge and park management.	**Chong Ren Ong** Species boundary delimitation of the genus *Pelargonium* (L'Her. ex Aiton) in Australia	**Michael Bull** Ecological interactions between hosts and parasites: *Salmonella* slyly slinks among sixty social sleepies	**Kerry Bridle** Land clearance not dieback continues to drive tree loss in a Tasmanian rural landscape	**Jim Thomson** Biodiversity modelling to identify priorities for conservation and restoration in human-modified landscapes of the eastern Amazon
1115	**David Bowman** Tree growth in Australia's eucalypt forests: what does macroecology tell us about future trends?	**Ray Ahmat** Working on country	**Richard Major** Urbanisation results in genetic isolation of endangered bird population inhabiting saltmarsh remnants	**Luke O'Loughlin** Invader-invader mutualism influences entry and establishment of other alien species in rainforest on Christmas Island	**Ingrid Stirnemann** Investigating environmental and disturbance gradients on vegetation heterogeneity: is measurement type important?	**Prue Addison** How well is long-term biological monitoring informing the management of Australia's marine protected areas?
1130	**Jerome Chopard** Modelling changing tree distribution around Perth in a changing climate	**Clive Aiken** Bunuba business on Bunuba country	**Claire Keely** The genetic structure of an endangered amphibian in an urban landscape	**Ryan Sharp** Plant-parasite stable polymorphisms: a simple but overlooked solution?	**Alison O'Donnell** Climatic drivers of wildfire occurrence and extent in semi-arid south-west Australia	**Graeme Newell** Development of assemblage models to assist conservation planning and prioritisation across Victoria
1145	**Katinka Ruthrof** Extreme drought and heat triggers severe dieback in multiple, dominant canopy species in south-western Australia	**Jeremy Freeman** Cross-cultural research for managing *Allosyncarpia* rainforest patches of the Arnhem plateau	**Siegy Krauss** Inbreeding and outbreeding depression in *Stylidium hispidum*: implications for mixing seed sources for ecological restoration	**Louisa Armstrong** The mycorrhizal facilitation hypothesis	**Adrian Davis** Enhanced flower production in resource-rich urban landscapes explains avian nectarivore abundance	**Ascelin Gordon** The utility of backcasting for developing conservation policy: modelling conservation interventions in urban fringe environments
1200	**Giles Hardy** Impacts of large scale drought deaths in Western Australia's northern jarrah (*Eucalyptus marginata*) forest	**Doug Williams** Cultural mapping and freshwater turtle monitoring in Githabul country	**Bernd Gruber** How sensitive are genetic estimators of population structure at detecting fragmentation?	**Jennifer Taylor** Rapid population turnover of the mistletoe *Korthalsella rubra* (Viscaceae) during drought	**Rebecca Stirnemann** Nest site selection and productivity: implications for the mao, an endangered honeyeater	**Steven Chown** Continent-wide risk assessment for the establishment of non-indigenous species in Antarctica

Wednesday 5 December (cont)

	6A	6B	6C	6D	6E	6F
ROOM	State 1–2	Lake 1–4	State 3	Park	Grand 3–4	Grand 1–2
1215	**Niels Brouwers** Mapping tree damage caused by extreme drought and heat using a remote sensing approach	**Emilie Ens** Indigenous knowledge is fundamental to management of Indigenous owned Australia: case study from Arnhem Land	**Peter Selwood** Estimating the population history of an endangered bird, the helmeted honeyeater	**Nyree Weichel** Associations between shrubs, sap-suckers, and dominant ants in semi-arid Australia: beneficial for plants and herbivores?	**Alexandra Bowman** Fallen logs as resource traps in degraded chenopod shrublands	**Yvonne Buckley** The contributions of cost, management efficacy and demography to efficient management of invasive plants
1230	**Gillis Horner** Flooding, salt, grazing and thinning affect regeneration dynamics of river red gum (*Eucalyptus camaldulensis*) forests of the Murray River	Discussion	**Sara Ohadi** Success and failure of invasions: does genetic variation matter?	**Maggie Watson** Drivers of population-level effects of parasites and parasite virulence: life-history meets meta-analysis	**Jude Keyse** Beyond species richness: testing concordant patterns of species and genetic diversity in Indo-Pacific marine fauna	
1245	**David Ellsworth** Eucalyptus Free-air CO2 enrichment ('FACE') and how atmospheric CO2 is affecting Cumberland Plain biodiversity	Discussion	**Christina Richards** Mechanisms of response to novel environments in genetically depauperate invasive Japanese knotweed	**Victor Resco de Dios** Passive facilitation: an overlooked component of tree-grass interactions in a semi-arid grassland		
1300–1400	LUNCH					Exhibition Foyer
1300–1400	Editorial board meeting (Ecological Restoration and Management					Park Room
1400–1530	**CONCURRENT SESSION 7**					
	7A Symposium: Australian phenology	**7B Symposium: Linking Indigenous and Western ecology**	**7C Ecological genetics**	**7D Herbivory**	**7E Population and metapopulation dynamics**	**7F Ecological expertise and decisions for management**
ROOM	Park	Lake 1–4	State 3	State 1–2	Grand 3–4	Grand 1–2
CHAIR	Lynda Chambers	Christine Schlesinger	Aaron Adamack	Ben Moore	Clive McAlpine	Libby Rumpff
1400	**Lynda Chambers** Southern Hemisphere phenology: is it changing and what are the main drivers of change?	**Oliver Costello** Firesticks: Aboriginal fire to enhance biodiversity, connectivity and resilience	**Tom Kelly** Genetic rescue of the mountain pygmy possum, *Burramys parvus*, through wild translocation	**Andrea Stephens** How do multiple enemies interact to reduce host-plant performance?	**Clive McAlpine** Conserving koalas in the 21st century: synthesising the dynamics of Australia's koala populations	**Libby Rumpff** How good are experts anyway? Validating a state-and-transition process model for adaptive management
1415	**Irene Hudson** Pyrus phenology in South Australia: life in a hot, dry climate	**Gerry Turpin** Establishment of an Indigenous-driven tropical ethnobotany centre	**Joanna Burgar** Who's for dinner? Determining bat dietary preferences utilising high-throughput sequencing genetic analyses	**Petah Low** Out on a limb: are eucalypt-feeding insects at greater risk of predation on young foliage?	**Judy Dunlop** Translocation removes island dwarfism in the golden bandicoot (*Isoodon auratus*)	**Judy Lambert** Giving ecology a place in resolving 'wicked problems'

Wednesday 5 December (cont)

	7A	7B	7C	7D	7E	7F
ROOM	Park	Lake 1–4	State 3	State 1–2	Grand 3–4	Grand 1–2
1430	**Marie Keatley** Analysis of long-term flowering records for river red gum and black box in a flooding forest	**Sonia Leonard** Integrating traditional ecological knowledge with land management activities: understanding ecological response to climate change in the Great Sandy Desert	**Julianne O'Reilly-Wapstra** The genetics of flammability in the eucalypt landscape	**Adam Frew** Effects of plantation management on eucalypt understory ecology	**William Bovill** Is immigration limited by habitat abundance or supply of dispersers? Patch-scale habitat use is important	**Marissa McBride** Trading off accuracy and effort in eliciting expert assessments of extinction risk for threatened species
1445	**Deepa Shree Rawal** Climatic effects on growth phenology of co-occurring eucalypts	**Simon Booth** Working for warru: an update on the reintroduction of black-footed rock wallaby (*Petrogale lateralis*) to the Anangu Pitjantjatjara Yankunytjatjara lands, South Australia	**Sichong Chen** Tropical oaks have larger genome sizes than do their temperate relatives within and among genera	**Helen Waudby** Effects of grazing on plant biodiversity and reproductive phenology in arid cracking-clay ecosystems	**Chris Pavey** Dynamics and spatial ecology of the desert rodent *Pseudomys australis*: importance of refuges for persistence	**Joslin Moore** How good are our decision models? An experimental test of optimal surveillance
1500	**Irene Hudson** The effect of current and past seasonal climate on eucalypt flowering: identifying early/late flowering years	**Malcolm Lindsay** Interactions in monsoon vine thickets: people, plants, fauna, fire and restoration in the Dampier Peninsula, Western Australia	**Nevil Amos** Species and sex specific mobility manifest in a range of landscape genetic responses in a suite of declining woodland birds	**Ben Moore** Environment, herbivory and the evolution of foliar chemistry in the red ironbarks (*Eucalyptus* series Siderophloia)	**Rannveig Magnusdottir** Diet changes in American mink population in Iceland	**Alison Specht** Attitudes to interdisciplinary collaboration in the Ecological Society of Australia: do members differ from non-members?
1515	**Rebecca Darbyshire** Methods matter: implications of phenological method selection for impacts and adaptation in fruit tree flowering	Discussion	**Aaron Adamack** PopGenReport: simplifying population genetics analyses in R	**Karolina Petrovic** A world on a plate: heterogeneity in brushtail possum nutrition	**John Baumgartner** Bayesian hierarchical modelling of population growth rates	
1530–1600	AFTERNOON TEA					Exhibition Foyer

Wednesday 5 December (cont)

1600–1730	CONCURRENT SESSION 8					
	8A Symposium: Australian phenology	**8B Biogeochemistry and nutrient cycling**	**8C Symposium: Bridging the temporal divide**	**8D Competition and life history traits of plants**	**8E Population and metapopulation dynamics**	**8F Management practices and experiences**
ROOM	Park	Lake 1–4	State 3	State 1–2	Grand 3–4	Grand 1–2
CHAIR	Marie Keatley	Anne Tomlinson	Amy Macken	Mark Hovenden	Georgia Garrard	Emily Nicholson
1600	**Timothy Brown** Gigapixel resolution time-lapse imaging for phenological monitoring of every plant in a landscape	**Anne Tomlinson** Effects of native and exotic millipedes (diplopoda) on decomposition, nutrient release and plant growth	**Patrick Moss** Fires in the fens: fire history and management of the patterned fens of south-east Queensland	**Daniel Falster** Growth trajectories: a new way of understanding the influence of traits on plant growth	**Jill Lancaster** Population dynamics of aquatic insects: interactive effects of adult behaviour and density-dependent larval mortality	**Alison Skinner** Lessons learnt: theory versus practice of vegetation condition monitoring by natural resource management bodies
1615	**Anne Cochrane** Soil warming reduces seedling emergence in a Mediterranean-climate ecosystem	**Darren Giling** Can a little vegetation go a long way? Effect of vegetation replanting on whole-stream metabolism	**Felicity Shapland** Paleoenvironmental reconstruction over the late Quaternary period for patterned fens at Moon Point, Fraser Island	**Habacuc Flores Moreno** A comparison of recruitment success of introduced and native species under natural conditions	**Maria Boyle** Modelling effects on populations with temperature-dependent sex determination	**Alexander Gold** Using thresholds to guide natural resource management: toward resilience or business-as-usual rebranded?
1630	**Peter Dann** Predicting the onset of breeding and moulting in little penguins from ocean temperatures	**Le Bai** The colour of mud: blue carbon storage in Darwin Harbour mangrove communities	**Alexander Baynes** Palaeontology and species-area relations applied to conservation of terrestrial mammals around Shark Bay, WA	**Ian Wright** How does your garden grow? Disentangling the competing influences of traits, biomass allocation and plant size on field growth rates	**Amanda Edworthy** Causes of decline in the forty-spotted pardalote, an endangered habitat specialist	**Chooi Fei Ng** When to stop new management actions
1645	**Brian Hawkins** Fruit hotspots: using models of spatio-temporal resource availability to map seasonal fauna habitat	**Andre Siebers** Hydrological variation and dissolved organic matter in streams of the Pilbara, WA	**Marie Attard** The thylacine myth: stable isotopes and skull biomechanics reveal their actual diet and extinction risk	**Alex Haller** The relevance of life-history traits to the persistence of a rare herb (*Trioncinia retroflexa*) in semi-natural Queensland grasslands	**Nathan Emery** Populations are important for improving species distribution models	**Emily Nicholson** Making robust policy decisions using global biodiversity indicators
1700	**Meredith Mitchell** Flowering phenology of *Microlaena stipoides* in north-east Victoria	**Md Nazim Uddin** Phytotoxicity of *Phragmites australis* through residue decomposition	**Michael-Shawn Fletcher** A fire-driven catastrophic regime shift between forest and moorland in temperate Tasmania	**Claire Wainwright** Biotic interactions among annual plant species in a novel ecosystem	**Hania Lada** Inferring large-scale trajectories of change in fauna using remote sensing of forest-stand condition	**Cynnamon Dobbs** Bundles and tradeoffs of ecosystem services in the urban core
1715			Discussion	**Mark Hovenden** Competition within dense stands of *Eucalyptus regnans* saplings leads to facilitation		
1730–1930	Research Chapter meetings					Grand 1–2 and Grand 3–4
1730–1930	Invasive Species Research Chapter meeting					Lake 1–2
1730–1930	Indigenous Forum informal mixer					Park Room
1930–2200	Postgraduate mixer					Middle Park Bowling Club

Thursday 6 December

0730–1700	Registration open				Exhibition Foyer
0900–1000	**PLENARY SESSION 4** Chair: Kris French				Grand Ballroom 1–4
0900	Introduction to the ESA Gold Medal Award				
0915	Gold Medal Presentation: **How much starter is too much?**—**Michael Keogh**				
1000–1045	MORNING TEA				Exhibition Foyer
1045–1245	**CONCURRENT SESSION 9**				
	9A **Environmental stressors: the urbanisation syndrome**	**9B** **Sampling, monitoring and experimental design**	**9C** **Landscape disturbances and consequences**	**9D** **Community assembly and disturbance**	**9E** **Environmental management and land use**
ROOM	Grand 3–4	Lake 1–4	State 1–2	State 3	Grand 1–2
CHAIR	Michael Perring	Elizabeth Williams	Annabel Smith	Jane Catford	Keryn Paul
1045	**Nicholas Williams** Urbanisation, plant traits and the composition of urban floras	**Cindy Hauser** Observing the observer: experiments that estimate weed detectability	**Carla Catterall** Can revegetation projects rescue rainforest bird communities?	**Susanna Venn** Trait-mediated responses of alpine plants to experimentally altered snow cover	**Saul Cunningham** Biodiversity impacts of agricultural land use
1100	**Caragh Threlfall** The influence of different urban green spaces on wild bee abundance and diversity	**Kathryn Lambert** Monitoring cryptic species via quantified sound analysis	**Heloise Gibb** Restoration of trophic structure along a revegetation chronosequence	**Melanie Bishop** Traits of foundation species influence the enactment of a facilitation cascade in Australian mangroves	**Hannah Pearson** Reclaiming the woodlands: modelling for improved biodiversity management
1115	**Lizzy Lowe** The effect of urbanisation on the size and condition of golden orb-weaving spiders	**Christopher Jones** Vegetation condition in riparian areas: towards refinement of assessment and management	**Rachel Standish** Using restoration records to assess resilience of jarrah forest to climate change	**Jane Catford** Traits of exotic and native plants help explain why flow regulation facilitates riparian invasion	**Elizabeth Law** Integrating ecosystem services into land use planning, Central Kalimantan, Indonesia
1130	**Briony Norton** Leaf litter removal in urban green spaces: contrasting responses of ants and detritivores	**Dustin Welbourne** A new method for surveying terrestrial reptiles	**Melissa Bruton** Are passively regenerating woodlands a valuable resource? A case study with reptiles	**John Dwyer** Using species trait means underestimates community functional responses to environmental change	**Kelly Hunt de Bie** Monitoring and management of bush camp grounds in a Victorian national park
1145	**Teresa Mackintosh** The influence of urbanisation on wetland invertebrate biodiversity	**Bronwyn Hradsky** The effect of patch characteristics and trap configuration on trapping success	**David Wong** Improving performance of species distribution models for a disturbance-sensitive legless-lizard	**David McKenna** Spatial and temporal diversity patterns of bird assemblages in fire-prone mallee communities of Kangaroo Island	**Peter Curtis** Will *Xanthorrhoea glauca* subs. *angustifolia* survive the presciptive fire regimes on Victorian public land?
1200	**Megan O'Shea** Is translocation an effective conservation tool for striped legless lizards?	**Robert Reed** Monitoring rare mycophagous mammals: detecting the presence of potoroos via foraging dig surveys	**Gemma Hoyle** Soil warming increases diversity but decreases germination from an alpine soil seed bank	**Matthew Bruce** The influence of fire history on fauna occupancy in East Gippsland, Victoria	**Keren Raiter** Under the radar: offsetting cumulative, offsite, cryptic and secondary ecological impacts in intact landscapes

Thursday 6 December (cont)

	9A	9B	9C	9D	9E
ROOM	Grand 3–4	Lake 1–4	State 1–2	State 3	Grand 1–2
1215	**Michael Perring** Novel urban ecosystems and ecosystem services	**Elizabeth Williams** Temporal variation in microbat calls and implications for monitoring programs	**Annabel Smith** Germination in the world's tallest angiosperm (*Eucalyptus regnans*) and the impact of recurrent disturbances	**Peter McQuillan** Impacts of agricultural intensification on biodiversity: a case study from Tasmania	**Keryn Paul** Calibration of the Carbon Farming Initiative's reforestation modelling tool to improve estimates of carbon sequestration by environmental and mallee plantings
1230		**William Morris** On the accuracy of Bayesian models with informative priors: a comprehensive analysis using a large rainforest dataset		**Nigel Andrew** Insect responses to climate change: what are we testing for?	
1245–1400	LUNCH				Exhibition Foyer
1400–1530	**CONCURRENT SESSION 10**				
	10A **Symposium: Urban ecology in Australia**	**10B** **Sampling, monitoring and experimental design**	**10C** **Landscape disturbances and consequences**	**10D** **Community assembly and resource dynamics**	**10E** **Environmental management for species**
ROOM	Grand 3–4	Lake 1–4	State 1–2	State 3	Grand 1–2
CHAIR	Amy Hahs	Geoffrey Kay	Margaret Kitchin	Melinda Moir	Amelia Koch
1400	**Jenni Garden** Interactions between climate change, urbanisation, and the capacity of current protected areas to sustain biodiversity	**Gerry Quinn** Hypotheses, the Reverend Bayes, models and prediction: is our data-analysis paradigm changing?	**Margaret Kitchin** Long-term monitoring for fire management: ten years on in the Australian Alps	**Philip Barton** Species traits predict biodiversity dynamics at ephemeral resource patches created by carrion	**Peter Vesk** Testing the effectiveness of habitat restoration targeted at grey-crowned babblers
1415	**Samantha Imberger** Challenges of a long-term, large-scale manipulation experiment in an urban ecosystem	**Michael McCarthy** The optimal number of surveys when detectability varies	**Barbara Wilson** Guidelines for ecological burning regimes in *Banksia* woodlands: challenges in a peri-urban system in Western Australia	**James Cook** Convergence of multitrophic community structure across three continents	**Amelia Koch** Using Maxent to map potential nesting habitat of the Tasmanian wedge-tailed eagle
1430	**Karen Ikin** Conserving birds and their habitat in urban and future urban landscapes	**Brendan Wintle** Designing occupancy surveys and interpreting non-detection when observations are imperfect	**Luke Collins** Adding fuel to the fire: will revegetation of agricultural landscapes lead to bigger wildfires?	**Georges Kunstler** Competitive interactions between forest trees are driven by species' trait hierarchy, not phylogenetic or functional similarity: implications for forest community assembly	**Bryony Horton** Ecological complexities of bell miner associated eucalypt forest dieback in a NSW World Heritage Area
1445	**Virginia Harris** and **Dave Kendal** Diverse social values drive heterogeneity in urban parks and gardens	**Warren Paul** Causal modelling with multivariate species data	**Steve Leonard** Community safer places? Determinants of patches remaining unburnt in a major wildfire	**José M Facelli** Vegetation patterns and processes inside and outside groves of Casuarina pauper in a chenopod shrubland	**Martine Maron** Avifaunal disarray from a single despotic species: scale of the challenge and recommended responses

Thursday 6 December (cont)

	10A	10B	10C	10D	10E
ROOM	Grand 3–4	Lake 1–4	State 1–2	State 3	Grand 1–2
1500	**Cristina Estima Ramalho** Delayed effects of fragmentation on remnant woodlands of a rapidly urbanising biodiversity hotspot	**Emma Gorrod** Using adaptive management principles to design an ecological thinning trial in river red gum forests	**Glenda Wardle** Facing facts about fire in the desert: are we managing for conservation?	**Jodi Price** The functional assembly of experimental grasslands in relation to fertility and resource heterogeneity	**Yung En Chee** A state-transition dynamic Bayesian network model for the management of willows
1515	**Geoffrey Heard** On the road to ruin: metapopulation collapse in an endangered frog exposed to urbanisation	**Geoffrey Kay** Monitoring for outcomes in an Australian conservation incentive program: Environmental Stewardship Program		**Melinda Moir** Is the threat posed by coextinction overestimated in the world's biodiversity hotspots?	
1530–1600	AFTERNOON TEA				Exhibition Foyer
1600–1715	**PLENARY SESSION 5** Chair: Kris French and Ian Williamson				Grand Ballroom 1–4
1600	Awards Jill Landsberg Trust Fund Award 2012 winner: Amanda Edworthy and Kate Stevens 2011 winner presentation: Life history, spatial ecology and population viability of the migratory swift parrot—Dejan Stojanovic TNC Applied Conservation Award 2012 winner: Matthew Rees 2011 winner presentation: A tale of two white-tails: exploring the social values of Baudin's and Carnaby's black cockatoos—Gill Ainsworth ESA Members' Service prize—Sue Murray-Jones Student Prizes				
1700	Launch of ESA 2013, and Conference close				
1830–2300	CONFERENCE DINNER				Zinc at Federation Square

Friday 7 December

WORKSHOPS		
0900–1130	Smarter workflows for ecologists	Lake 1–2
0900–1230	Understanding the Commonwealth policy environment	Lake 3–4
1330–1545	Living and working with stress	Lake 3–4
1330–1730	Writing clearly and succinctly	Lake 1–2
0930–1700	Wild grasses of south-eastern Australia—identification and ecology (offsite)	Mitcham, Victoria
FIELD TRIPS		
0700–1730	Central Highlands—Long-term monitoring of the mountain ash	
0800–1700	Black Saturday Bushfires—Refuges and recovery	
7–12 Dec	Riverina remnant landscapes—Trust for nature	

General information

Conference venue

Sebel Albert Park Melbourne
65 Queens Road, Albert Park, Melbourne VIC 3004

Ph: 03 9529 4300

The Sebel Albert Park Melbourne is centrally located on Queens Road, overlooking Albert Park Lake, and a short tram ride to Melbourne's CBD.

Conference registration desk

The registration desk is located on the exhibition floor of The Sebel Albert Park Conference Centre.

Sunday 2 December	1500 – 1900
Monday 3 December	0730 – 1900
Tuesday 4 December	0730 – 1900
Wednesday 5 December	0730 – 1900
Thursday 6 December	0730 – 1700

The registration desk can be contacted during these hours on 0448 576 105.

Accommodation

For those registrants who have booked accommodation through the Conference Secretariat, please ensure that accounts are settled in full prior to your departure and that the appropriate deposit has been deducted from your account.

The Sebel Albert Park (conference venue)
65 Queens Road, Albert Park
Ph: 03 9529 4300

Citigate Albert Park (conference venue)
65 Queens Road, Albert Park
Ph: 03 9529 4300

Bayview on the Park
59 Queens Road, Melbourne
Ph: 03 9243 9999

Quest on Dorcas
8 Dorcas Street, South Melbourne
Ph: 03 9698 1500

Seasons Botanic Gardens
348 St Kilda Road, Melbourne
Ph: 03 9685 3000

Medley Hall, University of Melbourne
48 Drummond Street, Carlton
Ph: 03 8344 5476

International House, University of Melbourne
241 Drummond Street, Carlton
Ph: 03 9347 6655

ATM locations

An ATM is located in the Sebel Albert Park hotel lobby.

Nearby major bank ATMs:

ANZ—Melbourne Aquatic Centre (on other side of Albert Park)
NAB—St Kilda Road a few minutes walk from the hotel
CBA—southern border of Albert Park, several minutes walk from the hotel

Branches of all the major banks are in St Kilda and Melbourne CBD, both a short tram ride from the venue.

Catering

Morning, afternoon teas and lunches will be served each day in the exhibition foyer of The Sebel Albert Park Conference Centre and are included in your registration fee. Please note that the day catering menu selections for this conference are predominantly vegetarian. Special meals will be prepared for delegates who have pre-registered their requirements. These meals will be available from the marked station during meal breaks. Please visit the registration desk if you require assistance.

Conference carbon offsets

The Organising Committee appreciates the generosity of delegates who voluntarily contributed carbon offset funds. This revenue will go towards supporting landscape restoration in Habitat 141, run by Greening Australia.

Habitat 141 is a visionary, large landscape-scale conservation project in western Victoria and south-eastern South Australia that straddles the 141st parallel of longitude. Habitat 141 seeks to restore vegetated links between major national parks and nature reserves over a

700 km length stretching from 'Ocean to Outback'. Habitat 141 restoration activities focus on linking patches of existing vegetation on public and private land through direct seeding and seedling planting using a diversity of locally-adapted trees, shrubs and understory herbage. These large-scale works are guided by the latest conservation planning expertise and research.

Dress

The dress for all sessions and social functions is smart casual.

Exhibition hours

The exhibition will be open as follows:

Sunday 2 December	1730–1830
Monday 3 December	0830–1930
Tuesday 4 December	0830–1930
Wednesday 5 December	0830–1700
Thursday 6 December	0830–1600

Lost or found property

Please report any lost or found property to the registration desk.

Mobile phones and pagers

As a courtesy to other delegates and speakers, please ensure all mobile telephones and pagers are turned off or in 'silent' mode during all sessions and social functions.

Name badges

Your name badge is your entry to all sessions, exhibition, social functions, lunches, morning and afternoon teas. Please wear it at all times.

Online evaluation survey

Delegates are encouraged to complete the Conference evaluation survey as it assists us to plan future Conferences. An email will be sent to all delegates after the Conference providing a link to the online evaluation.

Parking

Parking is available at the Sebel Albert Park. Valet parking is available at $31 per day. Self-park options include: full day parking at $16 per car per exit OR early-bird parking at $12 per car per exit (entry prior to 0800 and exit between 1500 and 1900). Paid parking is also available in the area around Albert Park.

Participant list

A participant list has been provided to delegates upon registration. Anyone who indicated on their registration form that they did not want their name and organisation to appear on the participant list has not been included.

Penguins

Just down the road from the conference venue, at St Kilda Beach, you can spend the twilight watching the little penguins come up to nest for the night. The experience is free and is led by members of Earthcare St Kilda. For information and rules on how to experience the penguins without disturbing them, please go to http://stkildapenguins.com.au

Posters

Posters are located in the exhibition foyer of The Sebel Albert Park Conference Centre and will be available for viewing from 8.30 am Monday 3 December.

The Barbara Rice Memorial Poster Session 1 (even-numbered posters) will be held on Monday 3 December from 5.45 pm and the Barbara Rice Memorial Poster Session 2 (odd-numbered posters) will be held on Tuesday 4 December from 5.45 pm. Delegates are encouraged to view the posters, which have been grouped according to the Conference themes. Poster presenters are requested to stand beside their poster during the sessions.

Program information

A program at a glance can be found on page 16 and the full program can be found on page 19. The Conference organisers cannot be held responsible for any program changes due to external or unforeseen circumstances. Please check the noticeboard located near the registration desk for any changes to sessions.

Taxis

13Cabs 13 CABS (13 2227)
Maxi Taxi 13 MAXI (13 6294)
Wheelchair Accessible Taxis 9277 3877

Instructions for oral presenters

Instructions to presenters of oral papers

Time slots for oral presentations are 15 minutes. This is based on a 12 minute talk, and 3 minutes for question time/changeover. Session Chairs are instructed to ensure that ALL presenters adhere strictly to these times. Speakers will be gently warned when the talk reaches the 10 minute mark, and courteously but firmly invited to cease at the 12 minute mark. Time slots for symposia are the same.

Instructions to presenters of speed talks

Time slots for Speed Talks are 5 minutes. Please prepare for 4 minutes, allowing up to 1 minute for changeover. Session Chairs are instructed to ensure that ALL presenters adhere strictly to these times. Speakers will be gently warned when the talk reaches the 3-minute mark, and courteously but firmly invited to cease at the 4-minute mark.

There will be no time for questions in between presentations, but there will be opportunity for questions and discussion at the end of the whole session.

Instructions for poster presenters

Poster presenters are requested to have their posters up for display from 0830 on Monday 3 December through to 1600 on Thursday 6 December. Posters are being displayed according to themes, in numerical order. Posters will be displayed in the exhibition foyer of The Sebel Albert Park Conference Grand Lobby.

Poster presenters are required to be at their poster display during the following times:

- Barbara Rice Memorial Poster Session 1 (Presenters of even number posters to be in attendance, providing them time to discuss and describe their work) on the evening of Monday 3 December (1745–1900).
- Barbara Rice Memorial Poster Session 2 (Presenters of odd number posters to be in attendance, providing them time to discuss and describe their work) on the evening of Tuesday 4 December (1745–1900).

Poster presenters are also encouraged to be close to your poster during morning and afternoon tea breaks, and lunches, to enable anyone who wishes to discuss your particular poster topic to be able to find you and do so! We hope that this will allow you several hours of opportunity and exposure that will give you the widest possible audience.

A listing of posters, in numerical order is on page 244 of this handbook. Staff at the registration desk will be available to help you find the correct location for mounting your poster. Please ensure that you have your own Velcro spots.

Please ensure that you collect your poster at the end of the Conference. Any posters not collected by 6 pm on Thursday 6 December will be discarded.

Instructions for session chairs

Please be available in your allocated room at least 15 minutes before your session starts. Ensure you are acquainted with the AV and general room set up, and that all speakers are also familiar with the equipment that will be used. Inform your speakers of the exact time that each of their talks is to begin and end. All presentations must be uploaded in the Speakers' Preparation Room prior to the commencement of each session.

Please start sessions on time, even if people are still arriving. You are welcome and encouraged to introduce the session, but please keep this brief! Keep track of elapsed time during a presentation. It is your job to ensure that speakers start and finish on time.

For Oral Papers, please give speakers a warning shortly before their time is up (at 10 minutes) and then tell them when their time is up (at 12 minutes). This will allow 3 minutes for questions and changeover. This will give time for the audience to move between rooms after each presentation, if they desire.

For Speed Talks, please give speakers a warning shortly before their time is up (at 3 minutes) and then tell them when their time is up (at 4 minutes). There is no time for questions between speakers, and this will allow 1 minute

for changeover. There will be time for discussion at the end of the speed session in which case you will need to chair the session for specific questions for all speakers, and to facilitate general discussion.

If a speaker shows no indication of stopping at the required time, please ask them to stop immediately, even if their talk is not completed. Ensure that question time does not extend beyond the allocated time, even if there are still outstanding questions. There are opportunities during the breaks for additional questions to be directed to the presenter.

Please remind all delegates that their mobile phones need to be silent, or off.

Please do not start presentations early. If a speaker finishes early, or in the event that a talk is cancelled, please use this time by inviting questions from the previous presentation.

A volunteer will be available to assist you, and will contact the AV technician if required. Alternatively, please contact the registration desk on 0488 576 105.

Remember, you are in charge of your session. The audience will appreciate good chairing, which will keep proceedings on time, and speakers and audience under control.

Speakers' preparation room

The speakers' preparation room will be located in Room M10 (the first room past the exhibition area) and will be open during the following times:

Sunday 2 December	1500–1900
Monday, 3 December	0730–1730
Tuesday, 4 December	0730–1730
Wednesday, 5 December	0730–1730
Thursday, 6 December	0730–1730

All speakers are requested to report to their allocated room 15 minutes prior to the start of the session to meet with the session chair and to check that their presentation has been correctly loaded.

Sponsors

Silver sponsors

ACEAS-TERN

The Terrestrial Ecosystem Research Network (TERN) connects ecosystem scientists and provides critical research infrastructure to foster national multidisciplinary networks capable of acting at the scales needed to improve understanding and management of Australia's ecosystems.

The Australian Centre for Ecological Analysis and Synthesis (ACEAS) functions within TERN to support multidisciplinary integration, synthesis and modelling of ecosystem data by ecosystem scientists and environmental managers for improved ecosystem management outcomes.

E: tern.comms@uq.edu.au
E: aceas.tern@uq.edu.au
W: www.tern.org.au
W: www.aceas.org.au

Bronze sponsor

Murray–Darling Basin Authority

Our objective is to achieve a healthy working Basin through the integrated management of water resources in the long term benefit of the Australian Community.

MDBA manages the Murray River system in close cooperation with state authorities and partners to ensure reliable water supplies for all users. Further, the Authority implements programs in support of a healthy Basin environment, such as the Native Fish Strategy, and The Living Murray river restoration program.

GPO Box 1801
Canberra ACT 2601
02 6279 0572
www.mdba.gov.au

Lanyard and internet hub sponsor

La Trobe University

For over 45 years La Trobe University has been seeking knowledge, challenging convention, and changing the way people think. La Trobe was established in 1964 as Victoria's third university; and we enrolled our first students in 1967. We have campuses in Melbourne, Bendigo, Albury-Wodonga, Mildura and Shepparton.

Melbourne Vic 3086
P: 1300 135 045
W: http://www.latrobe.edu.au/

Capuccino café sponsor

The Centre for Integrative Ecology, Deakin University

The Centre for Integrative Ecology at Deakin University unites the work of ~100 staff, postdocs and PhDs addressing the fundamental question: *how does life react to change*? If you want to be part of this as a collaborator or PhD student, you are welcome to check us and the possibilities out at:
http://www.deakin.edu.au/research/src/cie

Locked Bag 20000
Geelong Vic 3220
03 5227 3115
www.deakin.edu.au

Conference app sponsor

Gaia Resources

GAIA RESOURCES
ENVIRONMENTAL
TECHNOLOGY
CONSULTANTS

Gaia Resources is a consultancy that responsibly delivers sustainable technology solutions to companies that work with the environment. We deliver solutions in field data capture, data management and Geographical Information Systems to our clients across Australia. Find out more about what we do on our web site.

08 9227 7309
www.gaiaresources.com.au

Fieldtrip sponsor

Greening Australia

Greening Australia

For 30 years Greening Australia has been working with business, government, landowners, community groups, land management agencies, schools and individuals to successfully combat loss of habitat through an innovative blend of practical experience, science and community engagement. Greening Australia is rolling out the green carpet and making the planet a better place to live.

Victorian Agri-Biosciences Centre (VABC)
La Trobe R&D Park
Bundoora Vic 3083

P: 03 9450 5300
E: general@gavic.org.au
W: www.greeningaustralia.org.au

Handbook insert

South East Queensland Fire and Biodiversity Consortium

SEQ Fire & Biodiversity
CONSORTIUM

Established in 1998, the South East Queensland Fire and Biodiversity Consortium is a network of land managers and stakeholders devoted to providing a coordinated response and best-practice recommendations for fire management, fire ecology and the conservation of biodiversity in the south-east Queensland region through education, community engagement and applied research.

Postgraduate mixer sponsor

QAECO

Quantitative
& Applied
Ecology
Group

The Quantitative and Applied Ecology (QAECO) group is a diverse bunch of ecologists who work across a wide spectrum of taxa and environments from frogs to flowers and deserts to desktops. As a group, our research foci include environmental decision making, ecosystem management, and conservation biology. We're located in the School of Botany at the University of Melbourne, and form part of two larger research groups: the ARC Centre of Excellence for Environmental Decisions (CEED) and the NERP Environmental Decisions Hub.

W: www.qaeco.com

Exhibitors

Greening Australia

Booth 1

For 30 years Greening Australia has been working with business, government, landowners, community groups, land management agencies, schools and individuals to successfully combat loss of habitat through an innovative blend of practical experience, science and community engagement. Greening Australia is rolling out the green carpet and making the planet a better place to live.

Victorian Agri-Biosciences Centre (VABC)
La Trobe R&D Park
Bundoora Vic 3083

P: 03 9450 5300
E: general@gavic.org.au
W: www.greeningaustralia.org.au

ACEAS-TERN

Booth 2

The Terrestrial Ecosystem Research Network (TERN) connects ecosystem scientists and provides critical research infrastructure to foster national multidisciplinary networks capable of acting at the scales needed to improve understanding and management of Australia's ecosystems.

The Australian Centre for Ecological Analysis and Synthesis (ACEAS) functions within TERN to support multidisciplinary integration, synthesis and modelling of ecosystem data by ecosystem scientists and environmental managers for improved ecosystem management outcomes.

E: tern.comms@uq.edu.au
E: aceas.tern@uq.edu.au

W: www.tern.org.au
W: www.aceas.org.au

Ecological Society of Australia

Booths 3,4

The Ecological Society of Australia Incorporated (ESA) is the peak group of ecologists in Australia, with over 1500 members from all states and territories, We aim to create a community of knowledge and understanding amongst ecologists and reach out to those working in related fields. We invite you to join us in our efforts to promote the scientific study of all organisms in relation to their environment and encourage the application of ecological principles in the development, use and conservation of Australia's natural resources.

Gail Spina
Executive Officer
PO Box 2187
Windsor QLD 4030

P: 07 3162 0901
E: executiveofficer@ecolsoc.org.au
W: www.ecolsoc.org.au

La Trobe University

Booth 5—Internet Cafe

For over 45 years La Trobe University has been seeking knowledge, challenging convention, and changing the way people think. La Trobe was established in 1964 as Victoria's third university; and we enrolled our first students in 1967. We have campuses in Melbourne, Bendigo, Albury-Wodonga, Mildura and Shepparton.

Melbourne Vic 3086
P: 1300 135 045
W: http://www.latrobe.edu.au/

Andrew Isles Natural History Books

Tables 6, 7

We are the leading natural history specialist bookshop in Australia. Established in 1981, we hold a world-class inventory in new, secondhand and rare antiquarian books and wildlife art. Rare natural history books are our specialty and we ship books to anywhere in the world. We have a large range of books on ecology, conservation, biology, statistics, botany, birds, mammals, reptiles, amphibians, fish, invertebrates, marine, entomology, fossils and palaeontology. Our shop in Prahran is open Monday to Friday 9.00 am to 5.30 pm and Saturday 9.00 am to 12.30 pm.

Rear of 115–117 Greville Street
Prahran VIC 3181

P: 03 9510 5750
E: books@Andrewlsles.com
www.Andrewlsles.com

Surrey Beatty and Sons

Table 8

Our companies publish works including our quarterly journal *Pacific Conservation Biology* is to be found in many countries throughout the world, a reflection of the high esteem in which they are held by the scientific community and centres of learning, as a result of which SBS is considered a major participant in the field of natural science publishing.

Surrey Beatty & Sons Pty Ltd
Publishers of Natural Science

P: 02 9602 3888
E: books@surreybeatty.com.au
W: www.surreybeatty.com.au

CSIRO Publishing

Tables 9, 10

CSIRO Publishing operates as an independent science and technology publisher with a global reputation for quality products. Our internationally recognised publishing program covers a wide range of disciplines, including agriculture, the plant and animal sciences and environmental management.

W: http://www.publish.csiro.au/home.htm

Wiley Blackwell

Table 11, 12

Wiley-Blackwell is the world's leading publisher in ecology, with an internationally renowned program of high-quality publications aimed at researchers, students and professionals in the field. Working with over 35 learned society partners, including the Ecological Society of Australia to publish Austral Ecology and Ecological Management and Restoration, we publish over 80 journals in ecology, conservation, evolution and zoology.

W: www.wileyonlinelibrary.com/subject/ecology

Sirtrack Ltd

Table 13

Sirtrack is located in Hawkes Bay, New Zealand. They specialise in the design, manufacture and export of wildlife tracking systems using state of the art transmitter and satellite technologies. The majority of Sirtrack products are produced by their highly trained team of experts in a purpose built production facility in New Zealand.

P: 1800 427 247 (Aus, free call)
P: 0800 SIRTRACK (NZ, free call)
E: sirtrack@sirtrack.com
W: www.sirtrack.com

Abstracts—plenary sessions

Fact, theory or fiction? Understanding long-term changes in woody cover in semi-arid and temperate woodlands

Ian Lunt[1]
[1]Institute for Land, Water and Society, Charles Sturt University

If you work on declining woodland birds, catchment hydrology, fire regimes or agricultural sustainability, woodland dynamics underpin your study system. Vegetation structure creates and regulates fauna habitat, disturbance regimes and ecosystem services, including catchment water and carbon sequestration.

Many semi-arid and temperate woodlands in eastern Australia have experienced major changes in structure since European settlement. Cover and/or density of trees and shrubs has increased in some areas, declined in others, and fluctuated over time in yet others. Many attempts to understand the processes causing these changes have been hampered by poor quantification, or over-simplification, of the patterns themselves. Consequently, considerable uncertainty and debate exists over the degree to which tree and shrub cover has changed (in uncleared areas) over the past 200 years, let alone the causes of changes. This uncertainty has social, economic and political repercussions. For example, purported thickening of trees and shrubs is a dominant narrative in best-selling books about ecological effects of European occupation of Aboriginal Australia. But what do we actually know of these changes? Can we move beyond site-specific case studies and embed documented dynamics in broader theoretical frameworks?

In this talk I attempt to integrate documented examples of woodland dynamics within broader, conceptual models of processes controlling ecosystem structure, and compare and contrast opposing dynamics. In addition to reviewing past dynamics, I ask; how may woodland structure change in the future, given ongoing changes in climate, land use and disturbance regimes? I propose that changing human land use will influence woody cover in many regions, and that climate change will act on ecosystems that are continuing to equilibrate to past changes in human disturbances. Consequently, disentangling climate change impacts from the legacies of past and novel disturbances will remain a formidable challenge.

Stress ecology and why everybody's doing it

Emma L Johnston[1]
[1]University of New South Wales and the Sydney Institute of Marine Science

As the anthropocene marches forward, environmental conditions are being altered on local, regional and global scales. This is blurring the distinction between fundamental and applied ecology as ecologists are increasingly delving into 'stress ecology', asking questions that would not be out of place in an ecotoxicology text book. With examples from my own research in marine systems, I review the basic tenets and approaches of ecotoxicology, and illustrate how they can be used in the study of the ecology of the anthropocene. By combining the two disciplines of ecology and ecotoxicology, my group have identified drivers of invasion success, indirect effects of chemical stress, plasticity of environmental niche space and substantial knowledge gaps. Intertwining the largely disparate fields of ecology and ecotoxicology is an important challenge for the next decade, and there are key lessons to be learnt from a respectful exchange between the disciplines.

The overwhelming importance of habitat size for food webs

Angus R McIntosh[1]
[1]School of Biological Sciences, University of Canterbury, New Zealand

The effects of habitat size on food webs are an under-appreciated contributor to the current biodiversity crisis. Firstly, predators are especially vulnerable to habitat contraction because the availability of space restricts their body size. Because mass-specific energy needs of predators also scale with their body size, a new theory suggests that the predator mass able to be supported per unit of prey resource will also scale with habitat size. In a study of 29 rivers covering three orders of magnitude in habitat size, a unit of habitat in a small ecosystem supported less predator biomass than an equivalent unit in

a large ecosystem. The lower energetic costs of large body size likely mean a unit of prey resource supports more biomass of large-bodied compared to small-bodied predators, so constraining predator size reduces the predator mass that can be supported. Secondly, by constraining predator movement and habitat heterogeneity, habitat contraction is likely to intensify species interactions. Thus, the effects of invasive brown trout on native fish in New Zealand streams were stronger in smaller habitats, and stream habitats being shrunk by drying had top-heavy food webs, predators with smaller trophic niche breadth, and shorter food chains. Intensification of interactions is also likely to lead to reductions in food web stability. Consistent with this, invertebrate communities in smaller streams were less resilient to an experimentally imposed disturbance than those in larger streams. Combined with the increased stochasticity associated with dispersal to smaller habitats, reduced stability likely contributes to the higher variability in stream community structure observed as stream size decreases. Finally, these habitat-size effects are likely to be exacerbated if climate change increases natural habitat disturbance because disturbance interacts with habitat size, so that in disturbed habitats (e.g., streams affected by flooding) predators are small, regardless of habitat size.

Species' range edges and the evolution of dispersal

Ben Phillips[1]
[1]Centre for Tropical Biodiversity and Climate Change, James Cook University

A species' range edge (the vague borderland between where a species is and where it isn't) is an interesting place. Given that all species engage in dispersal, the default expectation for a range edge is for it to move. Sometimes it does (as in an invasive species) but more often it is relatively stable for hundreds if not thousands of years. Why do some range edges remain stable for so long?

There are probably as many proximate reasons for stable range edges as there are stable range edges: species X dehydrates too rapidly to live in the desert; species Y can't survive extremely cold winters; and so on. But the ultimate reason for a stable range edge must be a breakdown in the adaptive process: species X can't *evolve* sufficient desiccation resistance to live in the desert; species Y can't *evolve* tolerance to low temperatures. So why does adaptation stall on stable range edges?

This is a tricky question to which we still do not know the answer. Here I will explain why we don't know the answer, why it matters, and then consider the possible role for the rapid evolution of dispersal in maintaining stable range edges.

Males exist. Does it matter?

Hanna Kokko[1]
[1]Research School of Biology, Australian National University

Much of population dynamic theory is built on the assumption that males do not contribute directly to population growth: they are assumed to provide enough sperm to fertilise all the females, and otherwise behave 'neutrally' (e.g. consume equally much resources as any female). There are, however, many potential routes how males can matter for population growth. Their very existence is the basis of the twofold cost of sex. This cost is twofold only under special circumstances, and can become smaller or larger depending on the role males play in population dynamics. In systems with biparental care (e.g. many birds), the cost is reduced, but sometimes male morphs differ in their consequences for population dynamics. I discuss this in the context of the endangered, polymorphic Gouldian finch. I also review more general cases where selection to outcompete conspecifics can lead to detrimental population-level consequences, including the curious case of the Amazon molly where an unusual type of asexual reproduction creates very unstable population dynamics.

Abstracts—concurrent sessions

Concurrent session 1A
SYMPOSIUM: Ecological fire management

Bird response to the spatial dynamics of small unburnt patches in a post-fire Mallee landscape

Laurence Berry[1], Don Driscoll[1], David Lindenmayer[1]
[1]The Fenner School of Environment and Society, Australian National University

Current fire management paradigms assume that the availability of small unburnt patches of vegetation may facilitate biodiversity preservation in extensively burnt landscapes. However, our current understanding of faunal responses to the size and isolation of post-fire remnants is limited. We tested bird responses to fire mosaic spatial attributes using a replicated natural experiment. Five treatment blocks each consisted of two size classes (1-3ha, 5-7ha) of unburnt patches crossed with two levels of isolation, and with two matrix sites, burnt in both 1987 and 2005 fires, at two levels of isolation. High bird species richness was strongly dependent upon patch size and the distance to the edge of the fire scar. At the species level five major response patterns emerged. All known old-growth favouring species were limited to continuous unburnt habitat. Three species were present only in patch sites and declined in abundance with increasing patch isolation and decreasing area. The distribution patterns of two species suggested a mainland-island metapopulation dynamic. Two species were relatively abundant at both burnt matrix and patch sites but declined with distance from the unburnt edge. Two species novel to the reserve were recorded only in the matrix.

The availability of small unburnt patches will increase biodiversity retention in post-fire landscapes. Future fire management actions should aim to encourage unburnt patch retention, limit the extent to which unburnt patches are isolated from the unburnt edge of the reserve and promote the preservation of large continuous unburnt areas.

Laurence Berry is a PhD scholar at the Fenner School of Environment and Society. His research concerns the mechanisms that underpin faunal persistence in extensively burnt landscapes. He completed a Bachelor of Biological Science at La Trobe University and worked at MDFRC before moving to the ANU.

Faunal refuges in fire-prone landscapes: does prescribed fire moderate wildfire impacts on bird assemblages?

Natasha Robinson[1], Steve Leonard[1], Andrew Bennett[2], Michael Clarke[1]
[1]La Trobe University, [2]Deakin University

Background/question/methods: Following a fire, unburnt patches are thought to act as refuges for birds and other fauna. Such patches are considered critical to faunal survival and persistence, providing resources that are otherwise unavailable in burnt landscapes. Accordingly, ecological fire policies aim to retain unburnt patches within planned burns. Moreover, when challenged by wildfire, recent planned burns are thought to resist burning or to burn at lower severity than surrounding long unburnt vegetation, thereby creating future refuges. However, the value of unburnt, or less severely burnt, patches has rarely been examined. This study aims to determine the relative importance of fire history and severity in predicting persistence of birds in burnt landscapes. Surveys were conducted in the 2009 Black Saturday wildfire-affected landscape of the Victorian Central Highlands within mixed foothill forest and gully vegetation. Sites encompassed fire severity classes ranging from unburnt to crown burnt. Fire history was defined as recently burnt (< 3 years prior to 2009) and long unburnt (> 19 years prior to 2009).

Results/conclusions: Preliminary findings confirm a trend of declining species richness and abundance with increasing fire severity. In addition, compositional differences amongst severity classes show winners and losers. Such results indicate that unburnt, and less severely burnt, habitat is providing important refuge to certain avifauna. However, the magnitude of this effect is dependent on fire history. Further investigation will look into potential tradeoffs between fire history and severity to determine optimum habitat preferences of birds within burnt landscapes.

Natasha Robinson is a PhD student in the Department of Zoology at La Trobe University. She has previously worked for the Department of Sustainability and Environment and Parks Victoria in ecological fire management.

Burning questions: investigating the relationship between fire mosaics and reptile communities in dry sclerophyll forests

Diana Virkki[1], Guy Castley[1], Cuong Tran[2], Tom Lewis[3]
[1]School of Environment, Griffith University, [2]Serco Sodexo Defence Services, [3]Agri-Science Queensland, Department of Agriculture, Fisheries and Forestry

Background/question/methods: Fire regime parameters, mainly frequency and extent, play an important role in shaping landscape fire mosaics. Understanding the influence of fire mosaics on biodiversity is critical as mosaic burning is widely advocated to promote biodiversity, but requires further testing at landscape scales. Therefore, this study aims to compare reptile assemblages in dry sclerophyll forests with differing fire mosaic histories in south-east Queensland to determine how reptiles respond to different fire regime parameters.

Unique spatial fire mosaics were identified at two sites based on: total number of fires (1-8), mean fire interval (0-12 years) and time-since-fire (3-10 years). In addition, a long-term fire experiment at Bauple State Forest was included to capture annually burned, triennially burned, long unburned (65 years) and infrequent wildfire (2006) areas. Reptile surveys were conducted at five plots within each fire history mosaic unit during two sampling periods (Summer 2011-2012 and September 2012). Landscape and vegetation parameters were quantified at all plots.

Results/conclusions: Initial results suggest the best models that describe both reptile abundance and richness in fire mosaic units include: total number of fires; fire interval; and total number of fires + fire interval. Relationships between reptiles and fire parameters across mosaic units did not hold at the experimental site, where very frequent and infrequent fire had little influence on reptile abundance and richness. This potentially contradicts the Intermediate Disturbance Hypothesis but requires further data to assess patterns and mechanisms.

Diana Virkki is two years into her PhD research investigating the responses of small vertebrates to repeated management burns and heterogeneous fire regimes in dry eucalypt forests of SEQ. Prior to this, Diana worked as a research assistant in fire ecology which lead to her research interest.

Experimental planned burns result in the loss of key forest structural elements

Greg Holland[1], Andrew Bennett[1], Anna Flanagan[1], Sarah Kelly[2], Michael Clarke[2]
[1]Deakin University, [2]La Trobe University

Background/question/methods: Fire is commonly used as a management tool in many parts of the world. Typically, the primary objective of planned burns is to reduce the risk of extreme wildfire, although burning to achieve ecological outcomes is becoming increasingly common. Despite this, our understanding of the role of fire in driving ecological processes remains limited. Here we use a series of experimental burns to determine the landscape-scale effects of fire on critical elements of forest structure (logs, stumps) in a dry forest system. Twenty-two 100 ha forest units ('landscapes') were selected for study in a large forest block in central Victoria. Of these, 16 were randomly chosen to receive experimental burns, stratified by burn season (autumn, spring) and burn cover (patchy, extensive). The remaining six study landscapes were left unburnt to serve as reference sites. Numbers of logs and stumps were recorded at multiple monitoring points per landscape before and after fire.

Results/conclusions: Fire resulted in changes to key components of forest structure at a landscape-scale. The number of logs recorded declined post-fire, with scarce large logs (>20 cm diameter) being lost at high rates. There was a positive correlation between the rate of loss of logs and burn extent. Fire also resulted in the loss of stumps. Loss of these structural features has implications for diverse ecological processes, including soil development, moisture retention, and provision of habitat. Such findings are critical for guiding the use of fire as an ecological management tool.

Dr Greg Holland is a Research Fellow with an interest in applied ecological research in human-modified landscapes. This includes studies of pattern and process to enhance biodiversity conservation in the face of landscape change. He is currently investigating the ecological outcomes of planned burns in a depleted and fragmented forest system

Conserving biodiversity in fire-prone landscapes: testing the relationship between species richness and environmental heterogeneity

Fiona Christie[1], Julian Di Stefano[1], Alan York[1], Holly Sitters[1], Matthew Swan[1]
[1]The University of Melbourne

Background/question/methods: Landscape scale approaches to biodiversity management require an understanding of the relationships between flora, fauna and landscape pattern. Current policy around the use of fire to meet conservation objectives has been applied based on the assumption that fire-induced heterogeneity at a variety of temporal and spatial scales will increase biodiversity. However, there is a paucity of empirical data to indicate optimal strategies to maximise conservation benefits. We investigated relationships between environmental heterogeneity and biodiversity in the Otway Ranges, Victoria. We considered environmental heterogeneity (vegetation type and growth stage as a function of time since last fire) as a predictor of biodiversity within thirty-two 100-hectare experimental units (mosaics). We sampled birds and mammals in one season and quantified mosaic heterogeneity using Shannon's diversity index.

Results/conclusions: Although theory suggests that spatio-temporal heterogeneity in landscape patterns may facilitate the persistence of multiple species across the wider landscape, we did not find strong evidence to support this tenet. Environmental heterogeneity was a poor predictor of species richness at the mosaic scale, although in general relationships were positive. At local scales (site) faunal assemblages differed with vegetation categories although generally not with growth stage. This suggests that maintaining a diversity of vegetation categories where possible may meet management objectives for maximising biodiversity of vertebrate taxa (birds and mammals) in fire-prone landscapes.

Fiona Christie has completed a PhD investigating the impact of urbanisation on ecological processes and her interest continues in landscape ecology. Her current position at the University of Melbourne has been focused on understanding the interactions between fire, landscape pattern and biodiversity.

Fauna and fire regimes: effects of the 2009 Victorian bushfires and previous fire histories

Richard Loyn[1], Edward McNabb[1], Josephine MacHunter[1], Matthew Bruce[1]
[1]Arthur Rylah Institute, Department of Sustainability and Environment

Background/question/methods: Fire is a profound agent of disturbance, and fire regimes need to be managed. DSE initiated studies to examine effects of fire regimes and impacts of the 2009 bushfires. Here we present work on effects of the 2009 bushfires in Bunyip State Park, and of previous fire regimes in East Gippsland. In Bunyip SP we examined 68 sites surveyed for nocturnal fauna in the early 2000s: half of them were burnt in 2009. In East Gippsland we surveyed 152 sites (in 22 landscapes 20 km square) with contrasting fire histories from two ecological vegetation divisions (EVDs), and related biodiversity metrics to time since fire and fire frequency, type and patchiness. We assessed vegetation, fuel hazard, birds, bats and other mammals at these sites.

Results/conclusions: Forest birds were reduced to 60% of previous levels on burnt sites in Bunyip SP, based on comparisons with unburnt sites, varying between species and guilds. Some woodland birds entered the burnt forest next spring, including a spectacular influx of thousands of white-browed woodswallows from inland of the Great Divide, which bred for the first recorded time in this forest. Greater gliders and common ringtail possums had declined greatly in the last ten years of drought, and possums were further reduced on burnt sites. In East Gippsland most species were represented across a broad range of fire histories, but some appeared to favour early successional stages after fire and others favoured late successional stages (notably parrots, which nest in large hollows and feed on seeds).

Richard Loyn manages the Community Ecology Section at ARI, conducting applied research to help conserve biodiversity in complex landscapes. He has played a leading role in many aspects of applied ecology related to forests, wetlands, rural landscapes and wildlife conservation.

Concurrent session 1B
Animal behaviour

Home range size and overlap of northern quoll (*Dasyurus hallucatus*) on Koolan Island, Western Australia

Kimberley Christie[1]
[1]Mount Gibson Iron

Background/question/methods: The northern quoll (*Dasyurus hallucatus)* is listed as endangered under the *Environmental Protection and Biodiversity Conservation Act 1999.* Koolan Island hosts an abundant and healthy population of Northern Quolls that require continual management under the island's Northern Quoll Management Plan. In an effort to make improvements to the management of quolls in areas about to be cleared for mining, the home range size and overlap between quolls is determined. This may give an indication as to whether quolls could be relocated to new, undisturbed areas on the island outside their original home range, without excess stress or territorial fighting, rather than having to be kept in captivity and released on the edge of the newly disturbed area as per current regulatory requirements. In order to determine home ranges and overlap, 24 quolls were either fitted with radio-transmitters or tracked repeatedly using the 'spool and line' technique.

Results/conclusions: Based on data from 15 individuals with sufficient fixes, it was found that quolls had small home ranges, with an average of 3.9 ± 1.3 ha. This is much less than mainland populations, most likely due to their smaller body size or less habitat availability being on a small, partly cleared island. All quolls overlapped in home ranges, with an average of 4 other quolls. This high degree of overlap indicates that if sufficient habitat is available and the area is not too densely populated, quolls should tolerate each other within their home range.

Further research is required to determine the effects of relocation on quolls. A relocation study may be effective in ascertaining the stress levels and survival of relocated quolls, degree of conflict or acceptance between new and existing quolls, and the ability of relocated quolls to find sufficient habitat to breed and therefore maintain a self-sustaining population.

Dr Kimberley Christie recently completed her PhD (Zoology) at the University of Western Australia. She is now a research scientist at Mount Gibson Iron's Koolan Island operations studying the threatened Northern Quoll.

Development of a novel tracking technique for platypuses using acoustic telemetry

Josh Griffiths[1], Tom Kelly[1], Andrew Weeks[1]
[1]CESAR

Background/question/methods: Platypuses (*Ornithorhynchus anatinus*) occur in urban environments throughout eastern Australia. Urban waterways are highly modified including construction of dams and weirs, channelisation, habitat degradation, and changes to flow regimes due to increased runoff from surrounding impervious surfaces. Little is known about the response of platypuses to this anthropogenic activity and environmental changes. Tracking platypuses has previously been problematic due to their aquatic lifestyle and high mobility and traditional techniques are extremely time and labour intensive. In addition, large transmitters potentially increase foraging costs and can pose a risk to individuals by becoming entangled in underwater snags. Acoustic telemetry has been widely used in studies of aquatic and marine fish, however this technology has never previously been applied to platypuses. We conducted a pilot study to investigate the effectiveness of acoustic telemetry for tracking platypuses in two different aquatic systems in the greater Melbourne region.

Results/conclusions: Over 10,000 detections of 15 tagged platypuses were recorded from two waterways. The length of tag attachment varied from 1 to 30 days, with tag retention possibly affected by courtship behaviour. Receiver positioning and environmental interference were identified as key limitations of the system. Preliminary data revealed interesting information on platypus movements, behaviour, and habitat use that warrant further investigation. The results demonstrate that acoustic telemetry has great potential for investigating a number of aspects of platypus ecology and behaviour.

Josh Griffiths is a wildlife ecologist with over 10 years experience in small mammal research. For the past 5 years, Josh has specialised in platypus ecology and research in both Tasmania and Victoria.

A continent-wide analysis of the shade requirements of red and western grey kangaroos

Jessica Roberts[1], Graeme Coulson[1], Adam Munn[2], Michael Kearney[1]
[1]Department of Zoology, University of Melbourne, [2]School of Biological Sciences, University of Wollongong

Background/question/methods: Multiple factors affect where species can survive and persist across the landscape. A species' physiology, behaviour, and morphology, combined with the environmental conditions they experience, interact to constrain their activity and affect their energetic and water requirements. Activity constraints (affecting their ability to meet requirements) influence a species' range limits and may provide an index of habitat suitability. Here, we compare the behaviour of western grey and red kangaroos to better understand how differences in morphology and physiology may translate into differences in foraging and shade use. We use these behaviour observations and measured climatic conditions to calculate radiant heat tolerance thresholds, above which kangaroos are restricted to the shade and their activity is constrained. We apply these calculated tolerances to daily climate data across Australia and compare where physiological, morphological, and behavioural differences between species would have the greatest impact.

Results/conclusions: Western grey kangaroos spent significantly more time foraging and had higher predicted metabolic rates, despite performing less energetically costly behaviours than red kangaroos. Western grey kangaroos also spent more time in the shade during the day, moving into and out of the shade at lower radiant temperatures than red kangaroos. Notably, red kangaroos tolerated up to 10°C higher radiant heat loads. Predicted shade requirements of red and western grey kangaroos vary considerably across the continent, with the activity of western grey kangaroos much more constrained in the central and arid regions of the country. These results grant further insight into the potential underlying mechanisms affecting kangaroo distributions.

Jessica Roberts is in the process of completing her PhD, during which she has worked extensively with both biophysical and dynamic energy budget models. She is currently collaborating with researchers from around the world and is interested in pursuing postdoctoral opportunities in Melbourne.

Climate-mediated habitat selection in koalas in a fragmented rural landscape

Mathew Crowther[1], Daniel Lunney[2], John Lemon[2], Eleanor Stalenberg[2], Karen Ross[2], Murray Ellis[2]
[1]University of Sydney, [2]Office of Environment and Heritage

Background/question/methods: Animals must weigh up between quantity and quality of resources when selecting habitat. These decisions become even more difficult when these resources are patchy and differ greatly in quality in space and time. Koalas are a prime subject to study these effects as they have a specialised diet of eucalypt leaves, and a need to balance nutrient and water intake against toxins, all of which can change with soil type and climate. In addition, koalas spend most hours resting, and therefore choose trees for non-feeding purposes such as thermoregulation. We GPS-tracked 51 koalas to determine the shift in tree-selection between day and night, and with daily maximum temperature over 3 years in the patchy rural landscape of the Liverpool Plains, NSW. We recorded the species, patch type, shelter, DBH, height and elevation of each visited tree. We used generalised linear mixed effects models to compare tree use between day and night, and with maximum temperature.

Results/conclusions: Koalas used most trees within their home ranges which tended to be restricted to relatively small patches on farmlands. They also tend to select taller trees with more shelter. They also selected taller trees at lower elevations, with more shelter as the temperature gets warmer. In addition, koalas used more box eucalypts and redgums (feed-trees) during the night, and more *Brachychiton* and *Casuarina* (shelter-trees) during the day. This indicates that koalas need a wide-range of trees for both their day/night requirements, and to provide shelter from heat. Hence, a wide range of trees, across at different elevations, is required to maintain a koala population throughout the year. It also highlights the need for the retention and planting of more trees to increase connectivity across the landscape, and mitigate the effects of climate change on tree-dependant fauna.

Dr Mathew Crowther is a lecturer at the University of Sydney. His research interests cover a wide-range of topics in vertebrate ecology and data analysis. His current research includes the ecological role and identity of the dingo, and how koalas use resources across patch landscapes.

Intraspecific competition for suitable retreat sites in stressful thermal environments by the spider, *Morebilus plagusius*

Francesca van den Berg[1], Mike Thompson[1], Dieter Hochuli[1]
[1]School of Biological Sciences, The University of Sydney

Background/question/methods: Selecting a suitable diurnal retreat site is important for nocturnal ectotherms as it determines the thermal environment experienced during the day. For organisms living in thermally stressful environments, choosing the wrong retreat may increase the probability of exceeding thermal tolerances. Under these conditions, competition of suitable retreats should be high. We investigated how body size affected retreat site competition of flat rock spiders, *Morebilus plagusius. Morebilus plagusius* use exfoliated rocks on sandstone outcrops as diurnal retreats. In summer, the temperatures underneath these rocks often exceed 50°C. We put single spiders into an arena with a choice of two rocks differing in temperature and recorded the rock selected. The following night we introduced a second spider, of either equal or different body size and recorded the rock each spider selected and whether there were any fatalities. We repeated the experiment at three ambient temperatures, 10°C, 20°C and 30°C.

Results/conclusions: We found that 'single spiders' selected warmer rocks at 10 and 20°C but not at 30°C. When we introduced the second spider, body size and the difference in body size affected what kind of interaction occurred. Small spiders often shared rocks with other spiders. If two bigger spiders were paired, the largest spider would out compete the smaller spider. Fatalities often occurred if two adult spiders were paired. Fatalities were more common at 30°C. Our results explain the patterns of rock use in the field and show when the potential of exceeding thermal tolerances is high, spiders will engage in risky intraspecific conflict.

Francesca van den Berg completed her BSc(Adv) (Hons, Class 1) in 2009 at the University of Sydney. She is now doing a PhD at The University of Sydney.

The response of a sleepy lizard social network to altered ecological conditions

Stephanie Godfrey[1], Michael Bull[2]
[1]School of Veterinary and Biomedical Sciences, Murdoch University, [2]School of Biological Sciences, Flinders University

Background/question/methods: The behaviour of individuals is often constrained by temporal or spatial variation in ecological conditions. How do individuals respond to these changing ecological conditions, and what impact does this have on the resultant social organisation? We use a social network approach to ask this question in the pair-living sleepy lizard, *Tiliqua rugosa*. We attached GPS data loggers to lizards to record their movement, activity, and social interactions, during their activity period (Oct – Dec) across three years (2008–2010). The three years varied substantially in ecological conditions; from hot and dry in 2008, to cool and wet in 2010.

Results/conclusions: Lizards spent less time active, and overlapped in home range area more with conspecifics in 2008, than in subsequent years. Despite this variation in behaviour among years, the number and strength of connections among individuals was stable across years. However, the nature of the connections did vary among years. There was a higher incidence of intra-sexual associations and lower incidence of inter-sexual associations in 2008, than 2009 and 2010. Similarly, among male-female dyads, pairing intensity was lower, and extra-pair strength was higher in 2008, than 2009 and 2010. Thus, these results suggest that although the overall social network is tolerant to changes in ecological conditions, the nature of contacts within the network shift in response to ecological conditions.

Stephanie Godfrey is a postdoctoral fellow at Murdoch University whose research interests include behavioural ecology and wildlife disease ecology. A particular research focus is using social network analysis to understand parasite transmission in wildlife populations.

Concurrent session 1C
SYMPOSIUM: Plant adaptations to drought

Vulnerability of trees to drought-induced mortality is defined by a common climatic threshold

Patrick Mitchell[1], Anthony O'Grady[1], Libby Pinkard[1]
[1]CSIRO Ecosystem Sciences and Climate Adaptation Flagship

Increases in drought and temperature stress in forest and shrubland ecosystems are thought to be responsible for the increase in episodic mortality events observed globally. However, key climatic drivers common to mortality events and the impacts of future extreme droughts on tree survival have not been evaluated. Characterising extreme events such as drought are difficult given their unpredictable and sporadic nature and the limited availability of response data through time and space. Here we present an approach that uses standardised probabilities of the common climatic drivers associated with observed mortality events to define thresholds beyond which tree mortality may occur.

Background/question/methods: We used Australia as a case study to evaluate observed thresholds for previously observed mortality events across a range of biomes identified from a survey of published data. Using this approach, we evaluated future likelihood of drought mortality using GCM-derived data and sensitivity analysis on key drought-related parameters

Results/conclusions: The analyses show that observed mortality events occur when water deficits and maximum temperatures are high and exist outside 98% of the observed climatic range; this threshold was evident at all sites regardless of vegetation type and climate. Under a moderate warming scenario, the frequency of droughts capable of inducing mortality across Australia could on average double and the likelihood of extreme droughts coinciding with heat waves increase fourfold. A sensitivity analysis identified that temperature alone had an equal or larger effect than precipitation on both drought intensity and duration. This approach defines the climatic thresholds relevant to the underlying physiological mechanisms of forest mortality and provides a framework that can be readily coupled to models of ecosystem dynamics from the local to global scale.

Patrick Mitchell is researching the relationship between vegetation and water. His work explores the effects of drought, fire and climate variability on water cycling from the leaf to the whole catchment using methods in ecology, ecophysiology, hydrology and climate science.

The role of defoliating pests in drought mortality

Libby Pinkard[1], Audrey Quentin[1], Alieta Eyles[2], Michael Battaglia[1], Patrick Mitchell[1], Anthony O'Grady[1]
[1]CSIRO Ecosystem Sciences, [2]University of Tasmania

Background/question/methods: Trees are frequently subjected to abiotic and biotic stresses. Among these, insect defoliation and low water availability are common causes of crown dieback, mortality and loss of productivity. These stresses often co-occur (Kirshbaum et al). How such multiple stresses interact to amplify or moderate the consequences of drought and affect tree survival has received little attention. The conceptual model of McDowell et al proposes that the primary mechanisms of climate-driven tree mortality are hydraulic failure, experienced under conditions of high intensity drought, and carbon (C) starvation, experienced with longer duration droughts. In the context of McDowell's framework, key issues to resolve for understanding the role of defoliation in drought mortality revolve around whether defoliation alters drought intensity/duration through changes in water use and hence the pathways/mechanisms of drought mortality. Using a series of field and glasshouse experiments performed with *Eucalyptus globulus* we identify key physiological responses to drought, defoliation or their interaction, explore the implications of the physiological findings for the understanding of forest resilience, and propose future research priorities.

Results/conclusions: *E. globulus* responds to defoliation through increasing C uptake rather than depletion of carbohydrate reserves. The photosynthetic response to defoliation is dampened by whole plant sink limitation associated with drought. A range of physiological responses to defoliation under drought conditions suggest that defoliation amplifies drought. While a primary mechanism of drought mortality in *E. globulus* under relatively short-term terminal drought is hydraulic failure, our modelling suggests that drought conditions that still allow trees to maintain a narrow margin of hydraulic safety, combined with repeated defoliation, will increase the importance of C starvation as a mortality mechanism, leading to accelerated self thinning and scatter pattern mortality in *E. globulus* stands. We propose that defoliation will reduce resilience to drought during the period of crown recovery and perhaps beyond, and discuss this in the context of a resilience framework.

Dr Libby Pinkard is an ecophysiologist specialising in responses of trees to pests and abiotic stresses, with expertise in carbon uptake and utilisation and source-sink relationships, that she has applied to questions of forest productivity under current and future climates

Vulnerability of woody vegetation to drought-induced mortality

Brendan Choat[1], Steven Jansen[2]
[1]University of Western Sydney, Hawkesbury Institute for the Environment, [2]University of Ulm, Ulm, Germany

Background/question/methods: Shifts in rainfall patterns and increasing temperatures associated with climate change are likely to cause widespread mortality of forest plants in regions where the duration and severity of droughts increase. One primary cause of drought-induced mortality is hydraulic failure of the plant water transport system. Water stress creates trapped gas emboli in this transport system, which reduces the ability of plants to supply water to leaves for photosynthetic gas exchange and can ultimately result in desiccation and death. However, at present we lack a clear picture of how thresholds to hydraulic failure vary across a broad range of species and forest environments.

Results/conclusions: Using a new data synthesis of woody plants (478 species from 185 sites), we show that the majority of forest species operate with narrow hydraulic safety margins against injurious levels of water stress and therefore face a high risk of mortality if significant declines in rainfall accompany increasing temperatures. Safety margins were largely independent of mean annual precipitation, with many species highly vulnerable to hydraulic failure regardless of their current rainfall environment. These findings provide insight into why climate induced mortality is occurring not only in arid regions but also in mesic forests not normally considered to be at risk.

Brendan Choat obtained his BSc (Hons) in 1997 (JCU) and his PhD in 2003 (JCU). In 2011 he took up a Senior Research Lectureship at the Hawkesbury Institute for the Environment (UWS). He is currently undertaking a Humboldt Fellowship for Experienced Researchers at the University of Ulm in Germany.

Variation in leaf hydraulic vulnerability and leaf venation across a strong aridity gradient in eastern Australia

Chris Blackman[1], Sean Gleason[1], Wade Tozer[1], Yvonne Chang[1], Clair Laws[1], Alicia Cook[1], Mark Westoby[1]
[1]Macquarie University

Background/question/methods: The ability to maintain water flow in leaves under conditions of increasing drought-stress is intimately linked with plant survival and has been shown to shape species' climatic limits. However, the extent to which leaf hydraulic vulnerability ($P50_{leaf}$) represents an important aspect of drought adaptation across strong gradients of aridity remains unknown. We examined variation in leaf hydraulic vulnerability to drought-stress among a total of 50 species occurring within four sites across mid NSW varying in rainfall from 1350 to 200 mm per year. We also investigated how such variation in vulnerability is linked with important differences in leaf venation and xylem anatomy.

Results/conclusions: Leaf hydraulic vulnerability varied strongly across the aridity gradient; mean site $P50_{leaf}$ values ranged from -2.8 ± 0.77 MPa at the high rainfall site to over -6 MPa at the driest site, while species $P50_{leaf}$ values ranged from -1.5 MPa to over -8 MPa (final analysis pending). Significant variation in $P50_{leaf}$ was also found to occur within each of the four sites, highlighting potential trade-offs in plant water-use strategies that help promote species co-existence. Preliminary evidence across species suggests $P50_{leaf}$ is linked with important aspects of leaf venation design and xylem anatomy (final analysis pending). These findings provide fundamental evidence of the adaptive significance of leaf hydraulic vulnerability across rainfall zones and deepen our understanding of the functional role of leaf hydraulic design in drought tolerance.

Dr Chris Blackman was awarded his PhD from the University of Tasmania in 2011. His research examined the links between leaf hydraulics, leaf structure and function, and drought tolerance and recovery. Since his PhD, Dr Blackman has been working in comparative ecology with Professor Mark Westoby.

The adaptive causes of drought resistance via vessel diameter and plant size: stem size, not environment, predicts vessel diameter worldwide

Mark Olson[1], Julieta Rosell[2]
[1]Universidad Nacional Autonoma de Mexico, [2]Macquarie University

Background/question/methods: It is a comparative ecological maxim that plants in dry areas resist drought via narrow xylem vessels. Narrower vessels are supposed to provide greater drought resistance via greater cavitation resistance, leading to the expectation that plants in dry areas should have narrower vessels than those in moist ones. However, considerations of fluid mechanics (Poiseuille's law) lead to the contrasting expectation that xylem vessels should have similar diameters for a given plant size regardless of habitat. We sample across Australia, the Neotropics, Africa, Asia, and Madagascar from most orders of woody plants, to compile data on xylem vessel diameter and stem diameter in plants growing in habitats from desert to rainforest.

Results/conclusions: We show that dryland plants do not have narrower vessels than their counterparts of similar size in moist areas. We give reasons to suspect that natural selection acts on vessel diameter as an inseparable function of conductive path length. It is not, as traditionally depicted, an independent adaptive response to water availability. We show that there no developmental 'constraint' controls the relationship between average vessel diameter and stem size. Instead, scaling patterns between average vessel and stem diameters are almost certainly a product of adaptation.

Mark Olson is a plant evolutionary biologist in the botany department of the Institute of Biology at Mexico's national university. He specialises in the evolution of diversity in woody plant stems and the pro`spects and challenges involved in the study of adaptation.

Concurrent session 1D
SYMPOSIUM: Plant pollination and mate choice

The impact of exotic pollinators on native plant-pollinator networks

Laura Vary[1], Caroline Gross[1]
[1]University of New England

Background/question/methods: Understanding plant-pollinator dynamics can help identify key interactions that maintain plant communities. Pollinator networks quantify the linkages between plant and pollinator species and are an ideal approach for assessing impacts of non-native (exotic) pollinators on native plant communities. Our goal is to determine the consequences of exotic floral visitor introductions to the plant-pollinator network; exotic visitors may have beneficial or negative effects on plants and negative effects on native pollinators. We compared the impact of exotic pollinators in two endangered ecological communities (EECs), the Warkworth Sands Woodland (WSW) and the Howell shrublands. We determined the WSW floral visitor network for three different habitat conditions (intact, degraded, pasture) and the Howell shrublands network for two years over variable seasons.

Results/conclusions: We found yearly variation and the introduction of exotic visitors caused structural changes in the floral visitor networks for both EECs. In WSW, exotic visitors (*Apis mellifera*, *Melangyna viridiceps*) accounted for the majority of interactions in all WSW habitats and had higher visitation in degraded and pasture sites then intact WSW. A suite of native visitors interacted with listed-WSW plant species in intact WSW, but were not present in the other two sites. The Howell shrublands networks showed low dominance by exotic visitors in 2007 compared to 2011 when a new exotic visitor, the emerald furrow bee (*Halictus smaragdulus*) along with *A. mellifera* accounted for the majority of interactions. An investigation of irreplaceability in both EECs reveals that exotic visitors do not fulfil specialised services to critical plant species for the community.

Dr Laura Vary completed her PhD at the University of California, Irvine examining the ecology and evolution of plant breeding systems in the flora of Madagascar. She is now a postdoctoral researcher investigating plant-pollinator dynamics in Australian endangered communities.

Aiming for a blues revival: mimicry in blue *Thelymitra* (Orchidaceae) species

Trevor Edwards[1], Freya Thomas[1], Susan Hoebee[1], Peter Green[1]
[1]The Department of Botany, La Trobe University

Background/question/methods: Sun orchids (*Thelymitra* spp.) produce rewardless, sub-actinomorphic flowers which are dramatically different from most other Diurideae. Although various permutations of autogamy prevail in the genus, the anomalous floral form must have been driven by pollinators and the key to its evolution must lie with outbreeding species. To test the suggestion that *Thelymitra* is a guild mimic of blue-flowered monocot models that co-occur in Victoria, we undertook a comparative study analysing a range of morphological features that should show directional selection towards the putative models. We further explored the possibility that outbreeding blue *Thelymitra* spp. may have been stranded due to the rapid demise of a batesian model during Australia's rapid northern migration. Such a model should approximate the floral form and phenology of outbreeding sun orchids and should have co-occurred across a wide range. The genus *Orthrosanthus* has flowers of similar colour, size, shape and nastic movement to outbreeding blue *Thelymitra*s. In addition, the iris has widely disjunct populations across southern Australia suggesting vicariance; all species of *Orthrosanthus* are mesic, evergreen and shade intolerant; characteristics at odds with aridification.

Results/conclusions: Apart from spectral profiles, neither outbreeding nor autogamous species of *Thelymitra* show morphological traits that convincingly approximate the proposed guild models, with the exception of *O. multiflorus*. We provide data on reproductive success of *Thelymitra* populations in study sites at Anglesea which strongly suggest pollen limitation and we present preliminary findings from pollinator facilitation experiments with *Orthrosanthus*.

Dr Trevor Edwards is a South African expatriate with wide ranging expertise in plant reproductive strategies, conservation, biogeography and evolution of Gondwanan elements of the Australian-African floras. He has published on Lamiaceae, Papilioideae, Gesneriaceae, Acanthaceae and Thymelaeaceae.

Incest or abstinence: reproductive tradeoffs between mate limitation and progeny fitness in a self-incompatible invasive plant

Andrew Young[1], Jennifer Pierson[1], Steve Swain[1]
[1]CSIRO Plant Industry

Background/question/methods: A plant's mating system influences its success in invading new environments. Self-compatible species benefit from reproductive assurance during the early phases of the invasion process when founding populations are small, but can suffer fitness costs associated with high inbreeding. In contrast, self-incompatible (SI) plants can suffer mate limitation in small populations but maintain progeny fitness. SI plants often have complex dominance interactions among S-alleles that increase mate availability by allowing fertilisation between half- and full-sib relatives. Such biparental inbreeding generally has smaller fitness effects than selfing. Here we assessed if promotion of biparental inbreeding through selection for intermediate dominance S-alleles is a viable ecological and evolutionary strategy for the SI weed wild radish (*Raphanus raphanistrum*). We used a two-generation controlled-crossing experiment to generate self, full-sib, half-sib and unrelated individuals and measured their life-time fitness under field conditions. Diallel crosses were conducted to estimate S allele numbers, frequencies of dominance interactions and mate limitation in each population.

Results/conclusions: We found large negative effects of selfing on most fitness parameters e.g. biomass, flowering, seed set. Biparental inbreeding resulted in smaller but significant fitness reductions. Dominance interactions among S alleles significantly increased mate availability by facilitating fertilisation among related individuals. Interestingly, the importance of dominance in augmenting mate availability varied among populations and was positively correlated with the severity of inbreeding depression in selfed progeny. Taken together these data suggest that selection for intermediate dominance alleles may provide a novel evolutionary and ecological strategy for SI plants that maintains population viability during the colonisation process by maximising mating opportunities, and minimising inbreeding depression, while preserving self-incompatibility.

Andrew Young is Director of the Centre for Australian Biodiversity Research (CANBR), a joint conservation research initiative between the CSIRO and SEWPAC. He is a plant population and conservation geneticist.

Robust sampling yields new discoveries and informs pollination and mate choice of Simpson Desert plants

Tony Popic[1], Yvonne Davila[1], Glenda Wardle[1]
[1]Desert Ecology Research Group School of Biological Sciences University of Sydney

Background/question/methods: Concern about reduced pollination services for plant reproduction has stimulated programs monitoring pollinator assemblages and populations, but few studies have ventured into arid habitats. Species interactions are central to ecosystem function, and the successful management of agricultural and natural ecosystems, or threatened species, involves understanding and restoring interactions in ecological communities that promote resilient pollination services. We investigated the pollination ecology of the Simpson Desert sand dune plant community, between June 2010 and July 2011 over a 5000km^2 area. We characterised plant species' mating systems, floral morphology, phenology, and composition of the plant and flower-visitor community over space and time.

Results/conclusions: Of the regional plant species sampled (89 species), 70% received flower-visitors, 10% flowered but received no visitors, whilst the remaining were wind pollinated or failed to flower. Floral morphology was generally open, but one-quarter of species required manipulation by visitors for reward access. Experiments showed that 65% of plant species with flower-visitors can self. Adjacent dune zones (crest/swale, 100m apart) supported floristically distinct assemblages, and sites 70km apart were as similar in floral and visitor composition as sites 1km apart. 327 invertebrate visitor species were sampled, most being hymenoptera, with bees visiting 75% of plant species. Interaction networks constructed with clear spatio-temporal resolution were structurally similar despite turnover in diversity, composition and abundance of species and interactions. As visitors are not equal in their transfer of pollen, floral stage selection, or patterns of flight distance among flowers, variation in pollinator assemblages will affect plant mate availability, and potentially seed production.

Tony Popic is a PhD student studying plant-flower visitor interaction networks in the Simpson Desert with the Desert Ecology Research Group at the University of Sydney.

Quantitative genetics of flower shape in selfing and outcrossing *Arabidopsis lyrata* populations

Philippa Griffin[1], Emmanuel Bonjour[1], Yvonne Willi[1]
[1]Evolutionary Botany Lab, Université de Neuchâtel, Switzerland

Background/question/methods: Flower morphology is predicted to be under strong selection by pollinator preference. Where the need for pollinators disappears under self-fertilisation, this selection should be relaxed. This may lead to evolution of the 'selfing syndrome' traits that are commonly exhibited by selfing taxa—small flowers and little anther-stigma separation (Sicard and Lenhard 2011).

Arabidopsis lyrata is an emerging model system for the evolution of self-compatibility and the evolutionary impacts of selfing. In a large diallel cross design, we compared flowers from 4 outcrossing and 4 independently-evolved, largely selfing *Arabidopsis lyrata* populations. We quantified flower shape using geometric morphometrics, and measured 'selfing syndrome' characters. In parallel, we performed pollinator choice tests to assess the preference of generalist hoverflies. The following questions were addressed:

- What is the dimensionality of flower shape?
- How much genetic variation exists in shape and size within populations?
- Is there a common axis of evolutionary divergence in flower shape between outcrossing and selfing populations, and does the genetic architecture of flower shape pose a constraint to such evolution?
- Do generalist hoverfly pollinators prefer larger flowers?

Results/conclusions: We found that populations did indeed differ significantly in flower shape and size. As predicted, hoverflies mainly preferred large over small flowers. We discuss these results in the light of mating system variation, the direction of observed evolutionary change, and potential constraints in the evolution of flower shape.

Philippa Griffin completed her PhD on phylogenetics and drought tolerance of Australian alpine Poa grasses at the University of Melbourne in 2011. Since then she has been working on Arabidopsis lyrata flower morphology, population genetics and phylogeographic history with Yvonne Willi in Switzerland.

Breeding across environmental gradients and at range limits: a case study in Californian monkeyflowers

Jason Sexton[1]
[1]Bio21 Molecular Science Institute, University of Melbourne

Background/question/methods: Inter-population breeding can critically affect the fitness of offspring in stressful environments and may contribute to the maintenance of species' range limits. In order for plants to respond to rapid environmental shifts across environmental gradients they must be able to draw from a diverse gene pool, but what are the natural patterns of genetic diversity and gene flow across natural systems? To understand background patterns of gene flow across environmental gradients and towards range limits, plant abundance, genetic diversity and contemporary gene flow were examined along three transects spanning the entire warm-to-cold elevational range of the annual plant, *Mimulus laciniatus*, in the California Sierra Nevada Mountains. *M. laciniatus* is a highly selfing plant, but occasional outcrossing can have dramatic effects on fitness.

Results/conclusions: Plant density increased gradually towards both climate limits. Despite this increased density, populations at both climate limits had reduced genetic diversity, suggesting increased drift, selfing, and/or selection at limits. *M. laciniatus* populations experience increased inbreeding towards range limits, especially at their highest elevations where pollinators may be limiting. Populations occupying similar climates were more genetically similar, perhaps owing to elevation-based selection or phenological differences. Warm- and cold-climate limits may stem from limited genetic variation, a result supported by a prior experimental study at the warm edge in this system. Thus, long-distance gene flow events can have major impacts on plant performance and response capacity to rapidly shifting environments. Pollinator and dispersal vector corridors are important across and along environmental gradients to optimise adaptability of plant populations.

Jason Sexton is a US National Science Foundation Postdoctoral Research Fellow hosted at the University of Melbourne. His research focuses on species range limits and the role of gene flow in niche evolution and climate adaptation in plants.

Concurrent session 1E
Changing distribution patterns and range sizes

Flying-fox relocation from the Royal Botanic Garden, Sydney: gone for now, but challenges ahead

John Martin[1]
[1]Royal Botanic Gardens and Domain Trust

Background/question/methods: The relocation of the grey-headed and black flying-foxes (FF) from the Royal Botanic Garden Sydney (RBG) commenced in June 2012 under strict approvals from the New South Wales (NSW) and Commonwealth Governments. At the RBG a peak of 35 000 FF was recorded in May 2007, at the commencement of the relocation 5 000 FF were present. Monitoring associated with the relocation includes population surveys of 14 colonies within the Sydney region, assessing the reproductive success (proportion of females with pups) at up to six colonies and radio and satellite tracking.

Results/conclusions: In response to the industrial noise implemented for up to 45-minutes pre-dawn and up to 30-minutes at sunset the FF ceased roosting at the RBG within the first week. Two months later no roosting has occurred, but 10s to 100s of FF are attempting to roost each morning and pre-dawn noise is required everyday. Radio and satellite telemetry has recorded a relatively small number of movements to colonies within the Sydney region and no roosting in undesirable locations (e.g. residential). The majority of FF have moved well beyond this region, including Eden in southern NSW, Dubbo in Western NSW and Bundaberg in Queensland; over 1000km of the east coast. In the Sydney region the trend is for the FF population to increase through spring and summer. Importantly, with growing numbers of FF across the region it is likely that larger numbers of FF will attempt to roost at the RBG. If roosting re-establishes a second relocation may be necessary.

John Martin works in the field of applied urban ecology using mark-recapture and radio/satellite telemetry, conducting research and implementing management programs on Australian white ibis, sulphur-crested cockatoos and grey-headed and black flying-foxes.

Past is key to future: modelling historical distribution to guide brush-tailed rock-wallaby (*Petrogale penicillata*) reintroduction

Chris Malam[1], David Taggart[1], Tony Corrigan[2], Bertram Ostendorf[1]
[1]School of Earth and Environmental Science, University of Adelaide, [2]Ecodiversity

Background/question/methods: The Victorian brush-tailed rock wallaby (*Petrogale penicillata*) has undergone dramatic and extensive range contraction and population decline since European colonisation, with only 30 animals remaining in the wild. Captive-bred animals were reintroduced into the Grampians National Park in 2008 in a bid to re-establish a wild population; however success has been hampered by a number of factors. Identification of suitable habitat is critical to guide site selection for future *P. penicillata* reintroduction attempts. A presence-only modelling approach was used to predict the potential distribution of *P. penicillata* refuge habitat available within the Grampians National Park and adjacent Black Range State Park based on known historic scat locations. Six environment variables were evaluated: cliff density, rock complexity, lithology, elevation, vegetation, and water availability. Rock complexity was interpreted from satellite imagery, cliff density from 1:50 000 topographic data, and water availability based on surface water flow models.

Results/conclusions: Rock complexity and cliff density yielded the most significant effect on models (50.8% and 39.6%, respectively), with only minor contributions by vegetation (4.6%), elevation (3.2%) and lithology (1.6%). No relationship was observed for water availability. The distribution model identified eight key areas of high suitability presenting strong potential for future rock-wallaby reintroductions within the Grampians National Park.

Chris Malam is a recent graduate of the Bachelor of Science (Honours) program at the University of Adelaide. His topic, use of preserved scat to generate habitat models to help guide ongoing species management and future potential reintroductions of the endangered brush-tailed rock-wallaby to the Grampians National Park.

Revealing the cryptic distribution of wild deer in New South Wales

Dan Lunney[1], Mathew Crowther[2], Anthony English[2], Ian Shannon[1], Elly Stalenberg[1]
[1]Office of Environment and Heritage NSW, [2]University of Sydney

Background/question/methods: Feral deer are a key threatening process under the NSW *Threatened Species Act 1995* and a vector for exotic diseases, particularly FMD. However, hunters and some landholders identify deer as a resource. In 2006, we used a postal questionnaire with a user-friendly map to locate deer, and nine other iconic species, and used the combined distribution patterns to estimate of the likelihood of the occurrence of deer throughout NSW. In 2012, we asked each of the pest species officers, in each area they managed in OEH, to name the local species so that the deer distribution map could be species-specific.

Results/conclusions: Deer are most widespread from just south of Sydney in the Illawarra region, the southern highlands and southern NSW just west of the Great Dividing Range. The likelihood of deer being found in northern NSW and the far west is low. The most widespread species are fallow and red, with sambar, rusa and chital have smaller and disjunct distributions. Our findings represent a marked increase in area of occupied by deer compared to West and Saunders of the Department of Primary Industries (2007), thereby adding weight to their conclusion that 'Wild deer represent an emerging pest animal issue in NSW and Australia'. The distribution of invasive species must be documented if they are to be managed effectively and our findings have shown that community survey combined with local expert knowledge has made a valuable contribution to our grasp of the distribution of these cryptic species.

Dan Lunney is a senior principal research scientist in the Office of Environment and Heritage NSW with a long-term interest in wildlife research and management.

Prioritising investment to prevent sea level rise in the East Asia – Australasia flyway

Samuel Nicol[1], Richard Fuller[2], Tara Martin[1], Iadine Chades[1]
[1]CSIRO Ecosystem Sciences, [2]University of Queensland

Background/question/methods: Sea level rise due to a warming climate will preferentially inundate the low-lying coastal habitats that are critical staging sites for migratory shorebirds using the East Asia-Australasia flyway. Loss of these habitats will have different effects on shorebird populations depending on the structure of the flyway network. Predictions of the extent of habitat that will be lost under different sea level rise scenarios have been computed in a previous study, but we remain uncertain about which sea level rise scenario will eventuate.

Results/conclusions: Our study uses a partially observable Markov decision process (POMDP) to find an adaptive management solution to the problem of where and when to act in the network when the extent of sea level rise is uncertain. We determine which flyway regions are optimal for investment to minimise sea level rise impacts in each year of a 20-year timeframe based on an evolving model of the true extent of sea level rise. We demonstrate results for a number of migratory species using the network. Preliminary results computed using the migratory network for the eastern curlew (*Numenius madagascariensis*) under 0-50cm sea level rise suggest that the key area for investment is Indonesia, with some early investment in the Yellow Sea and Eastern Australia.

Samuel Nicol researches how to make good resource management decisions for conservation using mathematics and operations research techniques. He is currently a postdoctoral researcher at CSIRO Ecosystem Sciences. His current interest is how to conserve migratory species in areas that are subject to climate change.

Managing marine species under climate change: the importance of modelling demographic, spatial and ecological processes

Damien Fordham[1], Barry Brook[1], Camille Mellin[2]
[1]The Environment Institute and School of Earth and Environmental Science, The University of Adelaide, [2]Australian Institute of Marine Science

Recent efforts to improve estimates of range shifts and extinction risk under climate change have focused on integrating metapopulation processes into forecasts of distribution and abundance. We break new ground by linking ecological niche models with population models for two commercially harvested marine molluscs (blacklip abalone, *Haliotis rubra* and greenlip abalone, *H. laevigata*) inhabiting coastal reefs of South Australia. We used physiological experiments and site based demographic data to model the spatiotemporal relationship between sea temperature and abalone survival and fecundity. Harvest rates were estimated from 40 years of fisheries data describing annual catch rates in different management zones. We modelled population density as varying in response to key spatial drivers (e.g., habitat status, harvest pressure) conditioned by climate change. We show that accounting for spatial (as well temporal) variability in life history traits can have a substantial influence on predicted responses to future environmental scenarios. In contrast to previous correlative studies, we show that forecast population growth and expansion of South Australian abalone stocks under climate change is unlikely to occur because of important interactions between biological, seascape and anthropogenic processes. Our results underscore the need to consider biotic processes when assessing the influence of climate change on biodiversity.

Dr Damien Fordham is an ARC Super Science Fellow with interests in ecological modelling, conservation biology and global change biology. More specifically, he has a strong interest in the ecological and evolutionary consequences of human mediated change.

Concurrent session 1F
Ecosystem dynamics

Resilience: the concept and its measurement

Charles Krebs[1], Isla Myers-Smith[2], Sarah Trefry[2], Vanessa Phillips[2]
[1]Institute for Applied Ecology, University of Canberra, [2]Biological Sciences Department, University of Alberta, Canada

Background/question/methods: Resilience has become a popular term in the ecological literature. Despite this wide use, many papers make only passing reference to the term and do not explain what resilience means in the context of their study system or how it might be measured.

Results/conclusions: In an attempt to determine how resilience is being used in ecological studies, we surveyed 183 papers published between 2004 and 2008 that were identified under the topic 'resilience' by ISI Web of Science. Of these, 31% used the word resilience only once or twice (often in the abstract or keyword list), 65% did not define the term and 67% did not provide a citation to the resilience literature. We discuss two case studies of resilience to illustrate how this idea is used in practice, and relate it to classical ecological ideas of equilibrium and non-equilibrium dynamics of communities and ecosystems.

The resilience concept can either continue to be used as a vague panchreston or should be made more rigorous with a quantitative framework of measurement or an experimental protocol for comparing communities or ecosystems. We suggest that ecological science is poorly served by concepts with little or no quantitative precision.

Charles Krebs is Thinker in residence at the Institute for Applied Ecology at the University of Canberra, Emeritus Professor of Zoology at the University of British Columbia, and Honorary Professor in the Institute of Zoology at the Chinese Academy of Sciences, Beijing. He writes textbooks and studies small mammals.

Statistical inference for a multivariate diffusion model of an ecological time series

Melvin Varughese[1]
[1]Department of Statistical Sciences, University of Cape Town

Diffusion processes are powerful instruments for modelling continuous-time phenomena. Not only can these models account for a wide range of stochastic behaviour, but they also enable inference of the dynamics that govern the evolution of a process. As such, these models are suitable for the study of many ecological systems.

Background/question/methods: The dataset investigated is a 7-year, weekly time series recording the surface water temperature as well as the relative densities of the diatom *Pseudonitzschia australis* and the dinoflagellate *Prorocentrum micans*. By estimating the drift and diffusion functions of these processes nonparametrically, an appropriate multivariate diffusion model is developed. Subsequently, a modified MCMC algorithm is used to estimate the model parameters.

Results/conclusions: The diffusion model developed enables one to understand many of the mechanisms that affect the two plankton species. This includes the optimal temperatures for species proliferation as well as the nature of the inter-species and intra-species interactions. By gaining a more thorough understanding of such mechanisms, one can better gauge the impact of human activities on such ecosystems.

Dr Melvin Varughese is a Senior Lecturer in the Department of Statistical Sciences at the University of Cape Town. He has published a number of papers on the stochastic modelling of ecological systems and serves regularly as a reviewer in this area.

Three years of litter fall in a semi-arid mallee woodland: a focus on reproductive structures

Samantha Travers[1], David Eldridge[1]
[1]School of Biological, Earth and Environmental Sciences, UNSW

Background/question/methods: Rainfall is a major driver of productivity and diversity in arid systems. The response of dominant species to extreme abiotic conditions is a major driver of ecosystem function. Here we examine the extent to which woody plants respond to years of above-average rainfall. We consider the effects of landform, rainfall and a range of meteorological conditions on the mass of reproductive structures produced by two shrub species (*Senna artemisioides*, *Acacia burkittii*) and one tree (*Eucalyptus gracilis*) in a eucalypt mallee woodland in semi-arid eastern Australia. Multi-model inference and structural equation modelling were used on data collected over three years (2009-2011) to examine the relative effects of landform and climatic variables on the mass of reproductive structures of the three species collected in litter traps.

Results/conclusions: Multi-model inference indicated that rainfall frequency was the most important factor for all three species. The importance of other meteorological conditions varied markedly between species. Structural equation modelling supported these results, with strong and significant path coefficients, ranging from 0.34 to 0.46, for rainfall frequency in the past 12 months. Overall, our structural equation models explained 23%, 21% and 23% of the variance in the mass of reproductive structures for *Senna, Acacia* and *Eucalyptus*, respectively. Our analyses demonstrates the strong, direct and positive effects of rainfall frequency, highlighting the importance of the number of rainfall events rather than rainfall event size or environmental variables (temperature, wind, evaporation), in driving the production of reproductive tissue in woody plants in semi-arid environments.

Samantha Travers is undertaking research aimed at exploring how arid and semi-arid ecosystems function, specifically, relationships between soil processes and plants and animals, with an emphasis on the semi-arid woodland.

Carbon sequestration of environmental plantings on degraded agricultural lands

Shaun Cunningham[1], Timothy Cavagnaro[1], Keryn Paul[2], Ralph Mac Nally[1], Patrick Baker[1], Jason Beringer[1], Mark Eigenramm[3], Leon Metzeling[4], Ross Thompson[1]
[1]Australian Centre for Biodiversity, Monash University, [2]CSIRO Ecosystems Sciences, [3]Economics Branch, Victorian Department of Sustainability and Environment, [4]Monitoring and Assessment Unit, EPA Victoria

Background/question/methods: Afforestation is promoted as an effective way to sequester carbon and emerging carbon trading schemes provide economic incentives for widespread planting of degraded landscapes. Mixed-species plantings established in recent decades to mitigate environmental problems have the unique potential to sequester carbon whilst restoring biodiversity. Here, we quantified if establishment of environmental plantings on pastures led to substantial increases in aboveground and belowground carbon storage.

A representative chronosequence (5 to 45 years old) of 36 mixed-species plantings was surveyed in northern Victoria. Paired planting-pasture measurements were taken to determine changes in carbon with afforestation and to account for site differences. Carbon content was estimated for the trees, shrubs, ground layer, litter and soils down to 30 cm, soil N was measured, and various environmental and establishment variables were collected for each site.

Results/conclusions: Substantial increases in aboveground carbon were found three decades after planting, with 100 tC ha^{-1} in the trees and 5 tC ha^{-1} in the litter. Changes in soil carbon were minor over the same period, with substantial increases in carbon content found only in the surface 10 cm. The C:N ratio of surface soils increased with time since planting suggesting that soil carbon may be becoming more stable under tree plantings than pastures. After three decades, these plantings are not mature and, therefore, have further potential to accumulate aboveground carbon and for this carbon via litter to be incorporated as soil carbon. Mixed-species plantings provide an important opportunity to sequester substantial amounts of carbon whilst restoring degraded landscapes.

Shaun Cunningham is a forest ecologist with expertise ranging from ecophysiology to landscape ecology. His interests include restoring vegetation and ecological processes in degraded landscapes, mapping vegetation condition and physiological explanations for plant distribution.

Using diverse tree plantings to restore multiple ecosystem functions in carbon projects

Kristin B Hulvey[1], Richard J Hobbs[1], Michael P Perring[1], Rachel J Standish[1], Lori Lach[1], Rebecca Parsons[1], Tim K Morald[1]
[1]University of Western Australia

Background/question/methods: The restoration of ecosystem functions and services is increasingly a management priority. Throughout Australia, groups are interested in planting trees not just to restore woodlands, but also to sequester carbon. Monoculture plantings are common, however, diverse tree plantings may provide additional benefits including higher levels of carbon sequestration and other valued ecosystem functions and services. Through a field experiment in Western Australia, we explore how native tree diversity simultaneously affects three functions including: carbon sequestration, invasion resistance, and nutrient cycling. We selected species based on resource acquisition-traits (root structure and microbial associations), and in 2010 planted treatments that increased in functional-group richness. In 2011, we measured a carbon sequestration-index (summed tree height), weed invasion (weed cover), and soil nutrient availability (nitrate, ammonium, and phosphate). We used these data to determine if increased functional diversity maximised all three target ecosystem functions simultaneously.

Results/conclusions: After one year, carbon sequestration was highest in stands containing the single functional-group of deep-rooted trees. Total weed invasion was equal across treatments, although the cover of capeweed (*Arctotheca calendula)*, a high-priority pasture weed, was greatest in low-diversity treatments. Nutrient availability was equal among treatments. Our results indicate that at this early stage, the functions of carbon sequestration and invasion resistance could not be maximised simultaneously. In particular, the low-diversity treatment maximised carbon sequestration, while minimising invasion resistance to capeweed. Such functional tradeoffs, if they persist, may influence planting composition in carbon-sequestration projects with planting composition tailored to maximise the provision of target functions.

Kristin Hulvey is a member of the Ecosystem Restoration and Intervention Ecology (ERIE) Research Group at The University of Western Australia. Her current work focuses on restoring multiple ecosystem functions and services in Western Australian farmland/woodland systems through diverse native tree plantings.

Litter fuel in Australian forests: effects of climate across forest types in a changing world

Penny Watson[1], Paul Thomas[1], Ross Bradstock[1], Trent Penman[1], Owen Price[1]
[1]Centre for Environmental Risk Management of Bushfires, University of Wollongong

Background/question/methods: Litter on the forest floor provides both fuel for bushfires and habitat for fauna. Litterfall, decomposition, resultant accumulation rates and steady state loads vary considerably across forest types and locations. We assembled data from a wide range of studies and related it to current climate parameters to develop models of the effect of temperature and moisture on mean annual litterfall, decomposition rate, and steady state litter load. We asked whether forest type would affect these relationships, and whether implied trends in future fuel loads were consistent with the commonly postulated hypothesis of increased fire activity under a changing climate.

Results/conclusions: We found strong relationships between climate and all three litter parameters. In all cases, forest type was a significant factor in the best fit models. While both litterfall and decomposition tended to increase with rainfall and temperature, these trends varied among vegetation types, and by location along rainfall and temperature gradients. Thus the relationship of steady state fuel load to climate is complex, and likely to vary across space. Nevertheless, preliminary analysis suggests that under a warmer and drier climate, reduced fuel loads may be expected in many places, partially mitigating expected increases in fire behaviour due to worsening fire weather. However the strong effect of precipitation in all the preferred models suggests different outcomes for litter fuels depending on the direction of change in future rainfall. Spatially-explicit exploration of trends under a range of future climate scenarios is warranted.

Penny Watson has studied effects of fire frequency and post-fire age on plant diversity in forests and woodlands in NSW and Queensland. Since 2008 she has been researching the influence of vegetation type, and climate, on fuel development and vegetation structure in forest types across NSW.

Concurrent session 2A
SYMPOSIUM: Ecological fire management

Fire severity effects on invertebrate detritivores and their functional importance in leaf litter breakdown

Sebastian Buckingham[1], Nick Murphy[1], Heloise Gibb[1]
[1]La Trobe University

Background/question/methods: Globally, over 90 per cent of energy flow in forests passes through dead organic matter principally in the form of leaf litter. Leaf litter provides important resources for microbes, invertebrate detritivores and other fauna. Low severity planned burns have been widely promoted in Australia as a means of reducing fuel loads such as leaf litter. However, the effect of fire severity on leaf litter breakdown and the biota involved in this process is poorly understood. We used a field litter bag experiment to test the effects of fire severity and macroinvertebrates on litter breakdown. Invertebrates were excluded from half our litterbags using insecticide. We examined three fire severities: long unburnt, ground burnt and crown burnt within damp forest gully vegetation in the Central Victorian Highlands, which was affected by the 2009 Black Saturday wildfire.

Results/conclusions: On average, macroinvertebrates were responsible for 29% of litter loss. An interaction between fire severity and presence of invertebrates showed that invertebrates contributed more to decomposition under higher severities. Total decomposition did not differ markedly between fire severities. The composition of macroinvertebrate detritivores also depended on fire severity, with landhoppers (Amphipoda) most common in long unburnt and ground burnt sites and moth (Lepidoptera) larvae most common after high severity fires. Macroinvertebrates are thus particularly important drivers of litter breakdown after high severity fires, potentially reducing the build up of fuel and future fires. High severity fires are predicted to become more prevalent under climate change, so the role of invertebrate detritivores may become increasingly important.

Sebastian Buckingham is interested in the ecology and population dynamics of poorly dispersing invertebrates and their ability to respond to fire disturbance; using field and molecular techniques. He is working within the Fire Ecology Group, in partnership with the Department of the Sustainability and Environment.

Fire severity, history or landscape context: optimal attributes of refuges for mammal recovery post wildfire

Evelyn K Chia[1], Michelle Bassett[1], Steve Leonard[2], Euan G Ritchie[1], Michael F Clarke[2], Andrew F Bennett[1]
[1]Deakin University, [2]La Trobe University

Background/question/methods: Large wildfires are a fundamental driver of ecosystem structure and function across much of the globe. Planned mosaic burning is often recommended as a measure to ameliorate negative impacts of large fires on biota. However, the interacting effects of large fires, planned burning and landscape heterogeneity on fauna are poorly known. This study was based in the foothill forests of the Kilmore-Murrindindi region of Victoria, Australia, 1.5-4 years after the extensive Black Saturday fires that occurred in February 2009. We examined the effects of a large fire on mammal recovery by employing a landscape-scale, retrospective, and space-for-time approach. We asked, what is the relative influence of wildfire severity, pre-wildfire burning history and landscape context on the distribution and abundance of arboreal mammals. First, we conducted a stratified spotlight survey to examine the influence of fire severity, history, and topography on arboreal mammal abundance. Following this, we conducted a targeted survey to investigate how isolation from unburnt refuges influences arboreal mammal occurrence.

Results/conclusions: Six species were recorded, all in low abundance. Fire severity was the strongest driver of total arboreal mammal abundance: there was a higher abundance in unburnt compared to severely burnt sites, while ground-burnt sites did not differ from either. There was little influence of fire history on abundance. More arboreal mammals were recorded in gullies compared to slopes. Landscape attributes that provide refuge value for mammals within the wildfire boundary will be identified and can be applied in fire management to enhance ecological outcomes and biodiversity conservation in this fire-prone region.

Evelyn Chia is a PhD student at Deakin University researching the relative influence of large fires and landscape heterogeneity on the ecology of native and exotic mammals. This study is located in the foothill forests of the Kilmore-Murrindindi region after the Black Saturday fires, and is part of the Fire and Habitat Refuge Project.

Measuring outcomes for fire management: how well do surrogates represent biodiversity?

Sarah C Avitabile[1], Andrew F Bennett[2], Michael F Clarke[1]
[1]Department of Zoology, La Trobe University, [2]School of Life and Environmental Sciences, Deakin University

Background/question/methods: Fire is a natural process, responsible for shaping many ecosystems worldwide. Fire management within parks and reserves requires both suppression and prescribed burning to achieve fire protection and ecological objectives. We reviewed fire management plans from parks worldwide to identify their ecological objectives for fauna and how they proposed to evaluate the impact of fire management actions. Overall, these plans lacked specific, measurable ecological objectives—some stated that threatened species or focal groups, based on vital attributes, were to be monitored to examine the effect of fire management. These species or groups were proposed as surrogates for the effect of fire on other fauna or biodiversity. Here, we examine the efficacy of using surrogate species as indicators of the effect of fire on other faunal groups using data from a landscape-scale multi-taxa study of fire regimes in the Murray Mallee region, south-eastern Australia. Our aim was to examine how well measures of surrogates correlated with the diversity of other groups of animals or plants.

Results/conclusions: No adequate surrogates were found. There was little correlation between threatened species occurrence and any measure of species richness or diversity, and no significant correlations in the patterns of species richness between groups in the fire-induced mosaics. These findings indicate that multiple taxonomic groups need to be monitored to adequately assess the effect of fire on fauna, rather than relying on any simple surrogate measure. Such monitoring should be targeted to provide feedback on clearly stated, unambiguous and measurable ecological objectives.

Sarah Avitabile's PhD research was part of the Mallee Fire and Biodiversity Project and looked at the effect of fire regimes on invertebrates in the mallee. She is currently Project Coordinator for Mallee Hawkeye, studying the effects of fire on biodiversity in the mallee.

Inter-fire interval estimates: what insights do they provide for fire management?

Angie Haslem[1], Michael F Clarke[1], Andrew F Bennett[2]
[1]Department of Zoology, La Trobe University, [2]School of Life and Environmental Science, Deakin University

Background/question/methods: Guidelines concerning the length of time between fires (e.g. tolerable fire intervals) are common in Australian fire management. With the objective of maintaining biodiversity, minimum and maximum fire intervals are identified based on the life-history traits of key plant species. However, it is often difficult to obtain information on the number of years between recurrent fires, due to incomplete fire-history records and reduced temporal coverage of remotely-sensed imagery. Thus, the capacity to empirically assess the potential outcomes of such prescriptions is limited. We have developed quantitative predictive models of time-since-fire and inter-fire interval that provide novel insights in our semi-arid study region, the Murray Mallee. Non-linear mixed models were used to examine the effect of these fire-history attributes on two important habitat elements for fauna: *Triodia scariosa* (a perennial hummock-grass) and tree hollows.

Results/conclusions: Time-since-fire was the dominant influence on *T. scariosa*; inter-fire interval had less effect but was of some importance in early post-fire years. Live hollow-bearing stems were affected only by time-since-fire, whereas inter-fire interval influenced the occurrence of hollows in dead stems. Dead stems were more likely to contain hollows as inter-fire intervals increased. Results have differing implications for fire management. While current tolerable fire intervals are not expected to negatively affect *T. scariosa*, some maximum intervals are likely to limit ongoing hollow availability. Inter-fire interval estimates enhance understanding of how species/resources may respond to management based on tolerable fire intervals. These results emphasise the importance of accounting for slow developing resources when identifying tolerable fire intervals.

Angie Haslem's research in the field of fire ecology focuses on understanding how temporal aspects of fire regimes (time-since-fire, inter-fire interval) affect habitat attributes for fauna and sources of fuel.

Concurrent session 2B
Animal behaviour

Behavioural and ecological maintenance of a circular overlapping species complex: assortative mating in *Platycercus elegans*

Andy TD Bennett[1,2], Mathew L Berg[1], Raoul FH Ribot[1], Leo Joseph[3], Katherine L Buchanan[1]
[1]Centre for Integrative Ecology, Deakin University, [2]School of Earth and Environmental Sciences, University of Adelaide, [3]CSIRO Ecosystem Sciences

Background/question/methods: Assortative mating often plays a key role in speciation by promoting premating reproductive isolation through direct mate choice. Rare cases of ring species, or circular overlaps, offer an excellent opportunity to study speciation, because they can reveal how clinal variation across interbreeding populations may lead to reproductive isolation. In an 8 year study across south eastern Australia we measured phenotypic traits (including plumage coloration, and acoustic traits) among multiple populations, but particularly focusing on breeding pairs in two intermediate, clinally-varying populations to evaluate the contribution of assortative mating to population divergence. Highly variable yellow-red plumage, based on psittacofulvin pigments unique to parrots, has hitherto been the only trait used to define populations.

Results/conclusions: Surprisingly, we found no assortative mating for these pigmentary colours. We found that pigmentation was strongly associated with climate, and was discordant with microsatellite variation, indicating a key role for selection in maintaining diversity. By contrast, the ultraviolet-blue coloration based on feather nanostructure, showed assortative mating in both locations. UV-blue also varied geographically, but this variation was distinct from pigmentary coloration. Our results also suggest that structural coloration provides more significant sexual signals than pigmentary coloration in this parrot, and perhaps in parrots in general. Overall, our long term study reveals how climate, population history, natural selection and sexual selection interact to maintain diversity in this highly variable species, despite the presence of gene flow throughout the 'ring'.

Biography not available at time of printing.

Procreation or mastication: the behaviour of male grey-headed flying-foxes

Sophie Golding[1], John Martin[2], Justin Welbergen[3]
[1]University of Sydney, [2]Royal Botanic Gardens and Domain Trust, [3]James Cook University

Background/question/methods: Many polygynous species exhibit sex-specific variations in body condition. This variation is often studied in the context of an individual's reproductive efforts and contribution to reproductive success. For the male grey-headed flying-fox (*Pteropus poliocephalus*) seasonal variations in body condition have been observed with up to one quarter of their body mass lost during the breeding season. Territory quality is predicted to determine the reproductive success in male *P. poliocephalus*. The behaviour of territory defence is energetically costly due to foregone foraging and intraspecific competition. Males in better condition should return to their territories earlier as they can better afford these costs. However, it is not known if arrival time to their roost can be explained by male body condition. We investigated the timing of male *P. poliocephalus* returning to their day roost at the Royal Botanic Garden Sydney after nightly foraging over 18 months (December 2010 to May 2012). We predicted that variation in the return times could be explained by male body condition. We determine if on a given day, adult males in better body condition were more likely to return earlier to the colony.

Results/conclusions: Over the 18 months we observed males return to roost earlier than females and juveniles, significantly so during the breeding season (March-May). Our preliminary results suggest that males in better condition returned earlier to mating territories during the breeding season. This reflects that males in better body condition are more able to afford the substantial costs of maintaining their territories and so increase their opportunities for mating.

Sophie Golding's background is in ecology and social development. She has a broad interest in urban ecology and how conflicts between humans and wildlife can be managed. Her current work looks at behavioural ecology and how this can be applied in the conservation and management of threatened species.

New approaches to managing invasive species: agent-based modelling of foraging behaviour under environmental change

Matthew Malishev[1], Mark Burgman[1], Michael Kearney[2]
[1]School of Botany, University of Melbourne, [2]Department of Zoology, University of Melbourne

Background/questions/methods: The aim of my research is to find new, cost-effective options to manage invasive species. Understanding how animals make foraging decisions under varying food and weather may help us to better predict invasive animal movement throughout the environment. Animals search for multiple nutrients (e.g. protein, carbohydrate) and water to survive. Because of different environmental microclimates, they make complex movement decisions. I will apply new tools from a recently developed biophysical and microclimate modelling engine that uses the principles of energy and mass exchange (biophysical ecology) and realistic microclimates to model how animals find and use food and water. I will then build an agent-based model driven by this engine to create a bottom-up approach that translates movement patterns from the individual to the larger and more complex population level.

Results/conclusions: Agent-based simulations will be validated against empirical tests of foraging and movement behaviour under different environmental conditions of a prominent invasive species—the Australian plague locust—to ultimately develop a realistic energy budget model. This model seeks to understand movement decisions invasive animals make under a changing environment, addressing one of the biggest environmental challenges of the 21st century: conserving our natural environment by controlling the spread of invasive species.

Matthew Malishev enjoys thinking about how things in nature work and why they operate as they do. Foraging behaviour and predator decision making interests him, where he has worked on the biomechanics of herbivory and currently in nutritional ecology and how animals find resources in a varying environment.

Behavioural response of native prey to disparate predators: naivete and predator recognition

Jennifer Anson[1], Chris Dickman[1]
[1]University of Sydney

Background: It is widely accepted that predator recognition and avoidance are important behaviours in allowing prey to mitigate the impacts of their predators. However, while prey species generally develop anti-predator behaviours through co-evolution with predators, they sometimes show accelerated adoption of these behaviours under strong selection pressure from novel species.

Question/methods: We used a field manipulation experiment to gauge the ability of the common ringtail possum (*Pseudocheirus peregrinus*) to recognise and respond to olfactory cues of different predator archetypes. We predicted that ringtails would display stronger anti-predator behaviours to cues of the invasive European red fox (*Vulpes vulpes*) in areas where fox impacts had been greatest, and to cues of the native lace monitor (*Varanus varius*) in areas of sympatry compared with allopatry

Results/conclusions: We found that ringtails fled quickly and were more alert when exposed to the faecal odours of both predators compared to neutral and pungent control odours, confirming that predator odours are recognised and avoided. However, these aversive responses were similar irrespective of predator presence or level of impact. These results suggest that selection pressure from the fox has been sufficient for ringtails to develop anti-predator behaviours over the few generations since foxes have become established. In contrast, we speculate that aversive responses by ringtails to the lace monitor in areas where this predator is absent reflect recent co-existence of the two species.

Jennifer Anson's research involves examining the effects of disturbance processes on arboreal vertebrates, including direct and indirect responses to logging and invasive species and predator-prey interactions.

Individual foraging strategies of inshore little penguins and their response to changes in sea-surface temperature

Andre Chiaradia[1], Claire Saraux[2]
[1]Research Department, Phillip Island Nature Parks, [2]Centre National de la Recherche Scientifique, France

Background/question/methods: Compared with offshore seabirds, the foraging strategies of inshore bi-parental care seabirds are thought to be simpler. They breed close to their food source, both parents provide equally to their chicks while making daily foraging trips. In this simple foraging model, any increase in foraging trip duration would be triggered by external environmental factors. Sea surface temperature (SST), for instance, has been well documented to have a 4-6 month lag effect on breeding parameters of little penguins *Eudyptula minor*. Here, we present an 8-year study on the foraging strategies of little penguins, a constrained inshore central place forager with one the shortest foraging zone among seabirds.

Results/conclusions: Our results, derived from chick survival and fine scale colony attendance revealed some over-achiever individuals making more foraging trips than their partners. This situation actually represented the norm (75%), rather than the expected equal parenting, persisting over several years. Individuals also alternated between two consecutive long foraging trips and several shorter-ones when rearing chicks, a strategy rarely observed for inshore seabirds. Short trips provided food to chicks, whereas longer trips were triggered by the adult need to replenish its own energy reserves. Further, weekly chick growth and survival were negatively affected by weekly SST. Little penguins do use dual foraging strategies, displaying individual differences that may reflect in an inherent individual quality. It is vital to understand individual variations before making connections with environmental changes, since individuals seem to respond differently to the same environmental pressures.

Andre Chiaradia is a seabird ecologist with a research field on prey-predator relationships and interactions with their marine ecosystem. This is a multidisciplinary research in how a top marine predator responds to natural changes in the marine system and ways to predict their response to ecosystem changes

Concurrent session 2C
SYMPOSIUM: Plant adaptations to drought

Plastic and adaptive responses of NSW waratah populations to future climatic scenarios

Guomin Huang[1], David Tissue[1], Paul Rymer[1]
[1]Hawkesbury Institute for the Environment, University of Western Sydney

Background/question/methods: Predicted climate scenarios are expected to have substantial impacts on plants; however, the relative importance of phenotypic plasticity and genetic adaptation in promoting plant persistence in changing environments remains unknown. We employed ecological and physiological approaches to evaluate the capacity of genetically differentiated coastal and upland populations of the NSW waratah (*Telopea speciosissima*, Proteaceae) to respond to future climate conditions. By determining the main and interactive effects of atmospheric [CO_2], growth temperature and water availability on plant growth, photosynthesis, water relations, and resilience to stress, we aim to identify different ecological strategies that are optimal for NSW waratahs under future climatic scenarios.

Results/conclusions: Our results indicate that: (1) Coastal populations grow faster than uplands across all the treatments; there is no effect of elevated CO_2 on plant growth but elevated temperature increases growth in coastal populations; (2) No photosynthetic rate difference between populations has been detected; elevated CO_2 substantially promotes photosynthesis while elevated temperature has no impact; (3) Upland populations are more resilient to sustained drought and recover faster after re-watering than coastal populations; elevated temperature significantly accelerates the effect of drought.

Our findings support the prediction of two alternate life-history strategies in NSW waratahs. While upland genotypes are slower growing, they are more resilient to drought stress, which may be facilitated by allocating greater resources to below ground storage organs. Coastal genotypes may be able to take advantage of elevated CO_2 and temperatures to increase growth; however, they are susceptible to extreme climatic events such as drought.

Guomin Huang is a PhD candidate at Hawkesbury Institute for the Environment, UWS, focusing on the adaptive and plastic responses of different plant functional groups to predicted climate scenarios. Guomin has a BSc majoring in Biology from Nanjing University and undertook a Master's project in South China Botanical Garden focusing on plant ecology.

Separating fact from artefact in drought experiments using a process-based model

Remko Duursma[1], Jeff Kelly[2], Honglang Duan[1], David Tissue[1], Belinda Medlyn[2]
[1]Hawkesbury Institute for the Environment, University of Western Sydney, [2]Macquarie University

Background/question/methods: As drought periods are becoming more frequent, it is important to improve our understanding of how other climate change variables (increasing temperature (T) and [CO_2]) modify the response of plant carbon uptake and water use to soil water limitation. To date, experiments that study the interaction between T or CO_2 with soil water availability have yielded highly variable results, making it difficult to synthesise experimental data to inform global vegetation models. We argue that it is crucial to separate informative aspects of drought experiments from artefacts and feedbacks unique to each experiment. In particular, plant leaf area often increases in elevated [CO_2], and transpiration rate typically increases in elevated T treatments (due to increased vapour pressure deficit, VPD). Both these effects increase plant water use during a dry-down cycle, obscuring the possible effects of [CO_2] and T on the sensitivity to drought.

Results/conclusions: We present an approach to remove artefacts and feedbacks in experimental results using a process-based model. The approach allows us to focus on the direct effects of CO_2 and T on the plant response to soil drying. First, the model is parameterised to reproduce the actual measurements (of transpiration and photosynthesis during the dry-down). Then, artefacts and feedbacks are removed in the model simulations, to predict the [CO_2] and T effects in the absence of artefacts or leaf area feedbacks. We show for three examples that direct effects of CO_2 and T can easily be overshadowed by changes in leaf area or VPD between treatments. The method we present promises to yield a more consistent synthesis of experimental results.

Remko Duursma's research focuses on modelling vegetation function, including developing new models and testing these to climate change experiments. He is a research lecturer at the Hawkesbury Institute for the Environment, at the University of Western Sydney.

Elevated [CO_2] and warming effects on eucalypt response to drought

Honglang Duan[1], Remko Duursma[1], Anthony O'Grady[2], Brendan Choat[1], Jeffrey Amthor[3], David Tissue[1]
[1]Hawkesbury Institute for the Environment, University of Western Sydney, [2]CSIRO Ecosystem Science, [3]Faculty of Agriculture, Food and Natural Resources, University of Sydney

Background/question/methods: Elevated [CO_2] and temperature may alter the responses of tree seedling growth, photosynthesis, respiration, and whole-plant carbohydrate status when exposed to droughts. Few studies have addressed these important climate interactions or their consequences. We developed a simple model of plant carbon balance and then compared the simulation to independent experimental data in *Eucalyptus globulus* seedlings grown in two [CO_2] (400 and 640 ppm) and two temperature (28/17°C and 32/21°C) (day/night) treatments in a sun-lit glasshouse exposed to well-watered and drought conditions. In particular, we assessed the impact of elevated [CO_2] and temperature on the sensitivity of *Eucalyptus globulus* seedlings to extended drought.

Results/conclusions: Model projections included negative effects of sustained drought on growth, photosynthesis and respiration, along with an initial increase and then depletion in nonstructural carbohydrate (TNC) concentration. In contrast to the model, whole-plant TNC concentration did not decline substantially, although leaf starch was consumed during drought. Under drought, elevated [CO_2] initially increased growth, photosynthesis, and respiration while high temperature reduced photosynthesis. Impacts of elevated [CO_2] and temperature disappeared as drought was intensified indicating drought was the primary stressor in this study. Elevated [CO_2] resulted in higher whole-plant TNC reserve, but it did not significantly alter the carbon balance during a sustained drought. These results indicate that elevated [CO_2] and high temperature may alter plant responses under well watered or mild drought conditions. However, elevated [CO_2] did not alleviate extreme drought, suggesting minimal benefit to plants under long-term, warmer and high [CO_2] conditions anticipated in the near future.

Honglang Duan is a PhD student in Hawkesbury Institute for the Environment, University of Western Sydney. His main study is to investigate mechanisms of drought-induced mortality (e.g. Hydraulic failure, carbon starvation), particularly the effects of elevated CO_2 and temperature on the risk of mortality

Climate warming and precipitation modify tree-grass interactions and accelerate woody thickening in a warm-temperate savanna

Mark Tjoelker[1], Astrid Volder[2], David Briske[3]
[1]Hawkesbury Institute for the Environment, University of Western Sydney, [2]Department of Horticultural Sciences, Texas A&M University, [3]Department of Ecosystem Science and Management, Texas A&M University

Background/question/methods: Savanna tree establishment may be altered by climate change as warmer temperatures and water limitations shift competitive outcomes in favour of grass. To test this question, we examined tree-grass interactions among dominant species of a warm-temperate savanna in the southern United States. We compared the growth and establishment of two tree species, *Quercus stellata,* a canopy dominant, and *Juniperus virginiana*, an encroaching evergreen, in competition with the C_4 perennial grass, *Schizachyrium scoparium*, under four experimental climatic scenarios. Throughout a six-year period, we examined tree-grass interactions with warming (ambient, +1.5 °C) in combination with a long-term mean rainfall treatment and a modified rainfall regime that intensified summer drought.

Results/conclusions: The two tree species differed in growth and survivorship to the climate change scenarios. Across treatments, growth of *J. virginiana* was increased by warming and reduced by precipitation redistribution. Warming reduced *Q. stellata* survival, but had no overall effect on growth. Tiller production of *S. scoparium* plants was unaffected by warming, but reproductive tillers were suppressed by intensified summer drought. Growth rates of each tree species were initially suppressed by grass presence, but increased in subsequent years. Precipitation redistribution reduced growth rates of trees grown with grass. Both tiller number and survival of *S. scoparium* plants was reduced by the presence of *J. virginiana*, but not *Q. stellata*, once tree heights surpassed 1.1 m. The observed shifts in competitive interactions suggest that climate warming and summer drought will promote encroachment of *J. virginiana* and woody thickening in this warm-temperate savanna.

Mark Tjoelker joined the Hawkesbury Institute for the Environment, University of Western Sydney in 2011 as leader of the Ecosystem Function and Integration research group. He studies the impacts of global environmental change on ecosystems and the physiological ecology and biogeography of forest trees

Contrasting water relations are associated with species distribution and crown decline in four common sympatric eucalypt species in south-western Australia

Pieter Poot[1,2], Erik Veneklaas[1]
[1]School of Plant Biology, University of WA, [2]Department of Environment and Conservation

Background/question/methods: Drought-associated vegetation declines are increasingly observed around the world including Mediterranean south-west Australia which has experienced a 15% rainfall reduction over 40 years. We investigated whether differences in water relations can potentially explain species distribution and vulnerability to drought-induced decline in four co-occurring tree species. We compared seasonal and daily water relations of four common south-west Australian eucalypt species (i.e. *C. calophylla, E. accedens*, *E. marginata, E. wandoo)* on a site where they all co-occurred as well as on nearby typical sites for each species.

Results/conclusions: Species with their centre of distribution in drier regions (i.e. *E. accedens*, *E. wandoo*), were characterised by substantially lower leaf water potentials (predawn and midday), lower osmotic potentials, higher stomatal conductances, higher relative sapflow velocities and a much lower vulnerability to cavitation. On sites where they are dominant, *C. calophylla* and *E. marginata* showed greatly improved leaf water status indicating better soil water access. Our results suggest that the regional distribution of these species is consistent with their water relation characteristics and the implications that these have for growth and survival along a rainfall gradient. However, local distribution is also strongly dependent on soil profiles and root system architecture, with shallow-rooted *E. wandoo* only occurring on eroded soil profiles with clay layers close to the surface where it can make optimal use of its superior water extracting ability. In contrast, the wetter-zone species *C. calophylla* and *E. marginata* are deep-rooted and rely on accessing weakly held water in a large soil volume, explaining their dominance on deeper well-draining soils. Our work demonstrates that combining plant water relations with detailed local knowledge on soil profiles, species habitat preferences and root system architecture can greatly improve our understanding of local species distribution patterns. This is essential to improve our capacity to understand and predict drought-induced declines.

Dr Pieter Poot is a plant ecophysiologist from the Netherlands who arrived in WA 14 years ago. He is interested in the ecophysiological and evolutionary drivers of plant species distribution patterns. Currently Pieter has a shared position between UWA and the Department of Environment and Conservation.

Modelling diverse plant water use strategies: a meta-analysis of stomatal and non-stomatal responses to water stress

Shuangxi Zhou[1], Colin Prentice[1], Belinda Medlyn[1], Remko Duursma[2]
[1]Department of Biological Sciences, Macquarie University, [2]Centre for Plants and the Environment, University of Western Sydney

Background/question/methods: Many plant growth models simulate the drought effect by reducing the slope of the relationship between stomatal conductance (g_s) and photosynthesis (A). Others apply the drought effect function to A directly. It is not clear whether either of these approaches is sufficient to capture the drought response, or whether the effect of drought varies among species and functional types. We analysed the effect of drought on leaf gas exchange with a recently developed stomatal model that reconciles the empirical and optimal approaches to predicting stomatal conductance. The effect of water stress on the model's single parameter g_1, a function of marginal water cost of carbon gain ($\lambda=\partial E/\partial A$), was investigated in a meta-analysis of 23 datasets where photosynthesis, stomatal conductance and predawn leaf water potential were measured repeatedly under increasing water stress.

Results/conclusions: Species differed greatly in their estimated g_1 values under moist conditions, and the rate at which g_1 declined with water stress. In some species g_1 remained nearly constant or even increased. For most species photosynthesis was found always to decrease more than could be explained by the reduction in stomatal conductance, implying a decline in apparent carboxylation capacity (V_{cmax}). Species also differed in the water potential at which apparent V_{cmax} declined most steeply, and the steepness of this decline. Principal components analysis revealed a gradient in water relation strategies from trees to herbs, with the former tending to maintain more open stomata and higher apparent V_{cmax} at low water potentials.

Shuangxi Zhou is a PhD candidate at Macquarie University Shuangxi's present focus is modelling drought effects on leaf gas exchange in the context of stomatal and non-stomotal components, with a final objective is conducting large-scale data analysis of quantitative plant traits as basis of a new generation of DGVMs.

Concurrent session 2D
SYMPOSIUM: Plant pollination and mate choice

Do pollinators or pollen quality determine the reproductive success of arid zone acacias?

Cairo Forrest[1], David Roberts[1], Andrew Denham[1], David Ayre[1]
[1]Wollongong University

Background/question/methods: Several acacia species in the semi arid regions of far western NSW are considered to be threatened with extinction partly due to reproductive failure. Agricultural clearing and over grazing by stock and feral animals are obvious contributors to population contractions but a decades long period of sexual reproductive failure is unexplained but could reflect disruption of pollination systems or reduced availability of high quality mates/pollen. Reproductive success may often be constrained by drought years however, high levels of recent La Nina rainfall have provided a rare opportunity to observe and characterise mating systems under seemingly optimal conditions.

Results/conclusions: By using experimental hand pollinations, pollinator observations and population genetics we have asked whether the 'preferred' mating system differs from the current 'realised' mating system and how reproductive success varies with the diversity and availability of suitable mates. It's complex. Reproductive success seems constrained by pollinator activity, resource limitation, location and genotype. Some species have been spectacularly successful following recent rains and others continue to produce little seed. Data currently being analysed will indicate the nature of successful matings in the latter case.

Cairo Forrest is a PhD student at The University of Wollongong working on conservation of arid zone acacias in far western NSW. He uses genetic and ecological techniques to try to understand which mating system parameters make different species more or less vulnerable to fragmentation.

Patterns of pollination in woody plants in fragmented landscapes of south-west Western Australia

Margaret Byrne[1], Jane Sampson[1], Tanya Llorens[1], David Coates[1], Colin Yates[1], Neil Gibson[1]
[1]Science Division, Department of Environment and Conservation

Background/question/methods: The impact of fragmentation on patterns of pollination in widespread, continuous species is generally considered to be negative but the impact on pollination in species with naturally patchy populations is less clear. Pollination within and between populations is strongly influenced by pollinator behaviour that in turn is influenced by landscape and population features. Studies of pollen dispersal in woody plants in south-west Western Australia provide insight into aspects of pollination and mating systems in species that have naturally patchy distributions.

Results/conclusions: Pollen dispersal among populations is generally extensive and maintains genetic connectivity in fragmented landscapes with small remnant populations and paddock trees making an important contribution to genetic connectivity. While outcrossing rates appear to be maintained, the patterns of pollination among plants in small degraded population remnants compared to larger, intact remnants show changed pollinator behaviour leading to fewer mates contributing to seed crops and greater biparental inbreeding. In particular, shape and density appear to be strong influences on patterns of pollination within populations. Knowledge of the effects of population variables on patterns of pollination is important for application of conservation strategies in fragmented landscapes and for the design and implementation of restoration programs.

Margaret Byrne undertakes research in plant genetics for conservation strategies for rare and threatened plants and to inform biodiversity conservation at landscape scales in relation to pollination, remnant viability, restoration, refugia, phylogeography and adaptation to climate change.

Pollination and mating system variation in two sister triggerplant species, *Stylidium affine* and *Stylidium maritimum*

David Coates[1], Shelley McArthur[1], Kristina Hufford[2], Juliet Wege[1], Scott Armbruster[3]
[1]Department of Environment and Conservation, Western Australia, [2]University of Wyoming, [3]University of Portsmouth

Background/question/methods: Triggerplants (Stylidium) are relatively short-lived insect pollinated herbaceous perennial or ephemeral annual species. Stylidium flowers are characterised by a touch sensitive column that 'triggers' when contacted by the insect, effecting pollination. Flowers are protandrous and pollinator behaviour can lead to high levels of geitonogamous self pollination, but there is no evidence for any kind of prezygotic incompatibility. Effective outcrossing appears to be maintained in most perennial triggerplants because of post zygotic seed abortion following self pollination. *Stylidium affine* and S*. maritimum* are sister species occurring in south west Western Australia. Previous studies have indicated that unlike *S. affine* post zygotic seed abortion on selfing is effectively absent in *S. maritimum.* To better understand the evolution of this mating system difference we investigated post zygotic seed abortion levels and mating system variation in four populations of *S. affine* and two populations of *S. maritimum*. We used highly polymorphic microsatellite markers to estimate mating system parameters such as outcrossing rates, biparental inbreeding and the correlation of outcrossed paternity.

Results/conclusions: We confirmed that seed abortion is minimal after selfing in *S. maritimum* compared with *S. affine*. Despite the differences in seed abortion levels outcrossing rates were comparable in both species. Correlated paternity was between three and seven times higher in *S. affine* than *S. maritimum* indicating far fewer fathers are contributing to cross pollination in *S. affine* populations. These results are discussed in the context of the stylidium post zygotic abortion system and pollinator behaviour in these species.

David Coates is Program Leader for the Flora Conservation and Herbarium Program DEC WA. Program research includes conservation biology of threatened plants, habitat fragmentation, plant systematics. David's research interests cover population biology, conservation genetics and evolutionary biology

Does less mean more? A review of pollinator diversity and pollen limitation of angiosperm reproduction

Yvonne Davila[1,2], Elizabeth Elle[2], Jana Vamosi[1], Luise Hermanutz[3], Jeremy Kerr[4], Christopher Lortie[5], Richard Westwood[6], Thomas Woodcock[7], Anne Worley[8]
[1]University of Calgary, Canada, [2]Simon Fraser University, Canada, [3]Memorial University, Canada, [4]University of Ottawa, Canada, [5]York University, Canada, [6]University of Winnipeg, Canada, [7]University of Guelph, Canada, [8]University of Manitoba, Canada

Background/question/methods: Pollen limitation (PL), the reduction in plant reproductive success as a result of inadequate quantity or quality of pollen deposition, is widespread among flowering plants. Previous reviews have calculated that 60-73% of populations studied suffer significant PL. Although ~87.5% of angiosperm species rely on animals for pollination, suboptimal pollinator activity is frequently invoked as the cause of PL, and the degree to which low abundance, diversity, or efficacy of flower visitors cause PL is unknown. Plants relying on few pollinators may experience greater variation in their pollination service and success, compared with plants with more pollinators. Therefore, PL is expected to be lower when pollinator diversity is high. We conducted a review of studies that produced quantitative assessments of pollinator diversity and evenness with PL of focal plant species to determine whether existing evidence supports the hypothesis that pollinator diversity is directly related to PL.

Results/conclusions: Our analyses suggest that the relationship between PL and pollinator diversity (species richness, Simpson's index of diversity and evenness) is weak ($P<0.05$). There was high variability in the magnitude of PL for plants with low pollinator diversity and limited sample size at high pollinator diversity. Self-incompatible species exhibited higher degrees of PL than self-compatible species; however, there was no difference in the number of floral visitors between the two breeding systems. The inclusion of measures of pollinator diversity and effectiveness in conjunction with future PL studies are needed and will improve our understanding of the critical elements of stable plant–pollinator networks.

Yvonne Davila completed her PhD at The University of Sydney, investigating the pollination ecology of the generalist-pollinated *Trachymene incisa*. She completed a postdoctoral fellowship with CANPOLIN (Canadian Pollinator Initiative), investigating pollinator diversity and pollen limitation.

When mates run out: declining pollination service threatens cryptic recruitment failure in New Zealand trees

Alastair Robertson[1], Jenny Ladley[2], Sandra Anderson[3], Dave Kelly[2]
[1]Massey University, New Zealand, [2]University of Canterbury, New Zealand, [3]University of Auckland, New Zealand

Background/question/methods: Declining pollination service is normally detected as increasing pollen limitation where insufficient pollen is delivered to stigmas and the *quantity* of seed produced is reduced. However, perhaps as likely in self-compatible species is a shift to proportionately more inbreeding and a reduction in seed *quality*. We have been investigating the seed quality issue in two NZ trees—tree fuchsia *Fuchsia excorticata* and kowhai *Sophora microphylla* by measuring the rates of autonomous selfing and of inbreeding depression.

Results/conclusions: Pollination exclusion treatments show that both trees can self but both suffer very high rates of inbreeding depression such that it seems unlikely that any selfed seed will reach reproductive maturity. Rather than providing reproductive assurance, self-compatibility in trees exposes seedlings to potentially devastating inbreeding depression and the population to recruitment failure unless sufficient outcrossing occurs to compensate. Since abundant fruits seeds and seedlings may still be produced, this type of failure is cryptic and may remain undetected. A recent global review suggests that this situation may be commonplace since self-compatible trees typically show little or no inbreeding in adults despite frequent selfing in seeds. Cryptic recruitment failure warrants further investigation in trees where a change in pollination service is suspected.

A/Prof Alastair Robertson is an ecologist at Massey University, New Zealand. His research interests are in plant-animal interactions especially seed dispersal and pollination and in the impact of invasive species on ecosystem function.

Remnant *Pachira quinata* pasture trees have greater opportunities to self and suffer reduced reproductive success due to inbreeding depression

Paul Rymer[1], David Boshier[2]
[1]Hawkesbury Institute for the Environment, University of Western Sydney, [2]Department of Plant Sciences, University of Oxford, UK

Background/question/methods: Habitat fragmentation is extensive throughout the world, converting natural ecosystems into fragments of varying size, density and connectivity. The potential value of remnant trees in agricultural landscapes as seed sources and in aiding connectivity between fragments, has formed a fertile area of debate. This study contrasted the mating patterns of bat pollinated *Pachira quinata* trees in a continuous forest to those in pasture through microsatellite-based paternity analysis of progeny. The breeding system was determined by analysis of pollen tube growth and seed production from controlled pollinations. Fitness of selfed and outcrossed seed was compared by germination and seedling growth.

Results/conclusions: There was more inbreeding within pasture trees (multilocus outcrossing = 0.828 ± 0.015) compared to forest trees (0.926 ± 0.005). Pasture trees had slightly fewer sires contributing to mating events, but pollen dispersal distances were greater than in the forest. Paternity analysis showed variation in outcrossing rates among pasture trees with a high proportion of external and self pollen sources detected. A leaky self-incompatibility system was found, with self pollen having reduced germination on stigmas and slower growth rate through the style to the ovaries. Controlled pollinations also showed a varied ability to self among trees, which was reflected in the selfing rates among pasture trees shown by the paternity analysis (0-80% selfing, correlation of outcrossing 0.6). Self pollination resulted in lower seed set, germination and seedling growth compared to outcrossing. Despite occurring at low densities in agricultural landscapes, the remnant trees are involved in broader mating patterns, but show increased but varied levels of inbreeding, which result in reduced fitness.

Paul Rymer's research focuses on the ecology and evolution of organisms in natural populations, in particular plant-animal interactions, mating patterns, hybridisation and local adaptation, and how these factors drive and erode species diversity.

Concurrent session 2E
Changing distribution patterns and range sizes

Naturalised plants: the next wave of invaders under climate change?

Daisy Englert Duursma[1], Rachael Gallagher[1], Michelle Leishman[1], Lesley Hughes[1]
[1]Macquarie University

Background/question/methods: Since European settlement ~29,000 species of plants have been introduced to Australia, ~400 of these are invasive and 2,700 are naturalised. Invasive plants in Australia cost at least $4 billion annually and significant efforts are made to manage and understand these species. Naturalised species receive relatively little attention compared to invaders, despite the fact many are likely to become serious future weed problems. Our work aims to answer the following questions: (1) which naturalised plants have the potential of becoming significant weeds in the future and, (2) what areas of Australia have the greatest invasion potential? We used the species distribution model (SDM) MaxEnt to model climate and soil suitability for ~300 naturalised plants under current conditions, and projected the SDMs onto a suite of future climate scenarios for decades centred on 2020 and 2050. Future climate scenarios were generated from four global circulation models run under A2 and B2 emission scenarios. To assess potential impact of these species in the future, we overlayed maps of climate and soil suitability with layers containing vegetation, protected areas, natural resource management regions, local government areas, endangered ecological communities and other sites of conservation significance.

Results/conclusions: This modelling approach is a first step in identifying exotic naturalised plant species that may become problematic invaders under future climate. It also enabled the identification of regions of Australia with high invasion potential and naturalised species that threaten biodiversity. In conclusion the outcomes from the study will contribute directly to the management of invasive plants in Australia and will become publicly available as part of a decision support tool linked through the Atlas of Living Australia.

Daisy Duursma is a bioclimatic modeller interested in the impacts of climate change on biodiversity and developing and improving modelling methods. She is currently employed at the Department of Biological Sciences, Macquarie University.

Mapping sub-Antarctic cushion plants: random forest classification of very high resolution terrain and spectral data

Phillippa Bricher[1], Dana Bergstrom[2], Arko Lucieer[1]
[1]School of Geography and Environmental Studies, University of Tasmania, [2] Australian Antarctic Division, Department of Sustainability, Environment, Water, Population and Communities

Background/question/methods: The endemic cushion plant of sub-Antarctic Macquarie Island, *Azorella macquariensis*, is undergoing widespread and rapid dieback, leading to the species' listing as critically endangered. As part of understanding the causes of this dieback, there is a need to monitor the distributional changes. Detecting changes in the distribution and density of plant species requires accurate and high-resolution baseline maps of those species. The need for accurate and objective mapping methods has led to the development of many novel techniques in the fields of species distribution modelling and satellite image classification. Within the field of satellite image classification, there are major divisions between object-based and pixel-based training methods, and it is not always clear which is most appropriate to a given application. In this study, random forest classification was used to explore the effect of object- and pixel-based approaches on the accuracy of maps of the distribution of *Azorella macquariensis*. These models were created using pixel- and object-based classifications using a combination of terrain information and spectral data from very high resolution WorldView-2 satellite imagery.

Results/conclusions: The most accurate classification, with 90.9% accuracy, came from pixel-based classification using a hypothesis-driven subset of the potential input variables. Highly accurate maps of absent, sparse and moderate *Azorella* cover indicate that these maps provide a suitable baseline for monitoring expected change in the distribution of the cushion plants.

Dr Phillippa Bricher's PhD has developed methods to improve the mapping of the tundra vegetation on sub-Antarctic Macquarie Island that can be used to monitor distributional changes caused by pest eradications and other environmental change.

Seasonal and interannual variability in vegetation data: implications for survey design

Nick Schultz[1], Nick Reid[2], Greg Lodge[3], John Hunter[4]
[1]School of Environmental Science, Charles Sturt University, [2]Ecosystem Management, University of New England, [3]Department of Industry and Investment, Primary Industries, [4]University of New England

Background/question/methods: Many plant ecological studies and land use planning surveys rely on data collected in a single survey. Understanding how composition varies seasonally is important for interpreting vegetation data and informing survey design. In this study, six paired grazed and ungrazed native pasture plots (400 m^2) across the North-West Slopes of New South Wales, Australia, were monitored four times a year for 2.5 years.

Results/conclusions: Species density (SD, i.e. number of species per plot) varied greatly with season and inter-annual rainfall. Highest SD was recorded in spring, though SD in summer was not significantly lower, and a spring–summer peak in SD was not evident in the 2009 drought. The period of maximum SD at each site recorded only 60–72% of the total species recorded over 2.5 years. The patterns observed were similar in both grazed and ungrazed plots. Despite the variation in species composition within and between years, compositional differences among sites were much greater than within sites, suggesting that environmental and management gradients in species composition were more influential than seasonal and inter-annual variation in composition. We concluded that in the region's native pastures, surveys sampled in spring in years of average or above-average rainfall provide the best conditions for detecting annuals and species that regenerate from buds at or below the soil surface. If capturing a large proportion of site plant diversity is important, then vegetation surveys must be carefully timed, or repeat samplings must be factored into survey efforts.

Nick Schultz is interested in community ecology in fragmented landscapes. He has studied the agricultural landscapes of northern New South Wales, and is currently lecturing in vegetation and restoration ecology at Charles Sturt University.

Local differentiation in growth and plasticity in an Australian Alpine herb

Adrienne Nicotra[1], Deborah Segal[1], Gemma Hoyle[1], Paulina Lobos Catalan[1], Roger Good[2]
[1]Research School of Biology, Australian National University, [2]Australian National Botanic Garden

Background/question/methods: Understanding within-species variation in phenotype requires unravelling a complex mixture of genotypic, environmental and maternal effects. Environmentally induced phenotypic plasticity may vary among genotypes or ecotypes and may be adaptive, maladaptive or neutral. Species that are distributed across strong environmental gradients, especially those likely to have ample gene flow among populations, present an ideal system in which to examine drivers and consequences of phenotypic variation. We examined local differentiation and adaptive phenotypic plasticity in response to growth temperature in half-sib lines collected across an elevation gradient for an Australian alpine herb, *Wahlenbergia ceracea*. We asked whether seed that had developed at low, intermediate and high elevation within the natural range differed in mean trait values or in their responsiveness to temperature as seedlings.

Results/conclusions: Plants grown under warm conditions germinated and grew faster, producing more leaves, wider rosettes and taller stems. More strikingly, plants grown from seeds collected at low elevations grew faster than those from medium and high elevations. The low elevation plants also showed stronger temperature responses (more plasticity). The adaptive value of these responses also differed with elevation: whereas the plastic response was generally maladaptive for high elevation plants, it was either neutral or adaptive for the more plastic low elevation plants. These results provide evidence of adaptive plasticity in temperature response and also show the fine spatial scale over which population sub-structuring and selection gradients can operate.

Adrienne Nicotra is an evolutionary ecologist working on plant ecophysiology.

Unravelling the mysteries of nomadic species: refugia versus resource tracking

Claire Runge[1], Richard Fuller[1], Hugh Possingham[1]
[1]Environmental Decisions Group, University of Qld

Background/question/methods: Australia's nomadic species present a unique challenge for those interested in their conservation. These species often inhabit areas where conditions fluctuate unpredictably and dramatically. There are two broad explanations for how animals cope with this. The first is that they move around the landscape tracking conditions as they fluctuate, and the second is that they respond to resource shortages by retreating into refugia.

Results/conclusions: In my talk I will present a new technique for mapping the changing distributions of arid-zone birds using time-sliced distribution models coupled with spatially explicit estimates of occupancy. This innovative approach allows us to test hypotheses about how animals cope in fluctuating environments and plan for their effective conservation.

Claire Runge spent eight years working as a Forensic Chemist before returning to study in 2011. Her PhD combines a passion for birds with an interest in conservation planning. She is currently working on mapping the movement of Australian outback birds.

Predicting the response of a broadly distributed butterfly to environmental change: incorporating behaviour, flight and dispersal capacity

Madeleine Barton[1], Warren Porter[2], Michael Kearney[1]
[1]The University of Melbourne, [2]The University of Wisconsin

Background/question/methods: Understanding the mechanisms through which climate constrains the survival of organisms will allow us to predict how they are likely to respond to environmental change. Such mechanisms will largely depend on how the animal behaves within its microhabitat. Butterflies are particularly good at behavioural thermoregulating: by altering their location and posture while basking they can optimise core-body temperature, which directly affects flight capacity.

We developed a process-explicit, biophysical model for the common brown butterfly (*Heteronympha merope*) which accurately predicts the core body temperature of basking specimens in the field. We then incorporated empirical data on the thermal perfomance of flight in both male and female butterflies, in order to predict flight capacity. This final model was then used to predict flight activity-time and dispersal potential across the Australian landscape using long-term, spatially-explicit datasets of climate and terrain.

Results/conclusions: Our results illustrate how behavioural thermoregulation can affect flight capacity and overall fitness of the common brown at different population sites within its range. We also show how predicted dispersal capacity varies across the landscape, which may directly affect this species' vulnerability to thermal extremes. The mechanistic nature of these models means that they can be used to explore why past populations of the common brown have become extinct, as well as to predict how this species is likely to respond to future environmental change.

Madeleine Barton completed an undergraduate degree in Science with Honours, majoring in Genetics and Zoology at the University of Melbourne. She has recently completed a PhD with Michael Kearney.

Concurrent session 2F
Ecosystem dynamics

Effects of biological soil crust on seedling emergence in an *Acacia papyrocarpa* open woodland

Emma Steggles[1,2], José M Facelli[1], Phillip Ainsley[1,2], Leanne Pound[1,2]
[1]School of Earth and Environmental Sciences, University of Adelaide, [2]Department of Environment and Natural Resources, Adelaide

Background/question/methods: Biological soil crusts (BSCs) are key components of arid environments and they play a major role in determining the structure and function of arid landscapes. Investigating the role of BSCs and their influence on seedling emergence is essential to improving our understanding of arid ecosystems. Such information is also pertinent for managing and restoring ecosystems where the BSC is lost or disturbed through activities such as grazing and mining. Interactions between BSCs and five arid zone plants were examined in this research. Field and glasshouse experiments were used to study the effects of late successional stage BSC on seedling emergence, and seed extraction was used to examine differences in seed accumulation. Laboratory experiments were also undertaken to explore potential leachate effects of early and late successional stage BSCs on seed germination.

Results/conclusions: Results showed that BSC physically inhibited seedlings, as emergence increased when the BSC was disturbed in both field and glasshouse experiments. Seeds also accumulated differently between areas with and without BSC, with less propagules extracted beneath the crust. Propagule size was shown to be a critical factor. Late successional stage BSC produced allelopathic effects on the germination of three species, whilst early successional stage BSC accelerated germination in one species. These results indicate that the crust plays a pivotal role in influencing patterns of soil seed bank distribution and that different successional stage crusts affect seed germination differently. Overall, interactions between BSC and vascular plants were found to be species-specific and often the result of more than one process.

Emma Steggles completed her PhD in 2012 on soil seed banks and vegetation dynamics in Western myall open woodland in South Australia. She is currently researching root architecture and plant-soil-water relationships in the same ecosystem through an ARC-Linkage grant with Uni of Adelaide and Iluka Resources Ltd.

Can changes in flow regime alter community structure and ecosystem process in managed rivers?

Sally Hladyz[1], Michael Grace[1], Richard Kopf[2], Robyn Watts[2], Ross Thompson[1]
[1]Australian Centre for Biodiversity, Monash University, [2]Charles Sturt University

Background/question/methods: The regulation of the world's major river systems is a threat to global biodiversity. There is a growing awareness of the need to manage flows sustainably in regulated river systems. However, our understanding of flow-ecology relationships is limited, which hinders our attempts to manage these systems. Only a few studies have looked at how river flow regimes drive changes in key population processes and ecological functions. We investigated whether flow regime can alter aquatic macroinvertebrate biodiversity and a key ecosystem function (leaf-litter breakdown rates) in the Edward-Wakool river system in New South Wales. The Edward-Wakool system is a major anabranch and floodplain of the Murray River and has a history of regulated flows for irrigation. We sampled four rivers which differed in flow regime, low flows, natural flow pulses and restoration (environmental) flows. In each river we sampled aquatic macroinvertebrate communities on woody debris for eight months. We also examined leaf-litter breakdown rates for six months.

Results/conclusions: Preliminary findings suggested changes in flow regime shifted the balance between benthic and pelagic processes. At low flow benthic processes dominated with a higher proportion of consumers that fed on benthic algae. With restoration flows these processes were less important. In contrast, there was a strong link between pelagic food sources and filterers consumers. Proportions of leaf-shredding consumers did not change in response to flow and consequently, decomposition rates were similar among rivers. In summary, flow regime can drive changes in macroinvertebrate communities which may have consequences for higher trophic groups such as fish.

Dr Sally Hladyz is a community and ecosystem ecologist who has primarily worked in stream ecosystems. Her research has focused on quantifying the impacts of anthropogenic stressors (flow regulation, exotic species invasion, land use) on the structure and functioning of food webs and ecosystems.

Extreme climatic events drive mammal irruptions: 100-year trends in desert rainfall and temperature

Aaron Greenville[1], Glenda Wardle[1], Chris Dickman[1]
[1]Desert Ecology Research Group, School of Biological Sciences, University of Sydney

Background/question/methods: Extreme climatic events, such as flooding rains and heat waves have been identified increasingly as important regulators of natural populations. Climate models predict that global warming will drive changes in rainfall and increase the frequency and severity of extreme events. Consequently, to anticipate how organisms will respond we need to document how changes in extremes of temperature and rainfall compare to trends in the mean values of these variables and over what spatial scales the patterns are consistent. Using the longest historical weather records available for central Australia (100 years), we investigate if extreme climate events have changed at similar rates to median events, and if the frequency of large rainfall events has increased over this period. Specifically, we compared local (individual weather stations) and regional (Simpson Desert) spatial scales, and quantified trends in median and extreme weather values.

Results/conclusions: We found that median and extreme annual minimum and maximum temperatures have increased at both spatial scales over the past century. Rainfall changes have been inconsistent across the Simpson Desert; individual weather stations showed increases in annual rainfall, increased frequency of large rainfall events or more prolonged droughts, depending on the location. Long-term live-trapping records (22 years) of desert small mammals demonstrate that irruptive events are driven by extreme rainfalls and that increases in the magnitude and frequency of extreme rainfall events are likely to drive changes in the populations of these species though direct and indirect changes in predation pressure and wildfires.

Aaron Greenville is investigating ecological interactions in arid Australia, both within and between trophic groups, and how external environmental factors, such as rainfall and wildfire, influence these interactions.

Bats across biomes: comparing the value of wetland and dryland habitats within the Murray-Darling Basin

Rachel Blakey[1], Richard Kingsford[1], Brad Law[2,1]
[1]Australian Wetlands, Rivers and Landscapes Centre, [2]Forest Science Centre, NSW Department of Primary Industries

Background/question/methods: Australia's Murray-Darling basin is one of the world's most threatened river systems. Due to the interconnected nature of the basin's freshwater systems, management of the region's water and natural resource requires knowledge of broad ecological processes and organisms. Bats, in particular, play a key role in both aquatic and terrestrial foodwebs, yet ecologists currently have a very poor understanding of their importance for ecosystem function in the Murray-Darling. To provide guidance for future conservation strategies in the region, we conducted a large-scale survey of bat activity in the basin, with the aim of determining the importance of floodplain wetland and river habitats for bats.

We used systematic acoustic surveys in 2011 to measure overall bat activity, foraging activity, species richness and community composition for 7 habitat types within 7 large freshwater wetland systems in NSW, Victoria and South Australia. Habitat types were selected to represent a flooding frequency gradient and a range of vegetation structures.

Results/conclusions: Overall, 140,000 Anabat files were recorded from 195 sampling nights. Preliminary analyses for one wetland system indicate that overall activity, foraging activity and species richness was higher in frequently flooded treed habitats. Within open habitats, overall activity was similar between agricultural and open wetland habitats, but foraging activity was higher over the open wetland. Completed analyses will be presented to accurately quantify these relationships and conservation implications of continued degradation of rivers and wetlands will be discussed.

Rachel Blakey is in the 2nd year of her PhD project investigating the functional dependencies of ecosystems and bat communities in wetlands and rivers of the Murray-Darling. Her past experience has included environmental consulting, ecological restoration and freshwater conservation planning.

Mammalian ecosystem engineers can limit plant recruitment and alter plant composition in the arid zone

Simon Verdon[1], Steve Leonard[1], Heloise Gibb[1]
[1]La Trobe University

Background/question/methods: Extinctions cause significant ecosystem change because species affect the structure and function of their biotic and abiotic environments. In Australia's arid zone, catastrophic recent extinctions of mammals have resulted in the loss of digging omnivores, which provided seedling establishment sites in the form of foraging pits, but also consumed plants. Landscape-scale re-introduction programs provide an ideal venue to reconstruct interactions between locally extinct ecosystem engineers and plant communities. We performed a field survey and field manipulative experiment to determine the impact of ecosystem engineers on seedlings and vegetation at a re-introduction site in Australia's arid zone. Field surveys compared plant composition and ground cover characteristics of mammal re-introduction areas with an adjacent control for two vegetation types. We used a field manipulative experiment (n = 10 control, procedural control and mammal exclusion plots) to test the effect of CWR mammals on the herbivory rate of transplanted seedlings (*Enchylaena tomentosa* and *Acacia wilhelmiana*) and the abundance of naturally established seedlings.

Results/conclusions: Plant composition differed between landscape-scale mammal regimes. The field experiment showed that mammals affected plant abundance and seedling survival. Perennial forbs and subshrubs, which are known food items of the re-introduced mammals, were most abundant in mammal exclusions. Seedling herbivory rates were higher and fewer seedlings established naturally in the presence of re-introduced mammals. Ecosystem engineering mammals thus had significant impacts on plant communities. We suggest that plant composition may therefore have been substantially different before the ecological extinction of digging omnivorous mammals from most of mainland Australia.

Simon Verdon recently completed a bachelor of conservation biology and ecology with Honours at La Trobe University. He is interested in understanding ecological processes in order to achieve effective conservation

Foraging activity by the southern brown bandicoot as a mechanism for ecosystem services

Leonie Valentine[1,2], Katinka Ruthrof[2], Hannah Anderson[2], Michael Bretz[2], Giles Hardy[2], Patricia Fleming[2]
[1]Centre of Excellence for Environmental Decisions, UWA, [2]Centre of Excellence for Climate Change, Woodland and Forest Health, Murdoch University

Background/question/methods: Mammals that forage for food by biopedturbation can alter the biotic and abiotic characteristics of their habitat, potentially influencing ecosystem structure and function. Bandicoots, bilbies, bettongs and potoroos are the primary digging mammals in Australia, although the majority of these species have declined throughout their range. Our study examined the foraging activity of the southern brown bandicoot, a persisting digging Australian mammal. The amount of soil displaced and physical structure of foraging pits were examined from moulds of fresh foraging pits. We recorded soil water repellency and soil moisture levels along the foraging pit profile and adjacent undug soil. We also examined seedling germination in artificially dug and undug sites.

Results/conclusions: An individual southern brown bandicoot created 45 new foraging pits per night, and could displace approximately 3.4 tonnes of soil each year. Soil water repellency was highest on undug earth, and varied throughout the profile of a foraging pit. Soil moisture was greatest along the slope of the foraging pit. Seedling germination of native species was highest in artificially dug sites compared to undug controls. Southern brown bandicoots can displace substantial amounts of soil and their foraging pits create a microhabitat that facilitates higher germination of native plant species. The digging activities of this species are likely to contribute towards ecosystem processes, and the persistence of bandicoots may play an important role in maintaining the health and function of our woodlands and forests.

Leonie Valentine's research interests are focused around the link between fauna, the environment and disturbances. Leonie is very interested in understanding the mechanisms driving wildlife responses to disturbances; the role of fauna in maintaining ecosystem health; and, adaptive management strategies.

Speed Talks A
From physiology and behaviour to populations

Can times of plenty save palatable seedlings from herbivory?

Andrew Denham[1], Tony Auld[1]
[1]Office of Environment and Heritage, NSW Department of Premier and Cabinet

Background/question/methods: When infrequent climatic phenomena such as intense la Niña events cause unusually high rainfall over arid ecosystems, it is anticipated that a proliferation of vegetation growth will also allow recruitment of new seedlings of palatable overstorey shrubs (a form of predator satiation). However, there are relatively few data to support this contention. I examined survival of seedlings of *Acacia ligulata*, a common, fast growing, but palatable large shrub of arid NSW, during and after the la Niña event of 2009-2011 against a background of predominantly drought conditions over 15 years. I compared survival across three treatments, all vertebrate herbivores excluded (F), access to rabbits only (R) and access to all herbivores (Z).

Results/conclusions: Estimated short-term survival of seedlings improved in all treatments after the la Niña event, with survival in Z to 12 months increased from <1% to 7.8%. There was an interaction of treatment and time, such that before la Niña (Z=R)<F, but after la Niña Z<(R=F) suggesting a reduced impact of rabbits. Although the limited number of observations reduces confidence in the latter estimates, these results support the model of predator satiation. This increased recruitment success in a common species is likely to be reflected in cryptic, threatened or uncommon species for which data are more difficult to obtain. The capacity to estimate the relative effect of an uncommon event depends on the existence of enough data to provide a reliable background estimate—emphasising the need for long-term ecological studies.

Andrew Denham is a conservation biologist, examining impacts of threatening processes (such as inappropriate fire regimes, feral grazers, climate change and genetic effects of small population size) on plants.

Ecophysiological adaptation of savanna trees across an aridity gradient in northern Australia

Gregor Sanders[1], Ansgar Kahmen[2], Lucas Cernusak[3], Stefan K Arndt[4]
[1]Department of Forest Ecosystem Science, University of Melbourne, [2]Physiological Plant Ecology Group, ETH Zurich, [3]College of Medicine, Biology and Environment, Australian National University, [4]Department of Forest Ecosystem Science, University of Melbourne

Background/question/methods: Regulation of leaf water status is a critical function for evergreen trees in savannas with extended drought periods. This study compared seasonal shifts in stomatal conductance, leaf water potential and osmotic potential at full turgor in closely related evergreen species at five sites across 1300 km of wet-dry and semi-arid savanna in northern Australia, covering a rainfall gradient from 1700 mm to 300 mm.

Results/conclusions: Pre-dawn water potentials of *Eucalyptus* and *Corymbia* species were only up to 1.5 MPa lower at the end of the dry season in September compared to the end of the wet season in March. Midday water potential of the trees was generally well correlated with predawn water potential (mean difference of 1.3 MPa), which is consistent with isohydrodynamic hydraulic regulation. All species showed a similar behaviour across the gradient.

Stomatal conductance and osmotic adjustment were not correlated with the difference in predawn water potential between seasons. Therefore osmotic adjustment and strong stomatal control played only a limited role in plant responses to moderate drought stress associated with prolonged aridity across much of the climate gradient.

A significant reduction in total leaf area at the end of the dry season contributed to consistent rates of leaf transpiration between seasons and the low levels of stress. Our data show that whole plant adaptations were more important than physiological adaptations at the leaf level and that plant ecophysiological responses were surprisingly similar across a large rainfall gradient.

Gregor Sanders is currently researching drought adaptations in eucalyptus sp. across climatic gradients, at the University of Melbourne. He has previously assisted in ecological research at the University of Tasmania and has co-authored papers addressing on forest transition.

Potential risks of excluding the seed bank from plant population models

Vuong Nguyen[1], Glenda Wardle[1]
[1]Desert Ecology Research Group, School of Biological Sciences, The University of Sydney

Background/question/methods: Seeds are crucial for seedling recruitment and dispersal of plants and, are therefore, of fundamental importance for the persistence of populations. Despite this, dormant seeds present in seed banks have been omitted from many published plant population models. The extent of this problem and the consequences of ignoring the stored seed stage for plant population models are unknown. Here we addressed this knowledge gap by reviewing the literature and sourcing published information on seed dormancy and germination to include the seed stage in models where it was originally absent. Similarly, we targeted models that included the seed bank and removed it from the model. We compared population growth rates and extinction risks between models with and without the seed bank to determine the consequences of omitting the seed stage.

Results/conclusions: We found that for 77 plant species for which matrix models were constructed from 2008-2011, 38% omitted the seed bank stage despite evidence that seeds of these species have the capacity for long-term persistence. Furthermore, attention to the seed stage had not improved over the last decade. Simulations showed the impact of the seed bank on population persistence to be crucial for some species but irrelevant for others. Model predictions were also strongly influenced by the quality of the demographic data such as germination rates. We conclude that the impact of the seed stage cannot be assumed to be minimal and researchers need to adequately assess the role of the seed bank for each study species.

Vuong Nguyen completed an Honours at the University of Sydney in 2011 and is currently in the first year of a PhD, with research focusing on plant population modelling.

Recruitment in the rare Australian endemic conifer *Wollemia nobilis*

Heidi Zimmer[1], Tony Auld[2], John Benson[3], Patrick Baker[1]
[1]School of Biological Sciences, Monash University, [2]Office of Environment and Heritage NSW, [3]Botanic Gardens Trust

Background/question/methods: Persistence of long-lived species requires at least occasional recruitment. Understanding recruitment limitation in long-lived tree species is challenging because of potentially infrequent recruitment events. The conditions in which rare tree species recruit are of particular interest to land managers.

Wollemia nobilis (Wollemi pine) is one of the world's rarest tree species, with <100 adults persisting in four stands in Wollemi National Park, New South Wales, Australia. Our study aimed to identify the factors influencing *Wollemia nobilis* seedling and juvenile recruitment. We modelled variation in *Wollemia nobilis* seedling establishment, and seedling and juvenile growth and mortality rates, as functions of environmental variables.

Results/conclusions: There was large inter-annual variation in seedling establishment. Mortality was higher in smaller seedlings and juveniles, and no mortality occurred in seedlings > 30 cm. Mortality was lower in microsites with more direct light. Mean seedling growth rates were low (~ 5 mm per annum). Mean juvenile growth rates were higher than seedlings (~ 19 mm per annum) but more variable.

Maintenance of a slow-growing bank of juveniles has been observed in other Araucariaceae. Our results suggest that *Wollemia nobilis* has this recruitment strategy. However, recruitment of adult *Wollemia nobilis* from juveniles has not yet been observed.

Heidi Zimmer is currently working on doctoral research into the ecology of the Wollemi pine at Monash University. Her primary research interest is forest dynamics; highlights include projects on the tropical pine forests of northern Thailand and on the high-elevation forests of Papua New Guinea.

Flowering asynchrony between planted and native spotted gums is a barrier to gene flow

Myralyn Abasolo[1], David J Lee[1], Lyndon Brooks[1], Carolyn Raymond[1], Mervyn Shepherd[1]
[1]Southern Cross University

Spotted gums are one of the main plantation species in subtropical Australia. Select provenances from the northern regions are largely planted in the southern areas of its native range. It has been shown that spotted gums from the northern region is different from the southern region by microsatellites. Thus hybridisation between the planted northern region and the native southern region may disrupt ecological functions of the native populations. We studied flowering time of northern and southern *Corymbia citriodora* subsp *variegata* in a common garden.

Background/question/methods: Our objective was to determine if there is a genetic basis for the differences in flowering time between the northern (planted) and the southern (native) spotted gums. We also looked at environmental factors that determine year to year variation in flowering. We determined flowering synchrony between the southern and northern spotted gums. We studied 1855 trees from eight regions of spotted gums, three from northern and five from southern regions planted in a common environment. We conducted flowering surveys for three years every November each year and monitored flowering monthly for two years on a subset of 208 trees and used to determine synchrony.

Results/conclusions:

- There was evidence of genetically controlled variation in flowering time consistent over three years.
- There was congruence in the fluctuation of bud numbers and the fluctuation of heat sum across the three years of study period.
- We found a very low flowering synchrony between the northern and southern spotted gums.
- These demonstrate that flowering asynchrony is a major barrier to hybridisation. The genetically controlled differences in flowering time can be used to manage gene flow in plantations.

Myralyn Abasolo is a PhD student at Southern Cross University. Her research topic is, 'Assessing and managing gene flow from planted Corymbia in subtropical Australia.' Research results from her study will contribute to biodiversity conservation and maintenance of ecological balance in Corymbia native populations and communities by informing sustainable forest management.

Protective attributes of artificial refuges mediate the risk of predation in Boulenger's skink (*Morethia boulengeri*)

Gaye Bourke[1], Alison Matthews[1], Paul Humphries[1], Damian Michael[1,2]
[1]Charles Sturt University, [2]Australian National University

Background/question/methods: Refuges can provide protection for prey species, but may be equally attractive and accessible to some predators. Thus, the practice of adding artificial refuges to restore wildlife habitat may influence predator-prey interactions, and potentially benefit some species at the expense of others. This study used the predator-prey relationship between Boulenger's skink *M. boulengeri* and curl snake *Suta suta* as the basis for a series of laboratory experiments which explored the influence of snake predation risk and shelter attributes on the use of artificial refuges by skinks. Four overnight refuge choice experiments were conducted to determine: (1) predator-scent avoidance, (2) artificial refuge preferences, (3) a trade-off between a preferred refuge and predator avoidance, and (4) the effect of gap height on refuge preference.

Results/conclusions: Experiments revealed that skinks avoided predator-scented refuges in favour of identical, but unscented refuges. Skinks preferred timber over both iron and tile refuges, with iron having the lowest relative preference. When given a trade-off choice between a predator-scented preferred (timber) refuge, and an unscented least-preferred (iron) refuge, most skinks maintained their preference for timber. However, when the gap height of either the timber or iron refuge was manipulated, skinks shifted to the refuge type with the smallest gap. These findings suggest that protective refuge attributes, such as small gap heights, can offset the risk posed by predator-scent within a refuge, emphasising the need to consider predator-prey interactions when designing and using artificial refuges.

Gaye Bourke is a Bachelor of Environmental Science (Honours) student at Charles Sturt University, Albury, NSW.

Microbats produce echolocation buzz calls while drinking on the wing

Stephen Griffiths[1]
[1]Zoology Department, The University of Melbourne

Background/question/methods: Microbats (Microchiroptera) have extremely high surface-area-to-volume ratios due to their broad, highly vascularised wing membranes, resulting in a high rate of evaporative water loss, particularly during flight. In order to compensate for these losses, replenishment of 20-40% of daily water reserves is achieved by drinking at water sources. Microbats drink by swooping down to lap at the water's surface while in flight (i.e. drinking on the wing), a mode of drinking similar to that adopted by swallows and martins (Hirundinidae). However, recording quantitative observations of small, nocturnal, fast flying animals drinking on the wing is logistically difficult. My objective was to examine echolocation calls produced by microbats during drinking passes, to determine whether bats emit distinctive buzz calls similar to those emitted during foraging bouts. I developed a novel monitoring technique, simultaneously recording thermal video and ultrasound to document drinking behaviour of free-ranging microbats under natural conditions.

Results/conclusions: All echolocation call sequences produced during drinking passes were characterised by an increase in pulse repetition rate, slope, frequency and speed, culminating in a distinctive terminal buzz (drinking buzz) produced immediately prior to the bat touching the water. This pattern is analogous to foraging buzz calls produced during prey attack and capture. These findings represent the first empirical evidence that microbats produce buzz calls while drinking on the wing. The efficacy of using drinking buzzes to quantify the level to which microbats are exposed to environmental toxins while drinking from open water impoundments, such as gold mining tailings dams, is currently being investigated.

Stephen Griffiths is currently enrolled as a PhD candidate in the Zoology Department of the University of Melbourne. The primary focus of his research project is to investigate the potential risk that open impoundments storing wastewater at gold mines, such as tailings dams and process water ponds, pose to microbats.

Local and landscape features of water bodies and their importance for insectivorous bats and insects in an urban environment

Tanja Straka[1], Lindy Lumsden[2], Brendan Wintle[3], Fiona Caryl[1], Rodney van der Ree[1]
[1]Australian Research Centre for Urban Ecology, School of Botany, University of Melbourne, [2]Arthur Rylah Institute for Environmental Research, DSE, [3]Applied Environmental Decision Analysis, School of Botany, University of Melbourne

Background/question/methods: An abundance of emergent aquatic insects means water bodies provide important feeding grounds for some species of insectivorous bats. However, most studies on insectivorous bats in urban areas have neglected standing water bodies as feeding habitats. Knowledge about what habitat and landscape characteristics of water bodies drives their suitability to bats in urban areas is therefore lacking, despite the value of such information for urban planning. We investigated the role of urban water bodies for insectivorous bats as feeding grounds to determine what features influence insects and bats. We measured bat activity and diversity with acoustic detectors at 59 urban water bodies and 36 ecologically similar habitats without water ('reference sites') in summer and autumn 2012. Simultaneously, we measured the abundance of emergent aquatic and terrestrial insects using insect light traps.

Results/conclusions: Preliminary results demonstrate higher bat activity, species richness and insect abundance at water bodies compared to reference sites without water. Preliminary results on habitat structure and composition at water bodies suggest that vegetation and water body health are significant influences on bat activity and species richness. We discuss the implications of our findings and how they can guide management decisions for urban water bodies which are beneficial for bats as well as for other urban fauna.

Tanja Straka completed a Masters Degree at the Ludwig Maximilians University in Munich, Germany in 2007, majoring in zoology and ecology. Her research interests include conservation biology and ecology with a focus on insectivorous bats.

Surviving urbanisation: masked lapwing, *Vanellus miles*, experience greater reproductive success in suburban than agricultural environments

Adam Cardilini[1], Mike Weston[1], Dale Nimmo[1], Peter Dann[2], Craig Sherman[1]
[1]Deakin University, [2]Phillip Island Nature Park

Agricultural landscapes are being converted to suburban environments at a high rate throughout the world, however, little is known about the effects of urbanisation on the reproductive success of native species. We predicted that urbanisation would reduce reproductive success in two ways; 1) directly through habitat degradation, and 2) indirectly through a reduction in parental care due to an increase in disturbance (i.e., greater interaction with cars, humans). We investigated the effect of urbanisation on the reproductive success and parental care of the masked lapwing, *Vanellus miles*; a ground nesting bird that commonly occurs in both suburban and agricultural environments. Contrary to predictions, masked lapwings experienced greater reproductive success in suburban environments than those in agricultural environments. Lapwings in suburban environments were also more aggressive, and females had better condition than those found in agricultural environments. Despite urbanisation being attributed to a decrease in avian diversity, suburban environments act as high quality breeding habitat for the masked lapwing.

Adam Cardilini is a PhD candidate studying at Deakin University. He is interested in the influence that urbanisation has on life history traits of native species and how this might impact the reproductive success.

Contribution of mercury contamination to deaths in a newly discovered dolphin species

Alissa Monk[1,2], Kate Charlton-Robb[1], Saman Buddhadasa[3], Ross Thompson[1]
[1]School of Biological Sciences and Australian Centre for Biodiversity, Monash University, [2]Dolphin Research Institute, [3]National Measurement Institute Port Melbourne

Background/question/methods: Globally it is estimated that up to 37% of all marine mammals are at risk of extinction, due in particular to human impacts, including coastal pollution. Dolphins are known to be at risk from anthropogenic contaminants due to their longevity and high trophic position. While it is known that beach-cast animals are often high in contaminants, it has not been possible to directly attribute deaths to this cause, as it is not known whether levels may also be high in live animals from the same populations. In this study we quantitatively assess mercury contamination in the two main populations of a newly described dolphin species from south eastern Australia. This species is limited to coastal waters in close proximity to a major urban centre, and as such is likely to be vulnerable to anthropogenic pollution.

Results/conclusions: We compared mercury concentrations from biopsy samples of live individuals and necropsies of beach-cast animals and found that beach-cast animals were highly contaminated with mercury, at almost three times the levels in live animals. This strongly suggests that mercury is implicated in the death of at least some of these animals. Levels in live animals were also high, and are attributable to chronic low dose exposure to mercury from the dolphins' diet. Measurable levels of mercury were found in a number of important prey fish species. This illustrates the potential for low dose toxins in the environment to pass through marine food webs and ultimately result in marine mammal deaths.

Alissa Monk is a PhD candidate from Monash University studying ecotoxicology

Speed Talks B
Dispersal and distribution patterns

Performance of woodland annuals at 'home' and 'away': how important are soils versus climate?

John Morgan[1], Teri O'Brien[1]
[1]Department of Botany, La Trobe University

Background/question/methods: One way that plant species will respond to climate change is to track the shifting climate niche by dispersal processes, i.e. movement into new ranges with suitable temperature and rainfall. In many cases, such migrations will involve dispersal to new ranges on a different soil type (i.e. pH, texture, fertility). The importance of this abiotic factor is a rather neglected aspect of studies on climate change response and mitigation. In this study, we use two annual daisies (*Hyalosperma praecox*, *Triptilodiscus pygmaeus*) common in eucalypt woodlands and ask: 1) is performance (measured as survival to flowering) affected moreso by soils or climate? Using a seed sowing experiment, we placed seed in 'home' environments on 'home' soils, and contrasted performance to seeds sown in 'away' environments on 'away' soils.

Results/conclusions: There were few effects of climate and soils on germination in both species. Survival to flowering, however, was substantially higher on 'home' soils in either environment; there was almost no survival in either environment on 'away' soils. We conclude that soils play a key role on the performance of annual species, ultimately affecting species distributions. This factor needs to be better understood when modelling future responses to climate change.

John Morgan is a plant ecologist who studies long-term vegetation dynamics in herbaceous ecosystems. He is particularly interested in the role of disturbance and climate fluctuation as they affect plant population processes like germination.

Influence of habitat loss and fragmentation on koalas in a peri-urban landscape of south-east Queensland

Erin Waller[1], Clive McAlpine[1], Grant Brearley[1]
[1]Centre for Spatial Environmental Research, School of Geography, Planning and Environmental Management, University of Queensland

Background/question/methods: The impacts of habitat loss and fragmentation on biodiversity may vary as a result of different human land-use extents. Urbanisation is considered by many to be the most extensive and destructive form of human-induced landscape change. The problem of habitat loss and fragmentation has been well documented as a major cause of decline in the koala (*Phascolarctus cinereus*) throughout New South Wales and Queensland. However, to-date, less research has focused on these issues in peri-urban landscapes. Using faecal pellet ageing techniques and habitat assessments, detailed spatial analysis of key site and landscapes variables was used to determine the presence and habitat preferences of koalas in a peri-urban region of south-east Queensland.

Results/conclusions: Results are currently being analysed, however preliminary analysis indicate that koala populations have a preference for eastern eucalypt woodlands to open forests, regional ecosystem type which exist within these areas. Information gained from this research will be used to develop conservation priorities and management guidelines for this species in peri-urban landscapes.

Erin Waller is completing a Bachelor of Environmental Science, majoring in ecology at the University of Queensland. Her honours project is through the Spatial Environmental Research Association, UQ. Erin is interested in wildlife conservation, especially the declining koala population in south-east Queensland.

Mapping koala and eucalypt habitats in south-west Queensland using satellite imagery and field data

Brandy Ream[1], Leonie Seabrook[1], Clive McAlpine[1], Stuart Phinn[1]
[1]University of Queensland

Background/question/methods: As climate changes such as sea level rises, weather extremes the need to manage and map remote habitats becomes critical, using satellite remote sensing, can incorporate not just the standard map but additional data such as distribution of species and health of a habitat. However there is a lack of background data on remote habitats such as south-western Queensland koala habitats. The question was could a combination of GIS data and remote sensing data create better habitat maps to be used for conservation planning? Using fine resolution multi-spectral satellite remote sensing such as Worldview-2 and field data maps that related koala habitat use to tree spectral profiles could be created.

The first method was to look at land cover classifications, identifying areas of greatest change over time. The second method vegetation indexes provided a narrower focus on which tree groups had seen the greatest changes. The third method was to use spectral profiling, to see if it was possible to create a spectral profile of a eucalypt that could then be linked to koala tracking data.

Results/conclusions: Initial results indicate that landscape mapping such as land cover classification (SVM) and vegetation indexes do not provide a detailed view of the habitat. Broad scale changes such as chlorophyll changes due to La Nina/El Nino periods are observed and can be used to monitor habitat stress. Spectral mapping provides a detailed picture of individual trees based upon pixel spectral signatures therefore potential koala habitats could be identified based upon spectral profiles of eucalypts frequented by koalas.

Brandy Ream is a MPhil (Confirmed) Candidate in remote sensing and landscape ecology at the Centre for Spatial Environmental Research, School of Geography, Planning and Environmental Management at The University of Queensland. Research interest lie in integrating satellite remote sensing with landscape ecology to map and monitor koala-eucalypt habitat for the effects of landscape changes.

Halting the spread of cane toads in Western Australia

Reid Tingley[1], Ben Phillips[2], Mike Letnic[3], Gregory Brown[4], Richard Shine[4], Stuart Baird[5]
[1]School of Botany, University of Melbourne, [2]School of Marine and Tropical Biology, James Cook University, [3]School of Biological, Earth and Environmental Sciences, University of New South, [4]School of Biological Sciences A08, University of Sydney, [5]Research Centre in Biodiversity and Genetic Resources, University of Porto

Background/question/methods: Cane toads *Rhinella marina* have spread rapidly through northern Australia, but in order to invade further into Western Australia, the toads will have to traverse a narrow arid corridor where artificial water bodies will serve as critical stepping-stones for range expansion. We use a stochastic simulation model to explore whether it would be possible to halt the spread of toads into the Pilbara region of Western Australia by excluding toads from artificial water bodies.

Results/conclusions: We show that excluding toads from just one hundred artificial water bodies could prevent them from occupying 268,000 km^2 of their potential range in Western Australia; an area of land larger than Great Britain. Our analyses thus suggest that strategic removal of potential 'invasion hubs' along narrow habitat corridors can halt the spread of invasive species.

Reid Tingley studies the macroecology and invasion biology of amphibians and reptiles. He is particularly interested in using species distribution models to forecast invasions and the potential effects of climate change.

Long-term monitoring of fauna in the NSW conservation reserve system: filling the gaps

John Porter[1], Corinna Orscheg[1], Alison Foster[1], Natalie Izquierdo[1]
[1]Office of Environment and Heritage, NSW National Parks and Wildlife

Conservation reserve systems are an effective way of protecting biodiversity from many threats, but their ability to act as refugia from climate change remains unclear. Long-term broad scale fauna monitoring provides information essential to understand the effects of threats such as climate change on reserve systems and fauna populations, and to underpin effective management decision making. To date few such programs exist, leaving reserve managers with gaps in data on which to base their decisions. Here we present initial results for a new program which aims to undertake broad scale fauna monitoring on parks across 252,140 km^2 in eastern NSW using motion sensitive cameras. Rather than target a few charismatic, rare or threatened species, the program will monitor a broad range of medium-sized mammals and other fauna that have been identified as data deficient. This will allow changes in the distribution of common and widespread species to be tracked over time, and provide reserve managers with current information on key fauna populations. With 800 sampling locations and 11,500 trap nights annually, over an altitude span of 1,800 m, the program is among the largest in the world. We present initial results for year 1 of sampling and illustrate how the data can be used to examine the effects of climate change and other threats on wildlife populations in conservation reserves in eastern NSW.

Background/question/methods: What changes are occurring in the distribution of common and widespread fauna in NSW conservation reserves? Are conservation reserves effective refugia from the effects of climate change and other landscape scale threats? Are motion sensitive cameras effective tools for long term monitoring of fauna populations?

Results/conclusions: Initial results are presented and no trends are identified. Conservation reserves currently support a wide range of fauna populations, and further data will enable changes in distribution of a range of species to be identified. Motion sensitive cameras effective tools for broad-scale monitoring of fauna populations.

John Porter is a Research Scientist at the NSW Office of Environment and Heritage with more than 20 years experience in large scale fauna monitoring projects, including aerial survey of waterbirds

A new tool for detecting areas of extrapolation in species distribution modelling

Mohsen Mesgaran[1], Roger Cousens[1]
[1]Department of Resource Management and Geography, The University of Melbourne

Background/question/methods: Species distribution models (SDM) have been applied widely in ecology, evolution and conservation. They are used to make predictions to new space or time but the transferability of these models is questionable because the data used for the model calibration may not encompass the entire environmental space of species. The model may therefore extrapolate beyond the data range or novel combination of variables used to train it and lead to erroneous predictions. To address this problem, the most recent version of MaxEnt has provided a so-called MESS map (multivariate environmental similarity surface) which indicates where extrapolation has occurred. However, this method simply analyses the environmental coverage of each variable individually and is not able to identify changes in the correlation structure of data: for most models predictions to areas with different correlations between variables can be unreliable. Here, a new multivariate statistical method is proposed, based on Mahalonobis distance which takes into account changes in the correlation structure of data for detecting where the model extrapolates. We used sea wheatgrass (*Thinopyrum junceiforme*), a coastal invader, as an example to demonstrate the method, though, the technique is relevant to many species modelling systems.

Results/conclusions: The suggested method would enhance the reliability of the MESS map as it is not only based on the environmental range of univariate predictors, but also on their correlation structure. The similarity/novelty map produced by this method illustrates areas where the model extrapolates on a scale ranging from 0 (complete extrapolation) to 100 (no extrapolation). Further, if the assumption of normality holds, then for each point on the projection map one can estimate the probability of that point belonging to the data set used for model calibration. The suggested method can be used as a quantitative tool for exploring the uncertainty of predictions in SDMs.

Mohsen Mesgaran is a McKenzie Postdoctoral Fellow at the University of Melbourne, with a research interest in understanding the responses of weeds/invasive species to environment using physiological-based models. Mohsen's current focus is predicting the potential range of coastal invaders using sea wheatgrass.

Predicted invadedness of protected areas varies across species but is independent of treatment funding

Gwenllian Iacona[1], Franklin Price[2], Paul Armsworth[1]
[1]University of Tennessee, USA, [2]Florida Natural Areas Inventory, USA

Background/question/methods: Invasive plant management is a costly but necessary activity on most protected areas. Conservation planners would like to account for these costs over time, but are often constrained by incomplete distribution data at the sites. Here we use site level features (size, nearby households, elevation, winter low temperature, road density) to predict both aggregate and species specific invasive plant cover (invadedness) for 365 protected areas in the state of Florida, USA. We then use data on budget allocation for invasive species management over ten years to examine the relationship between invadedness and treatment funding at a subset of the sites.

Results/conclusions: Aggregate species invadedness at a protected area was predicted by protected area size and the number of surrounding households. Meanwhile, the site level factors that predicted invadedness of individual species varied across species. Allocation of funding for management could be predicted by site level features similar to those that drove invadedness, however there was no relationship between site invadedness and treatment funding. These results suggest that data on current funding allocation is not adequate for predicting future budgetary needs.

Gwenllian Iacona is a PhD student at the University of Tennessee advised by Dr Paul Armsworth. Her research interests include assessing the costs and benefits of conserving biodiversity, with a focus on the management of protected areas. She is visiting Australia on a CEED visitor fellowship.

The Atlas of Living Australia: an educational resource for ecology

Lee Belbin[1]
[1]The Atlas of Living Australia

The Atlas of Living Australia is a publicly funded and publicly available resource for information about species within the Australian region. The Atlas was funded under the Federal Government's National Collaborative Research Infrastructure System and the Education Investment Fund.

The Atlas has ~34 million records of ~212 thousand species, 500 environmental layers, images, video and extensive biologically-related information and analytical tools. The Atlas bio-data data and code are freely available under Creative Commons while Atlas functions were designed as web services, making the online functions of the Atlas available for anyone to re-use.

The Atlas addresses the general public, citizen scientists and the research community. Data can be imported, analysed and results exported. Mobile versions are available for iPhones/iPads (http://itunes.apple.com/au/app/ozatlas/id509021205?mt=8) and Android devices (https://play.google.com/store/apps/details?id=au.org.ala.mobile). Species information can be viewed, species sightings can be entered and lists of species within any defined areas can be easily obtained. The Atlas of Living Australia is therefore a valuable resource for use in education in ecology: from primary school to the research community.

Background/question/methods: The Atlas of Living Australia aggregates and makes available biological data from federal, state and territory agencies, museums and herbaria, specialist groups and the public.

Lee Belbin's career has evolved from geology (Cundill Meyers Pty Ltd: 1970), to geospatial lecturer (ANU: 1972), to analytical ecology (CSIRO: 1979) and to project management (AAD+: 1995). Lee has published more than 100 papers on geology, ecology, information management and policy.

Speed Talks C
Disturbance and ecosystem dynamics

The clarification of values, attitudes and risk perceptions to help resolve (or avoid) conflicts in invasive species management

Rodrigo Estevez[1], Christopher Anderson[2], Mark Burgman[1]
[1]Australian Centre of Excellence for Risk Analysis, School of Botany, University of Melbourne, [2]Omora Sub-Antarctic Research Alliance, USA

Background/question/methods: Biological invasions are a significant component of human-induced global environmental change, and their negative impacts have been widely documented. At the same time, non-native species constitute an essential part of human lives in almost all cultures. Decision makers and scientists have to constantly deal with social conflicts in the management of these species. These conflicts have generated new challenges for conservationists. We asked what the geneses of conflicts are. What are the cognitive levels of conflicts (system values or risk perceptions)? And how understanding conflicts facilitate invasive species management? We approach these questions by reviewing the burgeoning literature on the social dimensions of invasive non-native species. We found a growing interest to analyse people values, attitude and risk perceptions towards non-native species. It has produced a new body of knowledge that until now lacks systematic review.

Results/conclusions: We identified 80 articles addressing attitudes, values or risk perception towards non-native species. We explored different trends, such as year of publication, journals, taxa and countries. We categorised the studies according to their level of conflicts (risk perception or value system) and the area (lack of trust, potential impacts, animal rights and different uses). We contend that in conflicts related to invasive species research and management, it helps to determine if the disagreement occurs in a value system or risk perception level. Clarifying this may be helpful in prescribing recommendations for dealing with the situation. We propose a set of management recommendations according the type of problem. We conclude that people have conflictive interpretations and values of non-native species, which rather than ignoring should be integrated to the decision-making process.

Rodrigo A Estevez is sociologist and MS Biology. Actually he is a PhD Science candidate at the University of Melbourne. His research focuses on decision analysis in a range of areas, such as conservation biology, environmental planning and pest management

At the crossroads: does the configuration of roadside vegetation affect woodland birds?

Mark Hall[1], Dale Nimmo[1], Andrew Bennett[1]
[1]Deakin University

Background/question/methods: Linear networks of native vegetation are increasingly important for biodiversity conservation throughout the world, as human activities continue to fragment and isolate species' habitats. In Australia, roadside vegetation networks are a major feature of agricultural landscapes, often comprising the majority of remnant vegetation within the landscape. The aim of this study was to examine factors that influence bird communities in roadside networks: specifically to test the hypotheses: (1) that intersections support more bird species and different assemblages than straight sections; (2) that the value of intersection habitats is greater in landscapes with less tree cover; (3) that noisy miner presence in roadside vegetation affects bird assemblages; and (4) that bird diversity is influenced by structural complexity of roadside vegetation. We selected 26 pairs of sites, each consisting of a connected linear section and an intersection, with an overstorey of grey box *Eucalyptus microcarpa*. Pairs of sites were selected along a gradient of extent of woodland cover within 500m radius, and to range from open sites with a simple understorey to those with a structurally complex understorey. Birds were surveyed along a 1 ha transect for 20 mins at each site, during each of four survey rounds between April and June, 2012.

Results/conclusions: A total of 86 bird species were recorded, including 39 woodland-dependent species. While the number of woodland bird species was generally higher at intersections, this effect was secondary to that of noisy miner abundance and landscape context. Implications for the restoration and revegetation of roadside networks are discussed.

Mark Hall is currently completing his honours in Wildlife Conservation Biology at Deakin University. His key interests are landscape ecology, fire ecology and anything ornithological.

Cumbungi response to flooding at Lindsay-Mulcra-Wallpolla Islands in the Murray River system, north-west Victoria

Greg Cranston[1], Mark Henderson[1], David Wood[1]
[1]Murray Darling Freshwater Research Centre

Background/question/methods: Lindsay-Mulcra-Wallpolla Islands (LMW) is a floodplain anabranch system of the Murray River located in the north-west corner of Victoria. Cumbungi at LMW is monitored as part of condition monitoring under The Living Murray program with the aim of addressing the ecological objective of 'Limit cumbungi growth and promote greater macrophyte diversity'. Representative sections of the primary anabranch channels of LMW and the adjacent Murray River have been surveyed annually since 2006. Natural flooding of this system during 2010–11 provided an opportunity to monitor the disturbance and response of Cumbungi in a natural habitat post-flooding.

Results/conclusions: Pre-flood surveys of Cumbungi at LMW indicate expansion of this species from 2006 to 2010. Stable water levels as a result of low-flow and river regulation operations in the adjacent stretch of the Murray River is the probable cause for the expansion. Post-flood surveys recorded the near disappearance of visible above ground Cumbungi. This was attributed to elevated water levels (1-4 metres) for an extended period of time during the 2010–11 flood event which effectively 'drowned' the Cumbungi plants. While above-ground biomass may be largely eradicated, the below-ground biomass in the form of rhizomes, if undamaged or disturbed, allows Cumbungi to regenerate (Clark and Flanery 2007). Limited survival at LMW suggests a water regime threshold for Cumbungi, with water level and duration as determinants of Cumbungi persistence.

Surveys undertaken two years post-flooding show that Cumbungi distribution is still largely suppressed across LMW, possibly due to the continued variability in flow and water level post-flooding.

References: Clark E, Flanery F (2007). Cumbungi—*friend or foe?* You asked for it. Hot topics in native vegetation management, Greening Australia. Number 2.

Biography not available at time of printing.

Floodplain woodland dynamics and the dense regeneration phenomenon

Megan Good[1], John Morgan[1], Jodi Price[2], Peter Clarke[3]
[1]Department of Botany, La Trobe University, [2]Institute of Ecology and Earth Sciences, University of Tartu, Estonia, [3]Department of Botany, University of New England

Background/question/methods: Floodplain woodlands in the Murray Darling Basin have been heavily cleared for agriculture and now occur as small remnant patches throughout most of the wheat sheep belt. As such, there is limited knowledge about the landscape scale dynamics of these fragmented systems. Dense regeneration of floodplain eucalypts is common and is thought to be the result of human activities such as logging, clearing, and river regulation. Yet dense regeneration following disturbance could be a necessary part of a landscape scale cycle of recruitment and death. This is the basis for the patch dynamic model of woody plant persistence which was developed in South African savannas. We investigated this hypothesis by measuring tree size distributions of two floodplain woodlands; one dominated by *Eucalyptus coolabah* in northern NSW and the other dominated by *E. largiflorens* in southern NSW.

Results/conclusions: We found that dense tree recruitment occurs in patches where large trees are sparse. There was some evidence that the current structure of remnant woodlands is the result of episodic regeneration in the past. These findings indicate that the patch dynamic model shows promise as an explanation for floodplain woodland dynamics in Australia and that dense regeneration may not be a novel process. The relevance of these findings to the management of floodplain ecosystems will be discussed.

Megan Good is interested in the dynamics of floodplain trees and the role of landscape scale mortality and recruitment processes. She studied coolibah woodlands in northern NSW and is now working in black box and river red gum woodlands in southern NSW.

Temperature effects on seed bank persistence influence extinction risk

Tony Auld[1], Mark Ooi[2]
[1]Office of Environment and Heritage NSW, [2]School of Biological Sciences, University of Wollongong

Background/question/methods: The ability of seeds to maintain long-lived soil seed banks is a critical life history strategy that allows species' persistence in many habitats with fluctuating disturbances or environmental drivers of change. Temperature has a major influence on seed bank persistence and global warming can potentially alter or disrupt life history strategies in many plant groups with soil seed banks. We used population modelling to compare the relative extinction risks from predicted warming impacts on seed bank persistence in a species from a fire-prone ecosystem, *Acacia suaveolens*, with physical seed dormancy.

Results/conclusions: Modelling showed extinction risk increased markedly when annual seed survival in the soil was decreased, as may occur through warming of soils. Extinction risk was less sensitive to decreasing the amount of seeds that remains in the soil after any one fire, as *A. suaveolens* can rapidly replenish soils seed banks after a fire. Species with physically dormant seeds are likely to have a reduced capacity to maintain persistent soil seed banks under a warming climate. Disruption of this key life history strategy in plants could seriously compromise the resilience capacity of species.

Tony Auld is a Senior Principal Research Scientist who has worked on the dynamics of soil seed banks for several decades. My current research interest involves understanding how global warming may impact on persistent soil seed banks from a range of vegetation communities.

Soil seed bank ecology and its role in *Banksia* woodland restoration, Western Australia

Pawel Waryszak[1], Neal Enright[1], Phil Ladd[1], Joe Fontaine[1]
[1]Murdoch University

Background/questions/methods: The main urban areas of Western Australia (WA) are located on the Swan Coastal Plain—the 400 km long sandy landform between the Indian Ocean and Darling Scarp that encompasses the main habitat for endangered *Banksia* woodland. This floristically rich but poorly understood Mediterranean-type ecosystem is being rapidly destroyed by urban, horticultural and industrial development. In order to partially ameliorate the damage being inflicted on *Banksia* woodland vegetation WA land developers have been required to purchase offsets of, often degraded, land to where topsoil from construction sites can be moved to help rehabilitate the damaged areas.

The aim of this project is to restore *Banksia* woodlands by optimising germination and survival of native species from the soil seed bank contained within transferred topsoil. The project is a part of an offset program associated with the development of the Jandakot Airport 25 km south of Perth city. In the first year, key research questions are focused on enhancing germination by varying depth of returned topsoil, ripping, fencing, weed control and experimental additions of smoke. Subsequent work will examine the survival and persistence of germinants including treatments such as provision of artificial shade. Assessing the efficacy of a spectrum of novel restoration technologies will provide new insights for environmental management of endangered plant communities.

Results/conclusions: Preliminary results will be presented at the conference.

Pawel Waryszak is a PhD Candidate at Murdoch University in Perth. His PhD project investigates topsoil seed bank ecology and its role in successful restoration of Banksia woodlands. Prior to commencing his PhD he worked as a research assistant at Macquarie University in Sydney.

Logs in fire-prone landscapes: fire history and landscape attributes influence resource availability following wildfire

Michelle Bassett[1], Evelyn K Chia[1], Steve Leonard[2], Euan G Ritchie[1], Michael F Clarke[2], Andrew F Bennett[1]
[1]Deakin University, [2]La Trobe University

Background/question/methods: Logs are an important structural and habitat component in forests. Changes to fire regimes from climate change and increased fuel-reduction burning are likely to alter the long-term availability of logs in forest landscapes. Large, severe wildfires are particularly expected to affect this resource. The disturbance history and landscape attributes of a site may also interact with fire to determine the abundance of logs. We sought to understand the relative influence of the severity of wildfire, time-since-fire, fire frequency, topographic position, and land management on the abundance of logs. We used a space-for-time design to survey 88 sites in mixed-species eucalypt forest 18 months after the 2009 Black Saturday wildfire.

Results/conclusions: Fire severity had a significant negative effect on the abundance of smaller logs (5-30 cm diameter) on dry slopes. In damp gullies, only the smallest logs (5-10cm diameter) were reduced by severe fire. Larger logs (>30cm diameter), which were more abundant in gullies than on slopes, were not significantly affected by fire severity. There was some evidence, however, that frequent fire reduces their abundance. Location within a national park had a positive effect on abundance of logs in all size-classes, and was an important predictor of the availability of logs with hollows. This study supports other work highlighting the importance of gullies for biodiversity, particularly under scenarios of hotter, drier conditions and increased fire severity. It also highlights the importance of understanding how disturbance processes and landscape mosaics interact to drive the availability of key habitat components.

Michelle Bassett is a PhD student investigating the effects of wildfire on mammals, with particular focus on what constitutes a 'refuge', and the role of refuges for sustaining native mammals. This work forms part of the Faunal Refuges Project, a collaborative project between Deakin and La Trobe Universities.

Mosaic burning, heterogeneity and plant diversity

Janet Cohn[1,2]
[1]University of Melbourne, [2]Collaborative Research Network

Background/question/methods: Mosaic burning is practised with the intention of reducing the incidence and/or intensity of unplanned fires in south-east Australia. Mosaic burning aims to create heterogeneous environments, which in theory have a positive effect on biodiversity. However, there has been little research to substantiate this. The aim of this study was to examine whether the heterogeneity produced by mosaic burning increases plant diversity. The study was undertaken from 2011-2012 in the Otways National Park, Victoria. Mosaics were defined by their heterogeneity in vegetation communities (e.g. heath, forest) and growth stage (time since last fire), with a score of 0 representing the lowest heterogeneity and 6 representing the highest heterogeneity. Floristic data were collected along 4x100m transects in each mosaic. There were 36 mosaics, each 100ha in area.

Results/conclusions: Early analyses suggest that there is a weak but positive relationship between plant diversity and mosaic heterogeneity. As mosaics become more heterogeneous in vegetation communities and growth stages, there is a corresponding increase in plant diversity. Disentangling the relative influences of these two factors on plant diversity will be discussed, as will the contributions of different plant life-forms and functional types to trends in plant diversity. These initial results suggest that burning the landscape in mosaics to create heterogeneity increases plant diversity, which may have flow-on effects to animal diversity, at least at the scale measured in this study.

Janet Cohn is currently a Research Fellow in the Department of Forest and Ecosystem Science at the University of Melbourne. Her research interests include examining how changes in disturbance regimes and climate influence plant dynamics at the landscape scale.

Concurrent session 3A
Disturbance, recovery and resilience

Understanding the hydrological responses of wetland plants for restoring wetlands degraded by altered flood regimes

Lyndsey Vivian[1], Robert Godfree[1]
[1]CSIRO Plant Industry

Background/question/methods: Disturbance regimes globally have been modified by human activities, necessitating a detailed understanding of species' responses to altered disturbances. We examine the hydrological responses of three wetland plants in the Barmah-Millewa Forest, south-eastern Australia. River regulation has reduced the duration of winter-spring floods and increased the frequency of shallow summer floods, resulting in loss of *Pseudoraphis spinescens* (Moira grass) grasslands—critical waterbird habitat—and the invasion of *Juncus ingens* (giant rush). *Typha domingensis* (cumbungi) has become restricted to the wettest areas. We investigate whether these changes can be explained by each species' response to experimental drought, submergence and saturated conditions in a 9-week glasshouse trial. Understanding these hydrological requirements will guide the management of flooding, including environmental flows, for *P. spinescens* recovery and *J. ingens* removal.

Results/conclusions: *P. spinescens* exhibited rapid stem elongation under submergence, but produced greater stem biomass in the drought and saturated treatments. Initially, *T. domingensis* produced many stems under submergence; however, these died after four weeks. In contrast, *J. ingens* biomass, stem numbers and height were constant across treatments, suggesting that only prolonged floods—such as those that occurred historically, often lasting 5-6 months—and very dry summers will reduce *J. ingens*. Although *P. spinescens* elongated rapidly when submerged, drier conditions were favourable for biomass and stem production, indicating that its hydrological requirements should be met by regular flooding, interspersed with dry or saturated periods. These findings demonstrate that experimental hydrological studies are valuable in understanding and predicting species' responses to different flood regimes, including environmental flows.

Lyndsey Vivian is a post-doctoral fellow at CSIRO Plant Industry. She is researching the resilience of floodplain communities and the use of environmental flows for restoring degraded wetlands as part of CSIRO's Water for a Healthy Country flagship.

How much food on the floodplain? The contribution of frogs to wetland productivity alters with flood size

Joanne Ocock[1], Richard Kingsford[1], Trent Penman[2], Jodi Rowley[3]
[1]Australian Wetlands, Rivers and Landscapes Centre, University of New South Wales, [2]Centre for Environmental Risk Management of Bushfires, Institute of Conservation, [3]Australian Museum

Background/question/methods: Floods are natural disturbances that drive and control the spatial and temporal distribution of floodplain biota until drought disturbances take hold. Floods connect and extend over tens of thousands of hectares of Australian floodplains, producing productivity 'booms' in waterbirds, fish, plants and invertebrates. While frogs are predicted to also respond, their contribution to the 'boom' is unknown. We quantified frog productivity (15 species) in response to flooding and its variation with flood size. Frogs were surveyed over three consecutive floods on up to 32 sites in the Macquarie Marshes, a Ramsar-listed wetland in the Murray Darling Basin. Floods included a small environmental flow release, a medium environmental flow and a large natural flood. We calculated biomass of frogs per 100 m^2 and then estimated productivity for the entire floodplain for each of the floods.

Results/conclusions: Species, habitat type and flood size influenced productivity. There was considerable frog biomass on the floodplain, providing resources for predators. Three species of terrestrial non-burrowing frogs contributed most to productivity of flooded areas. Frog productivity closely matched flood size. Major reductions to frequency and extent of flooding on rivers would have had major impacts on frog populations, and their value to high order predators such as waterbirds and reptiles.

Joanne Ocock is a final year PhD student. She is investigating amphibian ecology in Australian floodplain wetlands, and has experienced both 'droughts and flooding rains'.

The impact of spring burning on the home range of breeding scarlet robins

Sarah Kelly[1], Mike Clarke[1]
[1]La Trobe University

Background/question/methods: With an increasing demand for planned burning on public land in Victoria, this study was set in box-ironbark forest and investigated the impact of planned burning on a focal species, the scarlet robin *Petroica boodang*. Burning was undertaken during spring 2011 at two different levels of burn coverage (35-50% and 75-90%). Radio-tracking was employed to look at the direct impact of burning on scarlet robins, changes in areas used before and after burning and changes in foraging behaviour and nesting success. Burn coverage and severity was mapped for each home range to determine any influence on movement results. Scarlet robins were also tracked in unburnt landscapes to provide a reference for seasonal changes.

Results/conclusions: Twelve scarlet robins were tracked before and after burning. All were found to remain in or return to the same general location within the landscape after the burn disturbance although there were some small shifts in the location and extent of home ranges used post-burn. Nests were not abandoned and new nests were constructed in the post-burn landscape. During high intensity burning, scarlet robins were observed moving into adjacent unburnt forest. Scarlet robins have proven to be quite resilient to high coverage burning of their habitat, remaining in areas of >90% burn coverage and canopy scorch. This also suggests a strong territorial attachment. Contributing factors might include the close proximity of unburnt forest, abundance of invertebrates, recent good rainfall, competition for territories with other scarlet robins or breeding commitments.

Sarah Kelly is currently undertaking a PhD with the Zoology Department at La Trobe University. Prior to this she worked for the Department of Sustainability and Environment, Victoria, in the areas of biodiversity and fire management.

Trait shifts across rainfall contrasts in tropical and subtropical rainforests indicate plant adaptations to drought

Tim Curran[1,2,3], Peter Clarke[1], Nigel Warwick[1], Tim Farkas[2,4], Jeremy Bruhl[1]
[1]School of Environmental and Rural Science, University of New England, [2]School for Field Studies, Yungaburra, [3]Department of Ecology, Lincoln University, New Zealand, [4]Department of Ecology and Evolutionary Biology, University of Colorado, USA

Background/question/methods: Severe droughts are increasingly frequent in many parts of the world; a trend expected to continue due to global climate change. Consequently, it is important to understand plant adaptations to drought to understand how vegetation might be affected and how best to conduct restoration. One way to identify putative adaptations is to compare likely drought resistance traits within pairs of closely related taxa across habitats with contrasting rainfall patterns. The rainforests of eastern Australia are ideal for this as many such pairs can be found in the mesic coastal habitats and nearby inland dry regions. We measured drought traits such as leaf size (length, width, area), specific leaf area (SLA), leaf angle, water use efficiency (WUE), wood density (WD), wood water storage capacity (WC) in 11 pairs from the subtropics and nine pairs from the tropics.

Results/conclusions: The most common trait shift was in leaf size; dry rainforest taxa mostly had smaller leaves. Recent work elsewhere has suggested that smaller leaves have higher vein density and thus lower hydraulic vulnerability and greater drought tolerance. As expected, many dry rainforest taxa also had higher WD, lower SLA, more vertically held leaves and higher WUE, though different taxa had different suites of these traits. Preliminary analyses suggest wood traits were generally uncorrelated with leaf traits, suggesting alternative axes in drought resistance traits relating either to plant stems or leaf structure and function. These results help identify key drought traits that can be used to parameterise dynamic global vegetation models to predict consequences of climate change.

Tim Curran is a Lecturer in Ecology at Lincoln University, NZ. He is particularly interested in using plant functional traits to understand how plants survive extreme climatic events, such as drought, cyclones and frost, or other disturbances, such as fire, and using these findings in restoration ecology.

Alien turfgrass impacts on coastal seed banks: implications for community resilience

Ben Gooden[1], Kris French[1]
[1]University of Wollongong

Background/question/methods: Invasive species might influence the long-term resilience of native plant communities to environmental change by modifying the supply and storage of propagules in the seed bank. We tested the effects of *Stenotaphrum secundatum* (an alien, stoloniferous, C4 turfgrass) invasion on viable soil and litter seed banks of coastal swamp forest of eastern Australia using a seedling emergence experiment.

Results/conclusions: Overall, seed banks from *Stenotaphrum*-invaded forest had significantly lower native seed densities, fewer species and different compositions than non-invaded forest sites. Native species richness was unrelated to all other key disturbance variables within the community or surrounding landscape (e.g. fire severity, canopy openness, anthropogenic land use intensity or forest patch size), indicating that native species losses are likely to have been driven by *Stenotaphrum* invasion rather than coincidental or counfounding habitat disturbances. However, invasion had no effect on the density of native woody (tree and shrub) propagules in the seed bank, although a survey of standing vegetation found that invaded sites had 60% fewer woody recruits than native sites. Together, these data indicate that recruitment limitation of woody species, which are crucial to the maintenance of forest structural integrity, in invaded forest patches is driven by competitive suppression of juveniles, rather than reductions in the supply of propagules to invaded sites. We conclude that invasion can reduce community resilience by lowering the supply and/or storage of propagules in the seed bank, and that restoration efforts might require active replenishment of the seed bank or replacement of missing species following *Stenotaphrum* removal.

Ben Gooden is a current PhD candidate within the Institute for Conservation Biology and Environmental Management, University of Wollongong. Ben obtained his BSC (Hons) in 2007 on the effects of *Lantana camara* invasion on native plant communities, and has now shifted his attention to grass invaders.

Resilience of temperate reefs: response of *Ecklonia radiata* (common kelp) to disturbance, herbivory and nutrients

Paul Carnell[1], Mick Keough[1]
[1]Department of Zoology, The University of Melbourne

Background/question/methods: Understanding the resilience of ecosystems has become increasingly important as we seek to determine the impacts of anthropogenic disturbance and to identify thresholds of ecosystems. We ran experiments on the shallow reefs of Port Phillip Bay, Victoria. Here we identified two main threats to the resilience of algal dominated reefs: increased sea urchin abundances and increased nutrients. One experiment tested the hypothesis that increased numbers of the sea urchin (*Heliocidaris erythrogramma*) create sea urchin 'barrens' at different densities of *Ecklonia radiata.* We tested this by setting up permanent experimental plots with two crossed factors: urchin density (control and increased) and kelp cover (control, 50%, 0%). Secondly, we investigated the role of disturbance and increased nutrients on kelp bed (*E. radiata*) recovery. Here we set up experimental plots at three different locations, with two crossed factors of kelp cover (control and 0%) and nutrient level (control, increased).

Results/conclusions: Results so far demonstrate how increased *H. erythrogramma* densities can strip reefs of brown macroalgae, but surprisingly this took 12 months to occur. Eight months into our experiment on increased nutrients we have already seen some unexpected results in the way *E. radiata*, and also *Undaria pinnatifida* (the introduced Japanese kelp) have recruited into plots. Results demonstrate that these kelp-dominated communities can respond in both predictable and surprising ways, underlining the complexity of what makes ecosystems resilient.

Paul Carnell worked on the recruitment dynamics of sessile marine invertebrates in Port Phillip Bay as both an Honours student and a research assistant, before starting his PhD. Paul is now into the third year of his PhD and actively looking for a Post Doc.

Using biological soil crusts to assess condition of semi-arid ecosystems

Cassia Read[1], Jane Elith[1], Peter Vesk[1], David Duncan[2]
[1]University of Melbourne, [2]Arthur Rylah Institute for Environmental Research

Background/question/methods: Biological soil crusts (BSCs) are the community of lichens, bryophytes, cyanobacteria and algae that exist on the top few millimetres of soil in arid and semi-arid ecosystems. Total BSC cover is used as an indicator of ecosystem condition, due to the sensitivity of BSCs to physical disturbance and their functional importance in ecological processes such as soil stability. Despite recognition that BSC composition mediates BSC function, species are rarely included in site assessments, due to the challenge of confidently identifying these cryptic organisms. In response to this issue, Eldridge and Rosentretter (1999) devised a simple classification of species into morphological groups for use in rapid assessments of BSCs. The utility of morphological groups for assessment of site condition is largely untested. We present results from multivariate regression tree (MRT) analyses of two independent datasets from north-western Victoria, to evaluate morphological groups as indicators of site condition compared to species composition and total BSC cover.

Results/conclusions: Multivariate analyses show morphological groups have a strong response to site condition and general habitat preferences, whereas species respond most strongly to direct and indirect environmental gradients, such as soil chemistry. We conclude morphological groups provide a useful tool for rapid assessment of semi-arid ecosystems.

Cassia Read is a PhD student from the University of Melbourne working on biological soil crusts of north-western Victoria, Australia; specifically, their distribution, dynamics and role in ecosystem function.

An audit of riparian restoration: following a restoration trajectory or meandering through a changed landscape

Tricia Wevill[1], Florentine Singarayer[1]
[1]University of Ballarat

Background/question/methods: Riparian ecosystems are amongst the most degraded systems in our landscape and there has been substantial investment in their restoration. To maximise environmental outcomes, there is an urgent need to develop the 'science' of restoration, and to move from small-scale implementation to application of knowledge at a broader landscape scale. Here we report on riparian restoration efforts in the Corangamite and Glenelg Hopkins catchments in south-western Victoria, focusing on tree and shrub structure and composition. Within each catchment, three age classes were identified; <4, 4-8 and 8-12 years post-restoration, as well as pre-treatment sites. Reference (remnant) sites were used to determine whether there was evidence of a trajectory in vegetation development towards a historical reference state. The study region was also mapped using 1750s ecological vegetation classes (EVCs) to identify historical states.

Results/conclusions: Twenty-four EVCs were identified in the study region, providing a potential pool of 101 tree and shrub species. Vegetation structure was well developed by 4-8 years and most restoration sites contained a broader selection of tree and shrub species than occurred within the mapped EVC for the site. Hence, most sites do not replicate historic reference states and contain a subset of the species present in remnant sites. Community development is likely to occur over greater time spans than those represented by these sites and restoring to reference states may not be the desired objective in a changed landscape. Hence, if we are to detect restoration trajectories and understand how to restore ecological function, audits that encompass long-term monitoring are vital.

Tricia Wevill is currently working as a research fellow on an audit of riparian restoration in south-western Victoria.

Concurrent session 3B
SYMPOSIUM: Restoration of ecosystem functions

Maintaining and restoring critical green infrastructure in urban areas: what matters most?

Richard Hobbs[1]
[1]University of Western Australia

Background/question/methods: Cities are where most humans live, and many are growing rapidly in both size and population. They present important challenges and opportunities for the maintenance and restoration of ecosystem services and the conservation of biodiversity. They represent perhaps the most dynamic environments on the planet in terms of changing spatial and functional characteristics and intensive human use. There is increasing focus on cities as key places to maintain and improve ecosystem services because of their role as the primary human habitat. Similarly, urban biodiversity, overlooked until recently, is taking on greater importance as cities envelop more habitat and also increasingly become the main, or only, places most humans interact with nature. In this context, how can we best make decisions and prioritise actions in relation to biodiversity and ecosystem services in cities?

Results/conclusions: Cities vary greatly in their age, size, human population density and mode of development. Parks, gardens, nature reserves and other greenspaces are often cherished parts of the city environment or are now being recreated to provide open space, access to nature and/or ecosystem services. Conservation and service provision goals can be either synergistic or involve tradeoffs. Reconciling tradeoffs requires an assessment of priorities, limitations, opportunities and likelihood of success of various types of activity. I consider these factors in the context of examples from Australia and elsewhere.

Richard Hobbs is Professor of Restoration Ecology and Australian Laureate Fellow at the University of Western Australia. His research focuses on improving the science and practice of intervening in ecosystems to achieve conservation and restoration outcomes in a rapidly changing world.

Stormwater runoff and biodiversity benefits of green roofs

Jeremy Lundholm[1]
[1]Biology Department, Saint Mary's University, Canada

Background/question/methods: Green roofs are known to contribute to stormwater retention, but the effects of plant choice and plant species diversity on green roof hydrological performance are poorly understood. I report on several studies on different extensive green roof systems in a cold, humid maritime climate. Modular systems were planted with different species in monoculture, representing five life-form groups, as well as mixtures containing three species per life form, and mixtures of up to five life forms. Experimental addition of water was used to determine capture in the biodiversity experiments. In other experiments, stormwater runoff was quantified using flowmeters from green roofs with different growing medium depths, and relative retention under different soil moisture conditions and storm sizes compared.

Results/conclusions: Among monoculture treatments, there was up to 34% variation in capture of experimentally added water. The best life-form mixture treatments had 12% greater capture than the best monocultures. Stormwater capture was not related to above-ground biomass and some treatments had worse capture than growing medium-only controls. Stormwater capture was highly influenced by preceding growing medium conditions, where in general, drier media captured more water. This was influenced by the vegetation with higher water loss rates (total evapotranspiration) resulting in greater capture. This suggests that optimising stormwater retention requires attention to the trade-off between water usage and plant survival. Succulents commonly used in the green roof industry showed some of the best performance of roof cooling functions, but had some of the lowest stormwater capture values. This suggests that mixing succulents with other life form groups may optimise both functions. While different life form groups showed differential stormwater capture, there was also great variability within the plant groups. Trait-based analysis is ongoing and should further improve our ability to predict the hydrological performance of green roof vegetation.

Jeremy Lundholm is a plant ecologist who studies urban ecology, green roofs, and the role of spatial and temporal heterogeneity in species coexistence.

Living roofs restore hydrology but need more moisture to restore native plants and invertebrates

Robyn Simcock[1], Elizabeth Fassman[2], Richard Toft[3], Renee Davies[4]
[1]Landcare Research NZ Ltd, New Zealand, [2]Department of Civil and Environmental Engineering, University of Auckland, [3]Entecol Ltd, New Zealand, [4]Unitec Institute of Technology, New Zealand

Question/methods: Research aimed to identify the extent to which extensive living roofs (50 to 150 mm deep substrate) can mitigate stormwater runoff, support native flora, and provide habitat suitable for native skink and invertebrate species.

Storm water runoff, plant survival and growth, and invertebrate abundance and diversity indices (native and adventive) were quantified for two conventional roofs and adjacent living roofs over several years. Media temperature and near-ground temperature and humidity were measured for approximately 12 months.

Results: Living roofs retained 55 to 75% of storms >2mm depth on a volume basis. Vegetation cover was controlled by moisture deficit; only a narrow range of native plant species survived in full sun without irrigation. Irrigation increased the diversity and growth of NZ native plants on living roofs with 50 to 150 mm growing media.

Soil moisture, humidity and temperature and invertebrate prey species on the living roof indicate the specific requirements of skinks are present in densely vegetated places on one roof. In particular *Festuca* have a dense growth form that modifies temperatures. *Festuca*'s dense skirts of dead leaves also favour invertebrates. The self-introduced invertebrate community is strongly biased towards adventive species and ubiquitous native species typical of degraded anthropogenic habitats. However, the number of native invertebrate species has increased over 5 years with more mobile species (flies and winged beetles) recorded in later years. An indigenous living roof with dense vegetation cover may provide the environmental conditions required for skinks with addition of humid refuges.

Robyn Simcock is a soil scientist and ecologist. Her research focuses on design and performance of bio-retention devices (e.g. green roofs, rain gardens and swales) that attenuate impacts of storm water runoff and provide NZ ecosystems.

Ecological templates for selecting green roof plant species to improve ecosystem function

Claire Farrell[1], Christopher Szota[1], Stefan Arndt[1], Nicholas Williams[1]
[1]The University of Melbourne

Background/question/methods: Green roofs can improve ecosystem function in our cities. However not all plant species are able to survive their water limited conditions and appropriate plant selection is essential to optimise the ecosystem services provided. One approach is to select plants from natural habitats with conditions similar to green roofs; shallow soils and extreme drought. Another is to use plant species with morphological traits that confer drought tolerance. This paper presents results of a glasshouse experiment comparing these approaches.

We assessed drought tolerance of 20 species from four shallow soiled or dry habitats; rocky grasslands, granite outcrops, arid clay pans and coastal dunes. Five species with different life-forms were selected from each habitat (small shrub, prostrate shrub, herb, grass-like monocot and geophytes). Survival, growth and physiological measures (transpiration, leaf water potential and stomatal conductance) were used to determine drought tolerance. Morphological traits (specific leaf area, shoot:root, succulence and stomatal density) were also measured. Statistical analyses were done to relate drought tolerance to habitat, life-form and morphological traits.

Results/conclusions: All species had traits related to drought tolerance and demonstrated a range of physiological mechanisms for coping with water stress, including conservative and plastic water use strategies. As species that reduced water loss survived longer, stomatal density and shoot:root were important traits for determining drought tolerance. Geophytes and grass-like monocots were the most tolerant life-forms, and habitat was less important than life-form or morphological traits. Plant selection based on life-form and morphological traits will improve green roof performance and their provision of ecosystem services.

Claire Farrell is a Postdoctoral Researcher based at the University of Melbourne, Australia, working on green roofs for Australian conditions. Her current research evaluates drought tolerance and water use strategies of native Australian plants to improve the ecological functioning of green roofs.

The influence of green infrastructure on human health and wellbeing

Mardie Townsend[1]
[1]School of Health and Social Development, Deakin University

Background/question/methods: Aside from the obvious benefits of providing places for physical activity which is health promoting, research has demonstrated that the availability of urban green spaces is associated with better overall health status (Heerwagen 2009). Such spaces can provide relaxation and restore emotional equilibrium following difficult events (Korpela 2003), can reduce stress (Nielsen & Hansen 2007), can improve spiritual, emotional, neurological and psychological wellbeing (Campbell & Wiesen 2009, Maas et al 2009, Peacock et al 2007, Sacks 2009) and can foster cross-cultural communication (Dyment & Bell 2006; Seeland et al. 2009). More recently, the focus has moved from such a broad scale view of green infrastructure to the benefits of particular elements of green infrastructure. For example, research has highlighted the potential human health impacts of loss of biodiversity, and of the urban heat island effect.

Results/conclusions: This presentation will draw on evidence from research (both Australian and international) to highlight some of the key human health and wellbeing benefits of the restoration of ecosystem functions using green infrastructure, both broadly and more specifically defined. In particular, the presentation will highlight the effects on human health and wellbeing of restoration of biodiversity, mitigation of the urban heat island effect and provision of useable green spaces in urban areas.

Dr Mardie Townsend is an Associate Professor in Public Health in the School of Health and Social Development at Deakin University, Melbourne. Among her teaching and research interests are the health impacts of the interface between humans and the 'natural' environment, and of ecological and social

Interactions between plant species and nitrogen cycling dynamics within stormwater biofilters

Emily Payne[1], Tracey Pham[1], Tim Fletcher[2], Perran Cook[3], Belinda Hatt[1], Ana Deletic[1]
[1]Centre for Water Sensitive Cities, Department of Civil Engineering, Monash University, [2]Department of Resource Management and Geography, The University of Melbourne, [3]Water Studies Centre, Monash University

Background/question/methods: Plant species interactions with nitrogen cycling differ considerably across both natural and modified ecosystems. In stormwater biofiltration, studies have noted species performance across a spectrum from highly effective removal to net leaching. A lab-scale study using 20 Australian native plants and 2 lawn grasses was undertaken across 18 months to investigate nitrogen processes and influences of species on biofilter performance. The single-plant columns included designs with and without a saturated zone at depth, and were watered with semi-synthetic stormwater at frequencies replicating typical wet and dry periods. Analyses included effluent nitrogen concentrations and volume, plant growth and root morphology and use of 15-N NO_3^- tracer.

Results/conclusions: The presence of vegetation and incorporation of a saturated zone exceed the importance of plant selection in biofilter design for effective nitrogen removal. With a saturated zone, species variation was minimal under wet conditions, ranging from average concentration reductions of 79% to 93% total nitrogen, but from 12% to 78% following extended drying. Removal of nitrate demonstrated the greatest inconsistency, but organic forms of nitrogen also contributed to poorer performance following drying. Dry conditions favoured species with minimal evapotranspiration, particularly the lawn grasses. The highest performing native species consistently included *Carex appressa* and *Juncus pallidus*. The results suggest biotic assimilation in the upper filter layers is the primary fate of incoming nitrogen, despite suitable denitrifying conditions in the lower layers of saturated designs. Effective species characteristics appear to include high growth and a dense mat of fine roots concentrated in the upper filter layer.

Emily Payne is a PhD student in the Department of Civil Engineering at Monash University. Emily's research investigates the processes of nitrogen removal from stormwater in biofiltration systems, with a focus on the influence of plant species. Prior to this Emily worked at engineering consulting firm Sinclair Knight Merz.

Restoring catchment-scale water balance using stormwater retention and passive irrigation systems

Tim Fletcher[1], Christopher Walsh[1,3], Matthew Burns[2,3], Perrine Hamel[2,3], Darren Bos[1], Peter Poelsma[2,3], Robert James[1]
[1]Waterway Ecosystems Research Group, University of Melbourne, [2]Department of Civil Engineering and Centre for Water Sensitive Cities, Monash University, [3]Cooperative Research Centre for Water Sensitive Cities

Background/question/methods: The management of urban stormwater through conventional drainage degrades waterways through changes to flows and water quality. Restoration of the natural flow regime requires retention of stormwater runoff, using techniques such as stormwater harvesting and green infrastructure to promote evapotranspiration and infiltration. We investigated the impact of two infiltration raingardens on evapotranspiration, infiltration and stormwater runoff. We also measured the impact of the infiltration raingardens on surrounding soil moisture and thus on evapotranspiration in the landscape. In the second part of the study, we trialled a novel approach to rainwater harvesting at the household scale, placing the emphasis not only on water conservation but on restoring the natural 'runoff retention capacity' of the landscape, by providing a passive irrigation trickle outlet within the tank. Using these empirical studies, we ran catchment-wide modelling scenarios to determine the potential to restore pre-development water balance.

Results/conclusions: The raingardens we studied infiltrated greater than 95% of runoff, with less than 5% being evapotranspired. We expected that the impact of the raingardens on surrounding soil moisture (due to lateral infiltration) would increase ET in the surrounding area (lawn), but this was not the case, with soil moisture even in areas unaffected by the raingarden not limiting ET rates. The results mean that the use of such infiltration measures will likely result in elevated baseflows. Rainwater harvesting alone was also unable to reduce flow volumes to near natural, but when combined with passive irrigation draining to garden areas, ET and infiltration fluxes approach natural levels. We conclude that a carefully chosen suite of green infrastructure and stormwater harvesting is necessary to restore the hydrology of urban waterways; consideration about how to design urban areas to achieve this objective will also bring benefits in amenity, thermal comfort and biodiversity.

Tim Fletcher is an ARC Future Fellow at the University of Melbourne, with interest in the management of water and waterways. He has particular expertise in management of urban stormwater to provide a resource for humans and for the protection of aquatic ecosystems.

Gap detection in habitat networks: locating restoration areas in Greater Melbourne

Fatemeh Poodat[1], Colin Arrowsmith[1], Ascelin Gordon[2], David Fraser[1]
[1]School of Mathematical and Geospatial Science, RMIT University, [2]School of Global, Urban and Social Studies, RMIT University

Background/question/methods: In order to maintain viable populations, dispersal between discrete habitats is critical for some threatened and keystone species in highly fragmented landscapes. Approaches to the enhancement of biological dispersal are often plagued issues of suitability of scale and level of detail. By applying graph theory to existing empirical data about species movement characteristics and behaviour in urban environment, we have come up with a method to prioritise restoration for maximising network connectivity, and apply it within greater Melbourne. Species-specific network models comprising of nodes (location of habitats) and links (probability of dispersal between habitats) were developed for the lace monitor, the fat-tailed dunnart, the growling grass frog, and the southern brown bandicoot. The values of links in each network were systematically changed to determine the potential contribution of links in improving the connectivity of the entire network and links were then prioritised in terms of their contribution. Network gaps were delineated by identifying the links with greater connectivity that were located within a biologically reasonable distance.

Results/conclusions: We demonstrated certain locations within the region that allow greater opportunities to improve connectivity of each species networks. Spatial overlaps in the species gaps make joint restoration projects for two or three of the four species in each municipality, potentially allowing multi-species habitat management. Assessing the entire Melbourne metropolitan region and then identifying restoration priorities in each of the local municipalities, enables the influence of local restoration to be understood in a regional context while establishing restoration targets.

Fatemeh Poodat; is undertaking a PhD research at RMIT University. She holds a master in Landscape Design and Bachelor of Environmental Sciences. Her PhD projects focuses on introducing an ecologically realistic methodology in order to assess connectivity of urban landscape for biological processes.

Concurrent session 3C
Plant ecophysiology

Dieback of floodplain forest is associated with groundwater depth during drought

Jacqueline England[1], Shaun Cunningham[2], Swaminathan Theiveyanathan[3], Matthew Colloff[1]
[1]CSIRO Ecosystem Sciences, [2]Monash University, [3]Bureau of Meteorology

Background/question/methods: Stand condition of river red gum (*Eucalyptus camaldulensis*) floodplain forest has decreased dramatically across the Murray-Darling Basin due to altered flow regimes under river regulation and recent extended drought. An understanding of the drivers of this dieback is vital to the effective management of these floodplains. Potential environmental drivers of stand condition were investigated on the low rainfall floodplain of Barmah forest. We hypothesised that, in the absence of flooding, groundwater availability is a strong driver of stand condition. We measured forest structure, soil moisture depletion, tree water use and depth to watertable (groundwater depth) in twelve stands covering a representative range of stand conditions over a two-year period during the extended drought.

Results/conclusions: Soil moisture depletion above the watertable was similar among different stand conditions. However, there was evidence that additional water (groundwater) was sourced in good condition stands, including soil water extraction from the saturated zone up to 12m depth and tree transpiration in excess of rainfall. There was no evidence of groundwater use by poor or declining stands. In the absence of flooding, groundwater depth was found to be below 10m in stands with forest dieback. This suggests a critical groundwater depth below which forest condition decreases and managed floods should be applied.

Jacqui England is a Research Scientist with CSIRO in Melbourne. She has a background in ecology and ecophysiology of native and planted forests. Her research is largely focused on forest growth, carbon sequestration and water use in relation to environmental and management factors.

Linking branch hydraulics with leaf level adaptations to water stress in arid environments

Gerald Page[1], Jie Liu[2], Pauline Grierson[1]
[1]Ecosystems Research Group, School of Plant Biology, The University of Western Australia, [2]Multi-scale Earth System Dynamics Group, School of Earth and Environment, The University of Western

Background/question/methods: Reduced leaf size is often correlated to increased aridity, where smaller leaves demand less water via xylem conduits in the stem. However, it is unknown if differences in the three-dimensional (3D) connectivity of xylem conduits that supply water to the leaf also reflect other adaptations to water deficits. We used X-ray microtomography (micro-CT) to quantify 3D xylem connectivity in ~ 5mm diameter branch sections of three co-occurring *Acacia* species of differing phyllode morphologies form the Pilbara region of north-west Australia. We then compared their branch 3D xylem connectivity with a range of 2D hydraulic attributes, minimum branch water potential and instantaneous rates of water use. These data were then compared to the distribution of the three *Acacia*/phyllode types across landscape gradients of water availability in the Greater West Angelas area of the Pilbara region.

Results/conclusions: *Acacia* trees with terete phyllodes had less negative water potentials and lower rates of water use than broad phyllode variants. However, 3D xylem connectivity was conserved among all species and phyllode variants. 3D xylem connectivity was also sensitive to changes in the vessel lumen fraction (F) but not to the size to number ratio (S). Our results demonstrate that differences in phyllode anatomy, not xylem connectivity, likely explain diversity of drought tolerance among close related *Acacia* species. Furthermore, these results may also explain subtle differences in landscape distribution of these species.

Gerald Page is a PhD student in the Ecosystems Research Group in the School of Plant Biology at The University of Western Australia. His PhD research investigates the linkages between morphology, ecophysiology and landscape distribution of members of the Mulga complex (*Acacia aneura* and close relatives).

Finding drought tolerance in high water users: balancing conflicting aims in green roof plant selection

Christopher Szota[1], Claire Farrell[1], Nicholas Williams[1], Stefan Arndt[2]
[1]Department of Resource Management and Geography, The University of Melbourne, [2]Department of Forest and Ecosystem Science, The University of Melbourne

Background/question/methods: Green roofs represent an exciting opportunity to improve urban hydrology by using stormwater which otherwise has detrimental effects on aquatic ecosystems. To be effective, plants must have high transpiration following rain events; but also have a high capacity to tolerate extreme drought between events. We used a habitat-template approach to identify native Australian plants from shallow-soil and/or drought prone habitats which may be suitable for use on green roofs. 20 species of 5 life-forms (geophyte, herb, monocot, prostrate shrub and shrub) from 4 habitats (rocky grasslands, granite outcrops, arid clay pans and coastal dunes) were subjected to several consecutive wetting and drying cycles in the glasshouse, where soil matric potential dried down to an extreme level (<-10 MPa) between rewatering events. Soil water status (pot weight), plant water status (midday and predawn water potential), stomatal conductance (Li-6400) and leaf osmotic and elastic adjustments (pressure-volume analysis) were used to compare key drought-tolerance mechanisms of these 'drought adapted' plants with well-watered control plants.

Results/conclusions: All species demonstrated mechanisms associated with inherent drought tolerance; however, the capacity to adjust and cope with cyclic drought varied substantially between species and life-forms. Plant selection for green roofs poses a new challenge in searching for species with what are typically conflicting traits: high inherent drought tolerance and high rates of transpiration. Through using plants from shallow-soil and drought prone environments we have identified life-forms which can improve the functionality of green roofs and urban hydrology.

Christopher Szota is an early career scientist specialising in plant ecophysiology, specifically drought tolerance and nutrient uptake mechanisms in Australian plants. He is currently working on drought tolerance mechanisms of plants from shallow-soil environments to evaluate their potential for use on green roofs.

Characterising waterlogging stress in mature eucalypt trees in the Pilbara, north-west Western Australia

Rachel Argus[1], Timothy Colmer[1], Tim Bleby[1], Pauline Grierson[1]
[1]School of Plant Biology, University of Western Australia

Background/question/methods: The creeklines of the Pilbara region in north-west Australia typify extremes of environmental stress, where vegetation can experience alternating cycles of severe water deficit and waterlogging. While drought tolerance of dominant Pilbara species has been relatively well-studied, possible impacts of waterlogging on both riparian and floodplain vegetation remain poorly described. Altered hydrology associated with mining may also impact on native vegetation. Here, we investigated the response of riparian eucalypts to increased surface flows resulting from dewatering discharge (release of groundwater from below the mining pit to the surface) along a creekline in the Hamersley Ranges. Artificially flooded impact sites downstream of the discharge point were compared to a reference site upstream of the discharge with rare naturally occurring permanent surface water. The following hypotheses were tested: (i) mature eucalypts will be more stressed at impact sites than at the reference site, (ii) stressed eucalypts will be associated with soil hypoxia and (iii) *Eucalyptus victrix* trees (waterlogging tolerance not well-described) will be more stressed than the co-occurring *Eucalyptus camaldulensis* subsp. *refuglens* (known to be waterlogging tolerant). Stress symptoms of mature trees were assessed using estimates of canopy cover, leaf water potential and gas exchange characteristics, soluble sugar concentrations and isotopic analysis. Oxygen availability in the substrate was assessed with redox probes and the rusting of steel stakes.

Results/conclusions: Eucalypt canopy cover was reduced by 30% at artificially flooded sites compared to the reference site ($p=0.033$). There was no difference in canopy cover between *E. victrix* and *E. camaldulensis*. Canopy cover and height above water were correlated ($R^2=0.423$) only in artificially flooded sites. Stream-side trees growing in predominantly hypoxic soils had less than 50% of the canopy cover of those in non-hypoxic soils ($p=0.012$). Further studies will investigate the impacts of substrate type on waterlogging severity in Pilbara eucalypts.

Rachel Argus is from Perth, Western Australia, and completed a Bachelor of Conservation Biology and Management with honours at the University of Western Australia in 2009. She is currently in her third year of a PhD at UWA.

Thirsty plants in NZ? Water stress in six species native to New Zealand

Cate Macinnis-Ng[1], Sarah Wyse[2], Luitgard Schwendenmann[1]
[1]School of Environment, University of Auckland, [2]School of Biological Sciences, University of Auckland

Background/question/methods: On an annual scale, most of New Zealand receives plentiful rainfall. However, as the climate changes, summer droughts are becoming more frequent and severe, particularly in the north of the country. This imposes water stress on plants that are not well adapted to cope with or avoid drought conditions. In a shadehouse experiment, we investigated impacts of water stress on seedlings of six species native to the North Island of New Zealand; *Agathis australis*, *Coprosma grandifolia*, *Coprosma lucida*, *Corokia buddleioides*, *Geniostoma ligustrifolium* var. *ligustrifolium* and *Melicytus ramiflorus*. Treated seedlings of each species were allowed to dry progressively while control seedlings were watered to maintain saturated soils. We measured leaf gas exchange and stem water potentials after 7 weeks and 12 weeks of water stress, and continued to monitor plant wilting status and survival for an additional 10 weeks.

Results/conclusions: Sensitivity to water stress (indicated by declining stem water potentials) varied considerably among species, and there was a marked difference between the congeners *C. grandifolia* and *C. lucida*. Strategies of drought tolerance and avoidance also varied as indicated by stomatal conductance values. Rates of assimilation were significantly impacted in *C. grandifolia* and *M. ramiflorus* due to stomatal closure, and these species also displayed the greatest declines in stem water potentials. *A. australis, C. lucida* and *C. buddleioides* were the species least sensitive to water stress; able to maintain leaf turgor for the longest period of the imposed drought, whilst also displaying the lowest reductions in assimilation rates relative to the controls.

Cate Macinnis-Ng is a Research Fellow in the School of Environment at the University of Auckland. She works with Luitgard Schwendenmann on carbon cycling in kauri forests of NZ. Their student, Sarah Wyse is investigating the ecology of plant interactions in kauri forests.

Drought stress physiology of sclerophyllous broad-leaved trees assessed with the non-invasive magnetic turgor pressure probe

Martin Bader[1], W Ehrenberger[2,4], R Bitter[2,4], J Stevens[3], B Miller[3], J Chopard[1], S Rüger[4], G Hardy[5], P Poot[1], KW Dixon[3]
[1]School of Plant Biology and Centre of Excellence for Climate Change, Woodland and Forest Health, University of Western Australia, [2]Department of Biotechnology, University of Würzburg, [3]School of Plant Biology, University of Western Australia, [4]ZIM Plant Technology, [5]School of Biological Sciences and Biotechnology and Centre of Excellence for Climate Change, Woodland and Forest Health, Murdoch University

Background/question/methods: *Banksia* woodlands in south-west Australia are currently facing multiple threats, including fragmentation and drought- or temperature-induced mortality due to the region's changing climate.

We examined, in unprecedented detail, water relations in *Banksia menziesii* R. Br. trees using a novel magnetic leaf patch clamp pressure probe (ZIM-probe) that allows continuous, real-time monitoring of leaf water status. Several ZIM-probes were installed across the crown and complemented by sap flow and traditional ecophysiological spot measurements.

Results/conclusions: Drought stress manifested as increasing daily signal amplitudes. Drought stress symptoms occurred more often locally than across the entire crown. Diurnal recordings during summer showed that stomatal down-regulation of transpiration commenced in the morning when vapour pressure deficit (VPD) reached 2-2.5 kPa. This early reduction in stomatal conductance prevented midday balancing pressures from exceeding 2.5 MPa. During peak summer, water status in the east and north responded more strongly to VPD than in south and west. Sap flow response to VPD reached a saturation plateau at *ca.* 2.5 kPa coincident with the onset of stomatal down-regulation. Unexpectedly high spring temperatures preceded the sudden death of several *B. menziesii* trees, suggesting a temperature- or VPD-related tipping point causing rapid hydraulic failure as evidenced by collapsing ZIM-probe readings recorded on an affected tree.

The ZIM-probe's high sensitivity renders it an ideal tool for drought stress monitoring and evaluating adaptive forest and woodland management strategies. In a warmer and drier future, local mortality events in *B. menziesii* populations may occur more frequently with strong impacts on community structure and ecosystem functioning.

Martin Bader has a background in plant ecophysiology and extensive experience with modern statistical modelling techniques. Prior to his appointment as biometrician/ecophysiologist at the New Zealand Forest Research Institute, Martin has worked in Switzerland and Australia where his research focused on global change ecology, particularly terrestrial carbon cycling and plant water relations.

Back from the brink of extinction: improving success of endangered plant translocations in south-western Australia

Christine Allen[1,2], Pieter Poot[1,2], Rachel Standish[1,2], Michael Moody[1,2,3], David Coates[1,2]
[1]University of Western Australia, [2]Department of Environment and Conservation, [3]University of Texas

Background/question/methods: South-western Australia is one of 34 global biodiversity hotspots as a consequence of its diverse endemic flora that is threatened by human activity. The increasing number of highly threatened species occurring in small fragmented populations has led to the adoption of seedling translocation as a strategy to conserve species. This study used an experimental translocation to determine the optimal survival and growth conditions for the critically endangered *Acacia awestoniana* which is endemic to the Stirling Ranges National Park, south-western Australia. Seedlings were planted into field plots with two microhabitat types (either located <1m or >1m from mature *Eucalyptus wandoo* trees) to test with and without competition effects of mature trees. These plots were subject to one of three summer watering regimes (no, monthly and weekly watering). Survival, growth and physiological response of seedlings as well as soil moisture in plots were monitored at the site for two years.

Results/conclusions: Total seedling survival was high (78%) with no difference between microhabitats and watering regimes. Seedling growth was significantly increased in plots with weekly watering ($p<0.005$) and those located >1m from mature *Eucalyptus wandoo* trees ($p=0.01$). Infra red imagery was used to successfully detect levels of water stress in seedlings. This research coupled experimental treatments with morphological and physiological responses to provide an insight into some favourable environmental conditions for seedling translocations. Results will be used to inform future translocations and reduce the risk of species extinctions.

Christine Allen completed an undergraduate degree and honours at the University of Wollongong, NSW in 2007. She was amazed at the diversity of flora in south-west Australia after attending the ESA conference in Perth and began her PhD at the University of Western Australia in March 2010.

Spectral detection of stress-related pigments in samphires of Western Australia

Victoria Marchesini[1], Tim Colmer[1], Louis Moir-Barnetson[1], Erik Veneklaas[1]
[1]School of Plant Biology, The University of Western Australia

Background/question/methods: Wetlands in north-western Australia have significant national and international value since they sustain a large number of endemic samphire species (*Tecticornia* spp.) which have a particular aptitude to grow under saline, waterlogged, and dry conditions. In this study we investigate ecophysiological aspects of these succulent species using a combination of spectral measurements, pigment concentrations and environmental variables. We correlated samphire tissue pigment concentration (chlorophylls, carotenoids and betalains) in plants from the Pilbara region in Western Australia with climatic data for the years 2008-2011. We also determined the relationships between pigments and field spectroradiometer readings for *T. indica,* one of the dominant samphire species in WA.

Results/conclusions: Pigment concentrations and their temporal dynamics in samphire tissues varied considerably between species. Comparison of pinkish-red and green samphires revealed differences in pigment concentrations and in reflectance spectra of visible light, in particular between 500 and 700 nm. Spectral indices such as NDVI, red-edge NDVI and the Water Index correlated well with chlorophyll concentration and could be potentially useful to estimate this variable through remote-sensing. This methodology offers a rapid and reliable approach to describe the condition of natural ecosystems and evaluate the impact of human activities in marshes and other wetland ecosystems.

Victoria Marchesini is a biologist and I has a master and PhD in Ecology from the University of Buenos Aires. She has been working on ecohydrology of semiarid environments for the last 6 years and is currently a research associate in the School of Plant Biology, University of Western Australia.

Concurrent session 3D
Complex species interactions

The effects of mistletoe on insectivore occurrence: insights from a removal experiment

David Watson[1]
[1]Institute for Land, Water and Society, Charles Sturt University

Background/question/methods: Numerous studies have documented positive relationships between diversity and mistletoe occurrence, with a recent experimental study revealing that mistletoe removal caused mean losses of 35% of resident bird richness in grassy box woodlands. Rather than nectarivores or frugivores, the guild that exhibited the greatest change was insectivores, but the mechanisms underlying this response are unclear. Here, I quantify changes in canopy-feeding and ground-foraging insectivores in woodlands where all mistletoe was removed, comparing them with patterns in control woodlands to determine which group is more sensitive, and infer whether canopy or litter-dwelling arthropod assemblages are more influenced by mistletoe occurrence.

Results/conclusions: In terms of species richness, both canopy and ground-feeding insectivores exhibited similar responses, declining by 34% and 30% (respectively) three years after all mistletoes were removed. Changes in incidence were less marked, with 18% and 19% declines in the two groups. When only residents were considered (occurring in at least two of the four seasonal surveys), the ground foraging insectivores exhibited the greatest change, losing on average 37% of their initial species number. These congruent responses suggest both canopy and litter-dwelling arthropod assemblages are boosted by mistletoe presence, with the greater sensitivity of ground-foraging insectivores further highlighting the role of nutritional limitation in driving widespread declines in this group. As well as evaluating shortcomings with the five-year dataset, I consider the implications of these findings for the management of remnant, restored and replanted vegetation, with mistletoe potentially enabling persistence of resident insectivores in otherwise poor quality habitat.

David Watson is an ecologist with a long-standing interest in mistletoes. In addition to the ecology of parasitic plants, his research focuses on developing solutions to habitat fragmentation and managing biodiversity in agricultural landscapes.

Inter- and intraspecific body size affects microhabitat use in a macropod community

Sarah Garnick[1], Julian Di Stefano[2], Graeme Coulson[1], Mark Elgar[1]
[1]Department of Zoology, University of Melbourne, [2]Melbourne School of Land and Environment, Department of Forest and Ecosystem Science, University of Melbourne

Background/question/methods: Body size affects key life-history parameters including dietary requirements and predation risk. The Jarman-Bell principle has been used to explain these effects between species in communities, or within species that show sexual body size dimorphism; our study is the first to look for both effects within a community. We used body-size theory to predict microhabitat use throughout the diel period in a community of three sexually-dimorphic macropod species. We radio-tracked western grey kangaroos (*Macropus fuliginosus*), red-necked wallabies (*M. rufogriseus*) and swamp wallabies (*Wallabia bicolor*) in the Grampians National Park between November 2009 and March 2010 and recorded plant functional group cover and plant species IDs at locations used by foraging and resting macropods. We predicted that the larger animals (between and within species) should use microhabitats with more abundant, poorer-quality forage during foraging than smaller animals. During resting, smaller animals (between and within species) should use greater concealment cover than larger animals, as they are more vulnerable to predation.

Results/conclusions: Foraging western grey kangaroos and swamp wallabies conformed to predictions, but red-necked wallabies used more open, poorer-quality microhabitats than expected. Only western grey kangaroos showed a within-species effect of sex on microhabitat use, and females foraged in higher-quality patches. Microhabitats used by resting animals generally offered greater concealment cover than those used for foraging, but there were no clear body size effects. While body-size theory offers a good general model for understanding microhabitat use in our community, behavioural adaptations like group foraging may circumvent body size constraints.

Sarah Garnick is completing her PhD on multiscale resource use in the macropod community of the Grampians National Park, in western Victoria

Predicting the impact of invaders on mutualistic networks

Laura Russo[1], Jane Memmott[2], Katriona Shea[1], Yvonne Buckley[3]
[1]Biology Department, Pennsylvania State University, [2]Biology Department, Bristol University, [3]Biology Department, University of Queensland

Background/question/methods: There is a mutualistic relationship between entomophilous plants, which depend on insect vectors for pollination, and anthophilous insects, which obtain food resources from flowers. In many ecosystems, this mutualism between plant and pollinator species leads to a dynamic and complex network of interactions, as species are continuously being introduced and lost. Many have suggested that these networks could be used to direct conservation strategies, but little is known about how network properties will change after an invasion, nor how they relate mechanistically to the structure of the community. We explore several hypotheses of invader behaviour and compare our expectations to real communities with and without an invader.

Results/conclusions: We find that it is possible to predict the invader's impact on the system if the behaviour of the invader, and the state of the system prior to invasion, are known. In general, the impact of the invader increases as its number of interactions increases. More specifically, invaders tend to increase average degree and nestedness, but decrease connectance, average cluster coefficient, and the number of separate compartments, or subsets, of the web. These changes can be explained by the tendency of real invaders to draw in new pollinators, which in turn tend to visit mainly the invader, and by the fact that the invader tends to have a much higher frequency of interactions than native species in this community. Overall, invaded communities appear to be more ordered, but less connected and less compartmentalised, than the community prior to invasion.

Laura Russo is a graduate student finishing her PhD at the Pennsylvania State University. She specialises on complex interactions within ecological communities, with a focus on mutualisms. She collaborates with Yvonne Buckley at the University of Queensland in Brisbane.

Invasive species interactions over multiple trophic levels: rabbit grazing impacts soil fauna in the sub-Antarctic

Aleks Terauds[1], Steven Chown[2], Dana Bergstrom[1]
[1]Terrestrial and Nearshore Ecosystems, Australian Antarctic Division, [2]School of Biological Sciences, Monash University

Background/question/methods: The rabbit population on sub-Antarctic Macquarie Island has fluctuated over the last 150 years with one of the most significant periods of increase between 2000 and 2008. Rabbit impacts on vegetation are relatively well-known but flow-on effects over multiple trophic levels have not been quantified. To investigate the impact of rabbit grazing on the underlying soil fauna community, we sampled 45 sites across the island (300+ samples) from a range of pristine habitats in 2001-02. The same sites were sampled again in 2008-09. The significant increase in rabbit numbers between the two sampling events meant that sites had a variety of grazing impacts, ranging from the complete destruction of overlying vegetation to little or no damage.

Results/conclusions: Rabbit grazing profoundly altered the composition, abundance and diversity of the underlying springtail communities. Heavily grazed sites not only showed a significant decrease in abundance and species richness, but also showed a change in species composition. The ratio of introduced to indigenous species in the soil fauna also co-varied with the level of grazing. Given that previous work has highlighted the importance of species identity in structuring soil fauna community composition, these results have important implications for broader ecosystem functioning and vegetation succession following the recent removal of the rabbits from Macquarie Island. This study is one of the first to comprehensively quantify introduced species interactions over multiple trophic levels in a natural environment and has relevance to the broader understanding of invasive species impacts, interactions and their management globally.

Dr Aleks Terauds is a spatial ecologist at the Australian Antarctic Division. He is interested in modelling patterns of diversity in the sub-Antarctic and Antarctic regions and clarifying physical-biological linkages in these environments, with an emphasis on invasive species effects and conservation planning.

Biotic interactions matter under climate change: evidence from an alpine heathland

James Camac[1], Dick Williams[2], Henrik Wahren[3], Ary Hoffmann[4], Peter Vesk[1]
[1]Centre of Excellence for Environmental Decisions, The University of Melbourne, [2]CSIRO Sustainable Ecosystems, [3]Research Centre for Applied Alpine Ecology, La Trobe University, [4]Bio21 Institute, Department of Genetics, The University of Melbourne

Background/question/methods: The effects of global warming on species should be examined in conjunction with other factors such as biotic interactions (e.g. competition/facilitation) and disturbance regimes. For instance, does competition and disturbance exacerbate or negate the effects of warming? This question is particularly relevant to Australian alpine landscapes, which are vulnerable to global warming, likely to experience an expansion of shrubby vegetation, and may experience more frequent fires. Here we examine the effects of experimental warming on growth rates of dominant alpine shrubs and whether factors such as competition and disturbance interact synergistically or antagonistically with warming. We addressed these questions by passively raising average growing season temperatures by 1.5°C using open-top chambers in two experiments in open-heathland. The first was a medium-term warming experiment established in 2003 on pre-existing vegetation in areas that were either burnt or unburnt by the 2003 bushfires. The other transplanted seedlings of four dominant alpine shrubs into experimentally burnt plots.

Results/conclusions: In the transplant experiment, there were strong, positive responses to warming in seedlings of dominant shrub species, but not in sub-dominant species. In both experiments, shrub growth rates decreased with increasing cover of surrounding snowgrass, and/or increasing proximity to snowgrass tussocks. In some cases this competition effect completely negated the warming effect. Projections of ecosystem response to climate change must account for disturbance and interactions between constituent species. Mitigation of a major, potential effect of climate change—shrub expansion—will involve managing alpine ecosystems to maximise the cover of alpine forbs and grasses.

James Camac is a PhD candidate within the Centre of Excellence for Environmental Decisions at The University of Melbourne. His current work is examining interactive effects of climate change, disturbance and species interactions. For more information visit: www.jscamacresearch.wordpress.com

Managing invasive plants on remote oceanic islands with complex species interactions

Justine Shaw[1]
[1]Environmental Decision Group, University of Queensland and Australian Antarctic Division

Island eradications have been successful across the world, however, most efforts have focused on vertebrate pests. Here I examine the management of invasive plants on oceanic islands scattered across the Southern Ocean. There are 22 oceanic islands between latitudes 37°S and 55°S including Australia's Macquarie and Heard Islands. These islands display high floral endemism and support few woody plants. They represent some of the most remote landmasses in the world with no permanent human inhabitants. All are nature reserves, yet approximately 185 non-native species have established. Invasive plants on these islands are known to threaten biodiversity. To date there have been 21 recorded management actions to control or eradicate non-native plants on Southern Ocean islands, which have had varied success.

Here I examine and describe the management actions and species that targeted in plant eradications across the region to date. I clarify the role of species traits, taxonomy, abundance and distribution in driving these invasions. New data from a long-term study (30 + years) of the invasive weed, *Poa annua* on Macquarie Island is presented to illustrate the complexity of managing invasive species. *Poa annua* management on World Heritage Heard Island where this grass is the only non-native plant present is also examined. I show how invasive herbivores can have a confounding influence on invasive plants and discuss the complexity of multiple invasive species interactions. The different responses of invasive plants to rabbit eradications across islands and the underlying reasons for this are also discussed.

Dr Justine Shaw is a postdoctoral fellow at the Environmental Decision Group UQ and the Australian Antarctic Division. She research the impact of invasive species on sub-Antarctic Islands and is particularly interested in multiple species interactions.

Wildlife in weeds: impacts and their implications

Emma Carlos[1], Michael Weston[1], Maria Gibson[1]
[1]School of Life and Environmental Sciences, Deakin University

Background/question/methods: Weed invasion is a significant threat to global biodiversity. In response, weed control is conducted, but often with little understanding of how invasions impact other species, in particular their impact on wildlife. This study examined the impacts of weed invasions on bird assemblages in two separate ecosystems in south-eastern Australia. Bird assemblages in invaded and un-invaded habitats were compared in a woodland invaded by boneseed *Chrysanthemoides monilifera* ssp. *monilifera*, and a coastal wetland ecosystem invaded by emergent boxthorn *Lycium ferocissimum*. In addition, specific birds were modelled with vegetation aspects to describe which influenced them most.

Results/conclusions: Bird assemblages were different between invaded and uninvaded areas only when the vegetation was structurally different. In the woodland ecosystem, the most common birds were strongly influenced by changes in canopy complexity that coincided with changes in shrub cover, not by the cover of boneseed. A similar pattern occurred in the wetland, where birds were influenced by the emergent nature of the boxthorn. Whether these responses were positive or negative was species dependent.

Incorporating wildlife into the monitoring process that is currently recommended before, during and after weed management would clarify important weed-wildlife interactions and allow for adaptive management that accounts for wildlife.

Emma Carlos is completing the final year of her PhD at Deakin University. Her research has focused on the habitat value of weeds for wildlife. This has involved observational and experimental studies, as well as social research, forming a holistic examination of the ecological and management issue that surrounds weed-wildlife interactions.

Concurrent session 3E
Biogeography and macroecology

Proteaceae are the world's most important clade for ecology

Mark Westoby[1]
[1]Department of Biological Sciences, Macquarie University

Proteaceae (ca 1600 species) have long been admired in the southern hemisphere as a clade that reflects the biogeographic history of Gondwana — a heritage clade for botanical sightseers to contemplate. A new global data synthesis now indicates that Proteaceae are actually the most important thing that has happened in the history of angiosperms -- important in the sense of having largest consequences for present-day ecology. A working group has mapped 5 plant ecological traits onto molecular phylogeny across nearly 50,000 species, about a 20-fold scale jump from the previous largest synthesis. A Kolmogorov-Smirnov Index measures how much difference each clade makes to the overall frequency distribution of each trait. On this K-S Index, Proteaceae are the top-ranked clade contributing to spread of ecological strategies worldwide for both SLA and leaf N. If not for Proteaceae, the global leaf economic spectrum would be markedly narrower.

Mark Westoby has been active in Australian ecological research since 1975. His interests include plant demography, vegetation dynamics on rangelands, ecological strategies and evolution of traits.

The relationship between small-scale environmental heterogeneity and plant species diversity: a macroecological approach

Riin Tamme[1], Antonio Gazol[1], Meelis Pärtel[1]
[1]Institute of Ecology and Earth Sciences, University of Tartu

Background/question/methods: Environmental heterogeneity is a concept often used to explain species diversity. A positive heterogeneity-diversity relationship is predicted by niche limitation theory, but this relationship has been found to vary with spatial scale (i.e. grain of heterogeneity or the size of patches). A small grain size often results in a negative heterogeneity-diversity relationship. Small patch size has a direct influence on plant individuals, possibly altering species interactions. We examine how environmental heterogeneity determines small-scale plant species diversity and if the same relationship applies to temperate grasslands in different parts of the world—Estonia, Iceland, Spain, Mongolia and Australia. Data were collected on variables of soil moisture, light availability, and species richness in small-scale plots (10 x 10cm) arranged in 2m long transects. For each transect, we estimated heterogeneity (coefficient of variation) as well as mean values of soil moisture and light availability. We used linear mixed models to explain species diversity.

Results/conclusions: Species diversity was positively related to heterogeneity in light availability (e.g. Estonia and Iceland), whereas soil heterogeneity had more often a negative effect on species richness (e.g. Iceland and Australia). We found that the relative role of environmental heterogeneity in explaining species richness patterns varies across the globe. Different evolutionary histories of the countries as well as differences in human influence may reveal the possible mechanisms for this inconsistent pattern. In addition to positive heterogeneity-diversity relationship, negative relationships can emerge, especially at small spatial scales.

Riin Tamme is a PhD student in University of Tartu, Estonia. Her main topic is focused on the relationship between environmental heterogeneity and plant species diversity.

Are species at low latitudes more likely to be spinescent: a two-pronged approach

Marianne Tindall[1], Shawn Laffan[1], Angela Moles[1]
[1]University of New South Wales

Background/question/methods: Many ecologists believe that plants should be better defended at lower latitudes. This prediction is based on the idea that there is more intense herbivory at low latitudes and this increases selection for defences against herbivores. Several tests of this idea have been made for chemical defences, but far less attention has been paid to physical defences and the empirical evidence is mixed. In this study, we quantify the latitudinal gradient of the proportion of species with spines using two datasets. First, using data for 5000 plant species from across Australia, and second, using data for over 500 species from transects along the west coast of North America.

Results/conclusions: Random effects logistic regressions show no latitudinal gradient in spinescence. This finding contradicts the accepted predictions about latitudinal gradients in defence. This large-scale study contributes to our understanding of plant defence distribution, the factors shaping these distributions, and the certainty with which we predict them.

Marianne Tindall is a fourth year student at University of New South Wales currently completing her honours in ecology.

Woody thickening of savanna ecosystems in northern Australia

David Gillieson[1], Robyn Cowley[2], Jeff Silverman[3]
[1]James Cook University, [2]NT Department of Regional Development, Primary Industry, Fisheries and Resources, [3]TerraGlobal Capital Pty Ltd

'Woody thickening' and 'bush encroachment' are world-wide phenomena of grassy ecosystems. A multidisciplinary Savanna CRC project studied woody thickening in northern Australia at over 400 sites in the Kimberleys, Victoria River District and Cape York Peninsula. Available data indicate that where woody thickening occurs it tends to be gradual, with substantial changes occurring over 10-30 year time spans. Estimates from serial aerial photography show increases in shrub cover ranging from 20 to 40% over a fifty-year period. At each field site measurements of tree basal area, tree and shrub height, canopy area and species dominance were made. Data on fire history were also collected. Various field measures of shrub cover were correlated with vegetation indices derived from ASTER and SPOT satellite imagery. Significant results were obtained for several vegetation indices. These results support development of broad scale monitoring of woody thickening using satellite data across northern Australia.

Background/question/methods: How extensive is woody thickening in northern Australian savannas? How fast has it happened and what are the environmental correlates of thickened savanna vegetation? Can woody thickening be detected using satellite imagery?

Results/conclusions: Woody thickening is present in many areas of the northern Australian savannas and represents a major change in ecosystem structure. Available evidence suggests that it has occurred over timescales of 10-30 years and relates to changes in wet season rainfall, and fire frequency and season. Increases in shrub cover of between 20 and 40% have been detected using a time series of stereo aerial photography. Although this method provides a reliable way of detecting woody thickening, detection using vegetation indices from satellite imagery is a more cost effective method over large areas.

David Gillieson's research is focused on using GIS and remote sensing to support natural resource management in tropical Australia and adjacent regions. He has used satellite and aerial imaging coupled with field surveys to assess structural change in woody vegetation in northern Australian savannas.

Variation in body size and insulation in koalas—how does it relate to climate?

Natalie Briscoe[1], Kathrine Handasyde[1], Andrew Krockenberger[2], Warren Porter[3], Michael Kearney[1]
[1]Department of Zoology, University of Melbourne, [2]School of Marine and Tropical Biology, James Cook University, [3]Department of Zoology, University of Wisconsin, USA

Background/question/methods: Many species exhibit geographical variation in morphological traits such as body size and insulation. For endotherms, traits such as body size and insulation influence the range of environmental conditions under which an individual is able to maintain their body temperature within physiological limits, while also influencing the energetic and hydric costs of doing so. We quantified geographic and sexual variation in body size and fur characteristics of the koala, *Phascolarctos cinereus,* one of Australia's most broadly distributed marsupials. We then examined the relationship between indices of body size and fur characteristics and a range of climate variables that reflect both average and extreme conditions, as well as energy and water availability. We also evaluated the impact of morphological variation on predicted survival, energy and water requirements using a biophysical model of heat exchange in koalas.

Results/conclusions: The level of insulation provided by koala pelts varied considerably across their range and correlates strongly with climate; dorsal fur depths in koalas from warm northern regions in Queensland were less than half that of koalas from cool southern Victoria. Head length also varied considerably along a north-south cline and correlated with climate variables, although these patterns were more complex. The combined effect of this morphological variation on predicted energy and water use of koalas is substantial and helps this species persist across such a broad climatic range.

Natalie Briscoe is a final year PhD student investigating how climate constrains the distribution of koalas and predicting the impact of future climate change. She adopts a mechanistic approach, integrating morphology, physiology and behaviour of a species with information on its climatic environment.

Does size matter? Species selection and mammalian body size evolution

Richard FitzJohn[1,2], Sarah Otto[1]
[1]Macquarie University, [2]University of British Columbia

Background/question/methods: There are many more small species of mammals than there are large ones. This basic observation is surprising given evidence that body sizes tend to increase over time. We test the hypothesis that the distribution of mammalian body sizes is generated by a conflict between species selection favouring small species versus the tendency for individual lineages to increase in body size over time. We use novel phylogenetically explicit Bayesian methods to jointly model trait evolution and its effect on speciation rates across 10 major clades spanning 97% of extant mammals.

Results/conclusions: There was little evidence for a single consistent relationship between body size and speciation rate; four clades showed the expected pattern (species selection against large species), four showed the opposite pattern (species selection against small species), and two clades had no significant speciation/body size relationship. In contrast, we found strong evidence for clade-specific differences in speciation rate that were not linked to body size.

Richard FitzJohn has just completed a PhD developing phylogenetic methods for investigating trait-dependent diversification at the University of British Columbia. Prior to this he investigated potential risks of GMOs (Landcare Research) and ecophysiology (Victoria University of Wellington).

Home range and body mass patterns: are all mammals equal?

Marlee Tucker[1], Terry Ord[1], Tracey Rogers[1]
[1]Biological, Earth and Environmental Sciences, University of New South Wales

Background/question/methods: Among mammals there is a strong positive relationship between body size and the area they use (home range) which is influenced by the costs associated with an animal's metabolic needs and locomotion. Re-entering the marine environment altered metabolic costs for mammals, and importantly, relaxed the cost of locomotion with buoyancy making mobility more energy efficient. Marine mammals attained great size and represent some of the largest mammals on earth, yet they were not included in models that describe our understanding of the relationship between mammalian body size and spatial use. To fill this important gap in our knowledge 312 mammals, including both marine and terrestrial representatives, were used to examine how home range and body size scale.

Results/conclusions: The home ranges of marine mammals are 60 times larger than terrestrial mammals of a similar mass, irrespective of phylogeny. The nature of the marine environment, which is fluid and dynamic, has altered the behaviour of marine mammals by relaxing energetic costs. The positive relationship between body size and home range was similar between marine and terrestrial mammals but the inclusion of physical environment (either marine or terrestrial) was an important driver in models describing trends, as the relationship for marine mammals shifted an order of magnitude higher. With the continued changes in spatial use of mammals caused by human land use and climate change, it is important to further our understanding of the drivers behind mammalian spatial behaviour.

Marlee Tucker is an ecology PhD student at the University of New South Wales. Her work encompasses macroecological patterns in mammals, specifically changes in home range patterns that have occurred with the invasion of the marine environment. This work contributes to our understanding of ecological patterns and potential future changes.

Biogeography in glaciated landscapes: the historical context of ecological and evolutionary divergence in the spotted snow skink (*Niveoscincus occelatus*) across Tasmania

Erik Wapstra[1], Hannah Cliff[1], Chris Burridge[1]
[1]School of Zoology, University of Tasmania

Background/question/methods: The spotted snow skink is distributed across a broad range of environments, from temperate coastal lowlands to isolated alpine mountain ranges in Tasmania. Across this range the species exhibits divergence in key traits such as age and size at maturity, modes of sex determination, and thermal physiology. Understanding the biogeographical history of populations is essential to partitioning the contributions of genetic variation and environmentally induced phenotypic plasticity to the divergence in these traits. More than 30 populations were sampled from across the entire species range, encompassing multiple lowland and high elevation zones. Lowland sites may represent potential glacial refugia, from which high elevation populations were recolonised following deglaciation. Relationships among populations were reconstructed using phylogeographic analyses of DNA sequence variation in mitochondrial (ND2, ND4) and nuclear (β-globin, β-fibrinogen, Rhodopsin and LC17/LC18) DNA.

Results/conclusions: The populations we sampled showed significant genetic divergence in both mitochondrial and nuclear genes with congruence among genes, but greater resolution from mitochondrial DNA. Alpine populations exhibited close relationships to adjacent lowland sites (putative refugia), with larger alpine regions (e.g. the Central Plateau) having composite genetic origins reflecting multiple recolonisation sources. These results are interpreted in terms of our knowledge of ecological and evolutionary divergence among populations across environments. Understanding the historical geographic relationships among these populations and historical routes and rates of movements between them is of particular interest in predicting their abilities to track changes in distribution under climate change. Our niche-based spatial distribution models of this species under climate change projections suggest significant range shifts and contraction into higher elevation zones in the next 100 years and our phylogeographic analyses reveal the potential of the species to make these shifts.

Hannah Cliff completed Honours at the University of Tasmania in October 2012. Hannah's broad interests lie in understanding the links between evolutionary processes, distribution patterns and landscape history, especially in the context of constrained landscapes (e.g. islands). Hannah is looking to gain further field experience, before pursuing future study.

Concurrent session 3F
Community assembly, diversity and dynamics

A new solution to a perennial problem: predicting species abundances using intraspecific trait variation

Daniel Laughlin[1], Chaitanya Joshi[1]
[1]University of Waikato

Background/question/methods: Environmental filtering tends to increase the functional similarity of species within communities leading to trait convergence, whereas competition tends to limit the functional similarity of species within communities leading to trait divergence. Unifying these antagonistic processes into a predictive theory of community assembly is required to improve our ability to mechanistically forecast species distributions. We have developed a new hierarchical Bayesian model that incorporates intraspecific trait variation into a predictive framework. The model emulates the process of environmental filtering by centring the samples on the expected mean trait values leading to trait convergence, but also incorporates limiting similarity because it represents the range of trait values that are possible within a given environment leading to trait divergence. In other words, the model maximises trait dispersion within the boundaries of the empirical environmental filter.

Results/conclusions: We tested the model along a 10°C gradient in mean annual temperature. The model explained a significant proportion of variation (44%) in species relative abundances, predicted the correct dominant species half the time, and accurately reproduced species' temperature optimums. The framework is generalisable to any ecosystem as it can accommodate any species pool, any set of functional traits, and multiple environmental gradients, and it eliminates some of the criticisms associated with recent approaches (e.g., the MaxEnt model). Incorporating intraspecific trait variation is the key to reconciling antagonistic processes of trait-based community assembly, and predicting species abundances can be accomplished without knowing or predicting community-weighted mean traits.

Daniel Laughlin is a senior lecturer of plant ecology at the University of Waikato. He received his doctorate in Forest Science in 2009 from Northern Arizona University. His research focuses on developing and testing predictive theories of community assembly using a functional trait-based approach.

Is there an ecological basis for species-abundance distributions?

Jian Yen[1], Ralph Mac Nally[1], James Thomson[1]
[1]Australian Centre for Biodiversity, School of Biological Sciences, Monash University

Background/question/methods: The species-abundance distribution (SAD) has been a focus of community ecology for almost a century, but there is no consensus on what causes the ubiquitous hollow-curve shape. Species-abundance distributions also are implicated in many ecological theories (e.g. niche and neutral theories), with the implicit assumption that SAD shape directly reflects ecological processes (e.g. resource partitioning, dispersal limitation). We tested this assumption directly, relating avifaunal SADs from the box-ironbark region of central Victoria to environmental covariates. We predicted that the processes driving SADs would leave a signature on the observed SAD, and that SADs would be correlated either spatially or with environmental factors. A Poisson-lognormal model was fitted to SADs, and the parameters of this model were interpreted as measures of SAD scale (abundance) and SAD shape (evenness). A Bayesian conditional autoregressive model was used to relate these scale and shape parameters to environmental variables.

Results/conclusions: Environmental variables and spatial autocorrelation were good predictors of variation in SAD scale, but neither environmental nor spatial factors were able to predict variation in SAD shape. By separating scale and shape, we found that SAD shape, which is the main focus of SAD studies, may have no ecological basis; SAD shape may be a statistical artefact. If this is a general result, SADs will contain little ecological information and cannot be used for testing ecological theories. Ecologists may need to look beyond ecology to explain the hollow-curve SAD shape.

Jian Yen is completing his PhD at Monash University, focusing on the role of energy in generating macroecological patterns. His work combines empirical and theoretical approaches and draws on the methods of non-equilibrium thermodynamics.

Functional diversity across multiple land uses: interpretations of redundancy depend on functional group identity

Gary Luck[1], Andrew Carter[1,2], Lisa Smallbone[1]
[1]Institute for Land, Water and Society, Charles Sturt University, [2]Ecology Consultants Pty

Background/question/methods: Examinations of the impact of land-use change on functional diversity (FD) link changes in ecological community structure driven by land modification with the consequences for ecosystem function. Most studies on this issue have been small-scale, experimental analyses: large-scale analyses across multiple land uses are lacking. We assessed changes in the FD of bird communities using 10 years of data collected across 24 land uses aligned along an intensification gradient. We tested the hypothesis that FD is higher in less developed landscapes, documented changes in diversity using four FD metrics, and identified levels of functional redundancy.

Results/conclusions: FD, measured using a dendogram-based metric, increased from high to low intensity land uses, but the observed values of FD did not differ significantly from randomly-generated expected values. In contrast, values for functional evenness (FEve), divergence (FDiv) and dispersion (FDis) had an inverse relationship with intensification and more often differed from expected values (e.g. 16 land uses had lower than expected values for FDis). Relations between FD and bird species richness (SR) yielded strikingly different patterns for the entire community vs particular functional groups. For all birds and insectivores, FEve, FDiv and FDis showed a linear decline with increasing SR suggesting substantial functional redundancy across communities. However, for nectarivores, frugivores and carnivores, there was a significant hump-shaped or non-significant positive linear relationship between FD and SR indicating a lack of redundancy. Interpretations of redundancy thus vary for different functional groups and related ecosystem functions (e.g. pollination), and can be starkly different to relationships involving entire ecological communities.

Gary Luck is Associate Professor for Ecology and Environmental Management at Charles Sturt University. Andrew Carter is a Principal Ecologist and co-founder of Ecology Consultants P/L. Lisa Smallbone is completing her PhD at Charles Sturt University on bird use of regrowth sites.

Mycorrhizal fungal communities along a soil age gradient in a plant biodiversity hotspot

François Teste[1], Etienne Laliberté[1], Hans Lambers[1], Kingsley Dixon[2], David Read[3], Michael Bunce[4]
[1]School of Plant Biology, The University of Western Australia, [2]Kings Park and Botanic Garden, [3]Department of Animal and Plant Sciences, The University of Sheffield, [4]School of Biological Sciences and Biotechnology, Murdoch University

Background/question/methods: In the absence of major disturbances over millions of years, soils become impoverished in nutrients, especially phosphorus. Mycorrhizal fungi are known to enhance phosphorus acquisition by plants, but there is evidence that this strategy becomes ineffective in extremely weathered soils, where non-symbiotic cluster-rooted plant species dominate. Along the Jurien Bay sand dune chronosequence in Western Australia we established permanent vegetation survey plots and fungal ingrowth cores to determine links between the aboveground community composition and diversity and the belowground fungal communities. We extensively sampled soil and roots from April to August to determine spore density of arbuscular mycorrhizal (AM) fungi and ectomycorrhizal (EM) colonisation. Also, using high-throughput DNA typing techniques (454 pyrosequencing) and fungal biomarkers, we started determining the composition and production of mycorrhizal fungal communities along this long-term soil age gradient in a global plant biodiversity hotspot.

Results/conclusions: Current results show that AM spore density decreased steadily from 90 000 spores m^{-3} in the young Quindalup dunes to 55 000 spores m^{-3} in the old Bassendean dunes. Mycorrhizal colonisation was generally low but peaked to 15.0% in the medium-aged Spearwood dunes and then dropped again to 9.1% in the Bassendean perhaps due to antagonistic effects of abundant cluster-root Proteaceae plants. However, the old Bassendean dunes harboured the greatest EM fungi richness and diversity. Mycorrhizal community composition and production is expected to follow similar trends. This research will deepen our understanding of the relevance of mycorrhizal diversity for plant nutrition and plant species coexistence.

François Teste's research is mostly field based, assisted by cutting-edge nutrient tracer (quantum dots, isotopes), molecular techniques (pyrosequencing), and root visualisation (minirhizotron, x-ray micro CT). PhD: UBC, Canada (Suzanne Simard and Daniel Durall).

Spatial scales of variation in sandy beach meiofauna in south-east Australia: implications for impact assessment

Belinda Cooke[1], Melanie Bishop[1], Ian Goodwin[2]
[1]Climate Futures, Department of Biological Sciences, Macquarie University, [2]Climate Futures, Department of Environment and Geography, Macquarie University

Background/question/methods: Far from biological deserts, sandy beaches contain more phyla than the world's rainforests. Despite this, coastal development and beach management rarely consider impacts to diverse sandy beach communities including the dominant group, meiofauna. For meaningful ecological impact assessments to be developed for meiofauna, we need to understand the scales across which they spatially vary. In this study, the scales of spatial variation in meiofaunal and nematode communities were assessed across three geomorphically similar beaches in geographic proximity using a spatial autocorrelation approach. This study assessed: 1) faunal and sediment conditions; 2) the patch sizes of meiofauna; 3) the extent of spatial autocorrelation at different scales and 4) the environmental variables affecting the faunal diversity at each site. On three embayed beaches in northern Sydney 30 samples were collected from each beach at fixed distances of 0.5 m apart along a transect. The three beach transects were selected a priori to be similar in terms of wave and beach conditions. A variety of univariate and multivariate statistics were used to analyse the community assemblage and sediment variables.

Results/conclusions: The study found: 1) significant variability in the faunal and sediment data of the three beaches; 2) meiofaunal diversity on a single beach was significantly autocorrelated at distances of 0.5m; 3) The extent of autocorrelation within each beach depended on the beach and level of taxonomic resolution; and 4) the meiofaunal community data showed a strong latitudinal correlation and was also related to sediment mean grain size and skewness.

Belinda Cooke has worked in a variety of environments in Australia and overseas on environment management, threatened species conservation and policy. Previously she has worked for the NSW Office of Environment and Heritage and Anangu Pitjantjatjara Yankunytjatjara Land Council.

Too much of a good thing? Temperature variability and species richness in woodland plant communities

Andrew D Letten[1], David A Keith[1,2], Michael B Ashcroft[3], John R Gollan[3,4], Daniel Ramp[4]
[1], Australian Wetlands, Rivers and Landscapes Centre, University of New South Wales, [2]NSW Office of Environment and Heritage, [3]Australian Museum, [4]University of Technology Sydney

Background/question/methods: At the level of individual species, fluctuating environmental conditions are typically perceived as harmful because they amplify demographic stochasticity and thus increase the probability of extinction. Conversely, at the community level, a substantial body of theory suggests that variability may actually promote species coexistence via temporal niche partitioning. An intuitive reconciliation of this apparent contradiction is a hump-shaped relationship between species richness and variability, akin to the related, yet mechanistically distinct, unimodal peak in diversity predicted by the intermediate disturbance hypothesis (IDH). However, unlike the IDH, a lack of appropriate data and methodological tools has hindered empirical tests of richness-variability relationships. To address the gap between theory and observational data, we investigated whether the magnitude of climate (temperature) variability, as predicted by an innovative fine-resolution climate grid derived from near surface climate loggers, could explain patterns of plant species richness across more than 2,000 floristic plots in the Greater Hunter region of NSW.

Results/conclusions: As predicted, the relationship between vascular plant species richness and variability in maximum temperatures (averaged across three temporal scales: intra-seasonal, intra-annual and inter-annual), exhibited significant unimodality that was unexplained by other environmental factors. In addition, the percentage deviance explained by temperature variability in the best-fit multiple predictor model was comparable to, but independent of that explained by absolute measures of temperature, humidity and rainfall. These novel findings not only corroborate emerging ecological theory, but also highlight the importance of treating environmental variability as an independent effect in the context of climate change research.

Andrew Letten is a PhD candidate with a research focus in plant community ecology and more specifically the role of environmental fluctuations in facilitating species coexistence.

Climate change management of conservation areas using functional traits

Jiajia Liu[1,2], Ferry Slik[1], Yunhong Tan[1]
[1], Xishuangbanna Tropical Botanical Garden, Chinese Academy of Sciences, China, [2]Graduate School of Chinese Academy of Sciences, China

Background/question/methods: Climate change is threatening biodiversity worldwide, including some species in nature reserves. Therefore, it is important to consider the dynamics of species composition under climate change. Assessing these dynamics from a functional trait approach may lead to a better understanding of how to adapt biological conservation strategies to climate change. We aim to i) identify which functional trait groups are more likely to respond to climate change; and ii) assess which habitat types are more vulnerable to threats driven by climate change. Here, we used a protected nature reserve in Xishuangbanna tropical rainforest, south-west China, as a case study and classified the forest into different habitat types. We collected 4 functional traits for all the woody stems in a 20 ha plot which was divided into 500 quadrats (20m by 20m).

Results/conclusions: We found that the mean value of wood density and seed mass differed significantly among habitat types, with ridge tops dominated by larger seeded and hard wooded species, and low valleys by species with larger leaves and higher maximum height. This pattern corresponds to a resource availability gradient, with water and nutrient availability declining towards upper slopes and ridges. Our results confirm that diverse habitats can harbour a large number of species with various traits, and this heterogeneity could buffer community response to environmental change. With droughts becoming more frequent in the future, species composition may shift towards hard wooded, short statured species. Knowledge of these possible shifts may help focus conservation on species and locations expected to suffer most from climate change.

Liu Jiajia, a PhD student in Chinese Academy of Sciences, working on the traits/phylogeny patterns of forest fragments.

Concurrent session 4A
Disturbance, recovery and resilience

What's happening in the long grass? Impacts of biomass accumulation on native grassland faunal communities

Mark Antos[1], Kally Yuen[2,1]
[1]Parks Victoria, [2]Australian Mathematical Sciences Institute

Background/question/methods: Native grassland communities are one of south-east Australia's most depleted ecosystems and they support a range of unique and threatened fauna species. This study examines the relationship between habitat structure and faunal composition and demonstrates the important role of disturbance and management of natural systems with a past history of anthropogenic utilisation. Regular nocturnal spotlight transects were used to detect fauna and novel methods of habitat assessment, including the use of golf ball visibility scores as a surrogate for biomass, were employed to help answer the following key questions: What are the population densities of different grassland fauna species? What are the habitat preferences of grassland fauna species and which habitat features are the key drivers of presence and abundance? How have fauna species and habitat features responded to management activities and natural disturbance and climatic events?

Results/conclusions: Following heavy rainfall and flooding, and low levels of biomass management and disturbance, there have been marked changes in habitat structure. Some species have benefited but other threatened species have declined substantially. Species preferring dense grass cover, such as the stubble quail, have flourished showing seasonal spikes in numbers. Other species, such as little button-quail and fat-tailed dunnarts appear to have been adversely affected by flooding and the resulting increase in grass cover. Overall faunal species diversity has declined over time and there is concern that threatened species such as the plains-wanderer appear to be no longer present at a number of protected grassland sites. The current and potential roles of using grazing and fire as tools to manage biomass and habitat for a range of different faunal species are discussed. This study also reveals the rapid dynamism of habitat and faunal composition changes in grasslands and the need for ongoing long-term monitoring to sample this variation.

Mark Antos's primary interest lies in the interactions between bird communities and habitat structure. He completed his PhD examining the foraging ecology of declining woodlands birds. He has since worked at Birds Australia engaging community groups in monitoring and currently is responsible for implementing state-wide monitoring projects at Parks Victoria.

Differential responses of two native marsupials to a planned burn

Justine Smith[1], Graeme Coulson[1], Alan Robley[2], Richard Hill[3]
[1]Zoology Department, University of Melbourne, [2]Arthur Rylah Institute for Environmental Research, [3]Department of Sustainability and Environment

Background/question/methods: Planned burning is commonly undertaken in south-eastern Australia to reduce fuel loads, and the risk of devastating wildfire. Fire is also increasingly used as a conservation management tool, ensuring appropriate habitat is available for key species. The southern brown bandicoot, *Isoodon obesulus,* and long-nosed potoroo, *Potorous tridactylus*, are two small mammals, inhabiting fire-prone regions of Victoria. With increased changes to fire regimes through planned burning, understanding how these two species respond to fire is essential for their long-term viability. Our research aims to investigate the immediate and ongoing post-fire responses of these two species. This information will be used to inform fire management practices. Using a combination of vertical camera traps, radio tracking and habitat analysis, we monitored a population of bandicoots and potoroos before and after a planned burn in south-west Victoria. Surveys took place immediately prior to the burn, immediately post-fire, and then at six month intervals for two years.

Results/conclusions: Both species were present throughout the burn site pre-fire. Post-fire, bandicoots were almost undetectable for 12 months. In contrast, potoroos occupied unburnt patches within the burn area. Investigation into post-fire habitat use by potoroos revealed a strong reliance on unburnt vegetation patches for nesting and foraging habitat. This indicates the importance of unburnt patches to potoroos, providing refuge habitat likely to assist in post-fire survival and re-colonisation. This study shows the contrasting post-fire responses of two similar species, with similar habitat requirements, highlighting the need to understand species specific responses to fire.

Justine Smith is currently in the final year of a PhD looking at fire ecology of long-nosed potoroos and southern brown bandicoots. She is interested in applied research that can be used to inform conservation management and ensure its scientific basis.

Planned burning and swamp wallabies: do they bounce back?

Carolina Galindez Silva[1], Alan York[1], Julian Di Stefano[1]
[1]Department of Forest and Ecosystem Science, The University of Melbourne

Background: Planned fires are commonly used to reduce adverse effects of bushfire to human life and property, but may also be used to conserve biodiversity. However, there is a gap of knowledge regarding the effect of fire regimes on biodiversity, particularly fauna. This study is focused on the response of swamp wallabies (*Wallabia bicolor*) to a prescribed fire in the Otways Ranges, Victoria, considering it influences the abundance of vegetation resources used by the wallabies.

Question: Is the home range size of swamp wallabies affected by a planned burn?

Methods: The study area includes a site burned in late March 2012 as part of the Department of Sustainability and Environment's (DSE) program of planned fire, as well as at a nearby control location. In January, male and female swamp wallabies were trapped and fitted with GPS collars to record their location 5 to 7 times a day. Individuals were tracked on foot and GPS data was downloaded remotely. Home ranges of 9 individuals were measured and compared before and after the fire.

Results/conclusions: Results show evidence that there is no difference between the size of the home range of the collared swamp wallabies before and after the fire event. From the management perspective, low intensity planned burn does not have an effect on the size of swamp wallabies' home ranges. These results will help to improve the capacity for land managers to achieve effective ecological and conservation-based management.

Carolina Galindez Silva's background is in behavioural ecology. She did an Honours with capybaras in Venezuela and Master studies with sika deer in Japan. During Carolina's PhD in Australia she is learning about how fire can have a positive effect on biodiversity, specifically on fauna, if it's managed properly.

Fire type and hemisphere determine fire effects on vertebrate diversity: a global meta-analysis

Louise Pastro[1], Chris Dickman[1], Mike Letnic[2]
[1]The University of Sydney, [2]The University of New South Wales

Background/question/methods: The effect of fire on biodiversity is contentious, with studies often revealing either positive or negative effects. For example, it is established that wildfires eliminate habitat and food resources and increase predation risk, however in some instances these effects are short-lived and no lasting effects on biodiversity are evident. Similarly, increasing numbers of studies are reporting that controlled burning has not provided the expected biodiversity gains. It is known that the impacts of fire can depend on factors such as taxon, habitat and fire type, but it is not possible to distinguish the relative effects of multiple factors within a single study. To address this we conducted a quantitative meta-analysis on the global effects of fire on the diversity of amphibians, birds, mammals and reptiles. To account for patch- and landscape-scale diversity we measured the effects of fire on both alpha and beta diversity.

Results/conclusions: The results indicate that controlled burns generally increase alpha diversity and wildfires increase beta diversity, and fire-effects on alpha diversity are more positive in the Northern than the Southern Hemisphere. Our results also highlight the importance of habitat in the effect of controlled burns; a factor which is often omitted in current fire management practices. We suggest that research on controlled fire in the Northern Hemisphere should focus on the influence of habitat and taxon in determining fire outcomes. Future Southern Hemisphere research should focus on mitigating the effects of wildfire and furthering our understanding of the effects of controlled burns.

Louise Pastro's research focuses on the effects of wildfire and controlled burning on plant, mammal and reptile diversity in desert habitats. Her research questions have an applied focus aimed at developing fire management programs that minimise the risk of further extinctions in this sensitive environment.

Comparisons between native and exotic liana biomass in eastern Australian rainforests

Liza Smith[1,2], Kristine French[1,2]
[1]Institute for Conservation Biology and Environmental Management, [2]University of Wollongong

Background/question/methods: Climbing plants can optimise resource acquisition through reduced investment in structural tissues, making them competitive against and often destructive to their hosts. Theory would predict that invasive vines should show characteristics that increase their competitive ability in the host habitat relative to the native vines. However, few studies have compared native and exotic woody vines (lianas), particularly at site and community levels. We devised allometric equations to predict vine aboveground biomass (AGB) from measurements of stem diameter at breast height (DBH) to investigate whether native and exotic lianas differ in their potential to invade and transform forest ecosystems. We compared biomass allocation amongst three native and three exotic liana species, then conducted surveys to determine the severity of liana infestation in 90 rainforest sites throughout eastern Australia.

Results/conclusions: Native and exotic lianas shared similar rates of increase of AGB with DBH and did not differ in either specific leaf area (SLA; leaf area per dry mass) or plant leaf area (leaf mass*average SLA). SLA values were higher than previous estimates for many tree species and for some of the lianas studied. Native lianas increased their leaf area with DBH at a greater rate than did the exotics, and contributed an average of 86% of the total liana biomass per plot in the rainforest sites that were surveyed. This study highlights the fact that native vines possess traits or growth strategies that enable them to effectively dominate rainforest communities, just as invasive exotic lianas have been observed to do. Thus as a group, lianas have the capacity to successfully invade and compete with hosts in closed forests through their enhanced capacity to obtain light to fuel rapid growth.

Liza Smith is currently the temporary curator for Janet Cosh Herbarium, University of Wollongong; previously worked as a research assistant investigating interactions between native and exotic lianas on their host trees and communities, in particular Cat's claw creeper and Madeira vine.

Concurrent session 4B
SYMPOSIUM: Identifying refugia for biodiversity

Identifying refugia for freshwater biodiversity across Australia

Cassandra James[1], Jeremy VanDerWal[1], Doug Ward[2], Samantha Capon[2], April Reside[1], Stephen Williams[2]
[1]School of Marine and Tropical Biology, Centre for Tropical Biodiversity and Climate Change, James Cook University, [2]Australian Rivers Institute, Griffith University

Background/question/methods: Freshwater ecosystems have very high biodiversity relative to their areal extent. They are particularly vulnerable to climate change because of their limited extent, their limited connectivity and, in much of Australia, their susceptibility to drying resulting from the high variability of temperature and rainfall. Identifying, protecting and managing freshwater refugia that will help protect our unique Australian biodiversity from the impacts of climate change must be a key component of all future conservation planning and policy. We investigate the relative stability of biophysical attributes of freshwater ecosystems regimes across the Australian continent. Using metrics describing hydrological and climate conditions that are relevant to freshwater biota we derive exposure surfaces for the Australian continent as the difference between current and future temperature and runoff regimes, and the number of standard deviations predicted future climates are from the current mean. These surfaces are then interrogated with respect to distribution of freshwater habitats and important biophysical attributes at various scales to identify the spatiotemporal extent and quality of refugia.

Results/conclusions: Climate change is highly spatially and seasonally variable. Future stable and unstable areas can be identified; we highlight the relatively stable areas that will be areas of least concern. However, many regions and freshwater biophysical features will experience climates well outside their current range of variability. Within unstable areas refugia will be a high priority, e.g. areas where temperatures are ameliorated through shading from vegetation or topographic shading.

Cassandra James's research focuses on identifying regions of potential freshwater refugia for species persistence under climate change. She has a particular interest in the vegetation dynamics of riparian, floodplain and wetland ecosystems.

Identifying refugia in a warming, drying global biodiversity hotspot

Grant Wardell-Johnson[1], Kimberly Van Niel[2], Colin Yates[3], Antonius GT Schut[1,4], Margaret Byrne[3], Gunnar Keppel[1,5], Stephen Hopper[6,7], Ladislav Mucina[1], Steven Franklin[8]
[1]Curtin Institute for Biodiversity and Climate, Curtin University, [2]School of Earth and Geographical Sciences, University of Western Australia, [3]Science Division, Department of Environment and Conservation, [4]Department of Spatial Sciences, Curtin University, [5]School of Natural and Built Environments, University of South Australia, [6]Royal Botanic Gardens Kew, UK, [7]School of Plant Biology, University of Western Australia, [8]Trent University, Canada

Background/question/methods: Refugia are habitats where species can contract to, persist in and expand from as the regional climate changes. Therefore they have potential for facilitating the regional persistence of biodiversity under anthropogenic climate change, and are critically important in climate change adaptation management. The identification of refugia is problematic in drying landscapes of subdued topography; exemplified by the South-western Australian Floristic Region (SWAFR)—a global biodiversity hotspot. In the landscapes of this region, refugia must provide protection against three increasing environmental stressors: reduced moisture availability, increasing fire severity and more frequent extreme temperature events. We review spatially explicit evidence for refugia in the SWAFR, based on the distribution of environmental (e. g. water, temperature, fire) and biological processes (species traits, phylo and phytogeography) in the region. High resolution spatial data, phylogeography, ecophysiology and community data provides an integrated, transdisciplinary framework for the identification and management of refugia in the region.

Results/conclusions: Current environmental and biotic signals such as high habitat heterogeneity, increased vegetation height and vigour, and populations outside their predominant range are good indicators for areas serving as refugia. Historical signals from the ecological and evolutionary dynamics of plant communities (i.e. species traits), and from phylogeographic patterns also separate refugia from the surrounding matrix. Particular riparian habitats, granite outcrop systems, high rainfall forest ecosystems and the few mountain ranges of limited extent provide a wide range of habitats with specific refugial characteristics. Experimental hypothesis testing is now needed to materially advance the understanding developed from our correlative and observational findings.

Grant Wardell-Johnson leads the team that represents a current Australian Research Council grant (Protecting the safe havens: will granite outcrop environments serve as refuges for flora threatened by anthropogenic climate change?). Grant works at the Curtin Institute for Biodiversity and Climate.

Incorporating climate change into conservation planning: an example using freshwater fish

Nick Bond[1], Jim Thomson[2], Paul Reich[3]
[1]Australian Rivers Institute, Griffith University, [2]School of Biological Sciences, Monash University, [3]Arthur Rylah Institute, Department of Sustainability and Environment, Victoria

Background/question/methods: Climate change is predicted to cause substantial shifts in the habitable range of many species, including those that are already threatened or endangered. Identifying potential climate change refuges is therefore an important element of prioritising habitats for protection and restoration from other forms of anthropogenic disturbance. We combined the outputs from statistical models of contemporary and predicted future distributions of freshwater fish under multiple climate scenarios with marginal-benefit conservation planning algorithms (using Zonation software) to compare the outcomes of prioritisations under different 'planned for' and 'realised' future climates. We also identified core refuge habitats in which species-occupancy remained high under both current and a future 'step-change' scenario.

Results/conclusions: Despite range shifts for many of the species examined, the rankings of individual river reaches were relatively similar for the different scenarios. River reaches harbouring threatened and endangered species were always among the most 'important' river reaches selected, and differed least between the scenarios in terms of their overall geographic distribution. The study demonstrates the capacity to incorporate species range-shifts into current restoration and conservation planning programs. The inclusion of multiple scenarios provides a form of insurance and should help avoid potentially maladaptive prioritisation decisions.

Nick Bond is a freshwater ecologist and senior research fellow with the Australian Rivers Institute. His primary research interests are in understanding the effects of landscape-scale drivers the distribution and abundance of stream biota, in particular the effects of hydrologic variability.

Aquatic invertebrate refugia: the importance of persistent pools as stable patches under climate change

Sylvia Hay[1], Kim Jenkins[1], Richard Kingsford[1], Patrick Driver[2]
[1]University of New South Wales, [2]New South Wales Office of Water

Background/question/methods: In dryland rivers, aquatic habitat expands and contracts with floods and droughts, producing a matrix of connected and disconnected habitats. During droughts, aquatic invertebrates may survive in pools, become dormant or disperse as winged adults. When water returns, surviving individuals migrate or emerge to repopulate newly wetted habitats. Persistent pools represent stable patches maintaining invertebrate communities despite prevailing adverse conditions. While the significance of these refugia is recognised, the processes that allow invertebrates to maintain viability via refugia have seldom been explored. We tested the importance of persistent pools as refugia for invertebrates, including the roles of microhabitats and habitat stability in defining communities. Persistent pools and dry channels on intermittent creeks were sampled each month, across a range of climatic conditions within the Macquarie River Catchment in New South Wales. We predicted that invertebrate communities within refugia would reflect susceptibility to temperature variability and drying.

Results/conclusions: Refugial pools comprised a range of microhabitats that supported distinct functional invertebrate communities under dry conditions, and higher community similarity with flow. Deep pools provided stable habitat utilised by some taxa under dry conditions. Preliminary analyses showed dry creek beds also represented significant short-term refugia for dormant stages of many aquatic taxa. Sustainability of aquatic refugia will decrease under climate change, with increased instream temperatures and reduced water availability compounding the effects of historical regulation. An understanding of the processes by which aquatic invertebrates are able to utilise refugia to maintain viability under harsh conditions allows critical thresholds for aquatic invertebrates to be identified.

Sylvia Hay is a PhD candidate at the University of NSW, investigating climate change impacts on aquatic invertebrates. Prior to this she was employed as an environmental consultant specialising in freshwater ecology.

In search of topographically mediated refugia under climate change

Tom Harwood[1], Randall Donohue[2], Simon Ferrier[1], Justin Perry[1], Tim McVicar[2], April Reside[3], Jeremy van der Wal[3], Kristen Williams[1]
[1]CSIRO Climate Adaptation Flagship, [2]CSIRO Water for a Healthy Country Flagship, [3]James Cook University

Background/question/methods: As future climate becomes warmer and rainfall patterns shift, Australia's biodiversity will be forced to adapt and disperse. For many species there will be limited capacity to disperse to entirely new territory over shorter time scales and they will be forced to seek best habitat nearby. The effects of broad scale climate change are likely to be mediated through local topography. Local topographically modified microclimates are likely to be important for many species, (often those which are cooler and moister than the surrounding landscape). Whilst the effects of terrain on radiation and temperature balance are readily modelled, water balance is a considerably more complex problem. Soil properties, and the flow and accumulation of surface and ground water are poorly understood for Australia, leading to uncertainty in the distribution of precipitation and consequent evaporation.

Results/conclusions: We demonstrate a new approach to simulate downscaled actual evaporation under climate change based on remotely sensed current evaporation, which provides a relative index of available moisture at an ecologically reasonable grid scale of 250m. Topographically downscaled climate change predictions for a full suite of GCMs and RCPs are used as inputs to generate community level generalised dissimilarity models for a range of organisms, which are subsequently interrogated using existing and novel spatio-temporal analyses to identify local refugia which are likely to support dispersal limited species over the next century.

Tom Harwood is a spatial ecological modeller, with experience in modelling microclimate, dispersal, epidemiology and geneflow. He is currently working with Dr Simon Ferrier and the Macroecological Modelling Team at CSIRO, developing new community and metacommunity models to address land use and climate change.

A method to identify microrefugia and an acid test using plant and invertebrate community distributions

John Gollan[1,2], Michael Ashcroft[2,3], Daniel Ramp[1]
[1]School of the Environment, University of Technology, [2]Australian Museum, [3]Australian Wetlands and Rivers Centre, School of BEES, UNSW

Background/question/methods: While the identification and protection of microrefugia is a sensible adaptation strategy for the forecast rise in temperatures, identifying microrefugia is notoriously difficult. As a result, researchers and practitioners are left to discuss their locations qualitatively or generalise that they occur in distinct habitats such as topographical depressions, boulder fields, granite outcrops, or sheltered gorges. We present our methodology that identifies the potential locations of microrefugia by quantifying patches that: (1) have the lowest or highest temperatures when assessed using fine-scale topoclimatic grids; (2) have relatively stable climates; and (3) are distinctly different from the climate of the matrix. To scrutinise the utility of our method, we examined plant community distribution/contraction in relation to potential microrefugia, while for contemporary invertebrate communities, we pitfall-trapped ants at 100 sites. For ants, we tested the hypothesis that increasing climatic stability and isolation from the matrix is positively correlated with biodiversity.

Results/conclusions: The potential microrefugia identified using our method corresponded with the locations of rainforests and alpine grasslands, which have been contracting to microrefugia over the last 2.5 million and 15 thousand years, respectively. A strong gradient of responsiveness to climatic stability and isolation varied across ant species. Some refugia were able to maintain warmer temperatures over the winter months, resulting in greater stability in ant populations. Our results highlight the next challenge in microrefugia research: dealing with organism-specific responses. The mosaic of potential microrefugia identified using our method offers an important first-step in this challenge through estimating their precise location using fine-scale topoclimatic data.

John Gollan is an invertebrate ecologist and a research fellow with the University of Technology, Sydney. His current work is part of an ARC LP and focuses on understanding climates near the ground, and how climate variability (as opposed to 'averages') influences invertebrate community dynamics.

Concurrent session 4C
Plant ecophysiology

Photosynthetic trait relationships in mistletoes compared to hosts: the hidden costs of cheating

Marina Scalon[1], Ian Wright[1]
[1]Department of Biological Sciences, Macquarie University

Background/question/methods: Leaf photosynthetic capacity (A_{mass}; maximum rate of carbon fixation per unit leaf mass) is strongly driven by leaf nitrogen concentration (N_{mass}; reflecting leaf protein) and structure such that high-A_{mass} species have both high N_{mass} and high specific leaf area (SLA, the ratio of leaf area : dry mass). In turn, high A_{mass} and high N_{mass} result in high maintenance respiration costs (R_{mass}). Mistletoes are woody parasitic plants that have no roots; with their haustorium they tap into the vascular system of their hosts and 'steal' nitrogen and water at very low cost. How do their cheating ways affect photosynthetic trait relationships? Here we report results from six mistletoe-host species pairs from a Northern Territory savanna.

Results/conclusions: Higher N_{mass} was reflected in higher R_{mass} similarly in mistletoes and hosts. However, for a given N_{mass} mistletoes had lower A_{mass} and SLA compared to their hosts. Mistletoes had ca 60% lower A_{mass} and 30% lower SLA in an allometric relationship where a 10-fold increase in SLA coincides with a 7-fold increase in A_{mass}. The lower A_{mass} cannot be explained by the lower SLA alone and nitrogen allocation to photosynthetic vs non-photosynthetic functions might play an important role. Interestingly, mistletoes have higher R_{mass} at a given A_{mass}, where a 10-fold increase in A_{mass} coincides with a 5-fold increase in R_{mass}, but just a 2-fold increase for hosts. Leaf maintenance costs, for a much lower A_{mass}, are markedly higher for mistletoes—for as yet unknown reasons.

Marina Scalon completed a MSc in Ecology at the University of Brasília (Brazil) and is now working towards a PhD at Macquarie University, Australia. Marin'a is interested in understanding relationships among plant functional traits, and how traits and trait relationships vary between different environments and functional groups, particularly focusing on the ecology and physiology of mistletoes and their hosts

Coordination of leaf gas exchange and stem hydraulic traits in *Eucalyptus* species from contrasting climates

Aimee Bourne[1], David Ellsworth[1], Brendan Choat[1], Anthony Haigh[2]
[1]Hawkesbury Institute for the Environment, University of Western Sydney, [2]School of Natural Sciences, University of Western Sydney

Background/question/methods: Understanding stomatal behaviour of plants is critical to accurately and reliably model transpirational water use. Yet, the extent that tree hydraulic characteristics influence stomatal behaviour and thus what characteristics are required to parameterise these models is still under investigation. In particular, we lack clarity in our understanding of hydraulic signalling and how hydraulic limitations impact stomatal opening. Do stomata close because reduced hydraulic conductivity impacts directly on leaf water relations? Or have leaf and stem traits evolved in a coordinated fashion such that stomatal closure occurs at water potentials that protect the stem from massive embolism?

Results/conclusions: We addressed these questions by measuring stomatal conductance and hydraulic characteristics across a range of water potentials on two contrasting *Eucalyptus* species. The point of stomatal closure, the water potential at 50% loss of conductivity (P_{50}), and the turgor loss point (π_{TLP}) were closely linked in both species. *E. crebra*, a species originating from drier climates, had a lower stomatal conductance and was more resistant to embolism than *E. tereticornis*, a species originating from more humid climates. However, differences between species in stomatal behaviour and hydraulic characteristics were not related to xylem vessel diameter or density. This suggests that other anatomical characteristics, such as vessel length or bordered pit structure, may be influencing stomatal behaviour and hydraulic characteristics in these species.

These findings support the need for further analysis of hydraulic traits and their influence on the point of stomatal closure as well as the inclusion of these traits into species-specific transpirational models.

Aimee Bourne is a postgraduate student in the Hawkesbury Institute for the Environment at the University of Western Sydney with interests in plant water relations and hydraulic differences among native tree species. She was recipient of the University medal from UWS for her honours work, and lives in the Blue Mountains, NSW.

Effect of the Black Saturday fires on forest water use: from leaf to stand

Rachael Nolan[1], Patrick Mitchell[2], Ross Bradstock[3], Patrick Lane[1]
[1]Melbourne School of Land and Environment, The University of Melbourne, [2]CSIRO Ecosystem Sciences, [3]Centre for Environmental Risk Management of Bushfires, University of Wollongong

Background/question/methods: Fire induced changes to vegetation dynamics in temperate forests have been demonstrated to affect evapotranspiration (E_t) rates through increases in plant size and density. These transient changes in forest structure result in substantial declines in stream flow for protracted periods after the disturbance, which has important implications for management of water supply. However to date research has focused on the wetter 'ash' forests of south-eastern Australia which regenerate via seedlings, it is unknown what changes in E_t may occur in those forests which re-sprout post-fire.

Following the 2009 Black Saturday fires in Victoria we monitored E_t rates between 1-3 years post-fire in both damp and dry re-sprouting eucalypt forest, incorporating a range of fire severity classes. Components of E_t including overstorey transpiration, rainfall interception loss and forest floor E_t were measured in conjunction with leaf area index, sapwood area and leaf physiology and anatomy.

Results/conclusions: Our results indicate that fire initially reduces E_t fluxes but these fluxes recover rapidly and even increase above rates observed in unburnt forest. These changes are dependent on fire severity and forest type, with damper forests having slower recovery rates and lower E_t fluxes overall. Measurements of leaf physiology in mature leaves, epicormic leaves and in seedlings indicate higher rates of stomatal conductance in seedlings, and to a lesser extent in epicormic leaves, which may be driving higher rates of water use per unit leaf area in the early stages of post-fire regeneration.

Racahel Nolan is in the final year of a PhD researching the effects of bushfires on forest structure and evapotranspiration in mixed species eucalypt forests that re-sprout post-fire. Her work has been undertaken in Melbourne's water catchments following the 2009 Black Saturday bushfires.

Insights into bark trait ecology based on 90 species from dry scrub to rainforest

Julieta Rosell[1], Mark Olson[2], Rodrigo Méndez-Alonzo[3], Wade Tozer[1], Mark Westoby[1]
[1]Macquarie University, [2]Universidad Nacional Autónoma de México, [3]University of California-Los Angeles

Background/question/methods: Despite bark's conspicuousness and the vital tasks it performs, we know little about the patterns and causes of bark variation. Previous research has offered invaluable insights into bark ecology, but it is still unclear how variable bark functional traits are, or whether bark coordinates functionally with other parts of plants. Measuring bark and wood traits in a wide phylogenetic (90 species/40 families) and environmental (xerophytic scrub to rainforest) range, we aimed to answer: Is variation in bark associated with variation in other plant traits? Are there resource allocation tradeoffs in bark, e.g. between bark thickness and density? Do bark traits differ between branches and main trunks? What is bark's contribution to water storage and mechanical support?

Results/conclusions: Bark and wood density and water content per unit of dry mass are strongly associated, with bark tending to be less dense than wood and to have twice the water content. Species with thicker bark in trunks do not necessarily have thicker bark in branches. However, between trunks and branches, water content is similar and density is proportional, being lower in branches. Bark thickness increases with xylem diameter, except in savannas, where thickness is highly variable. In branches, thickness is moderately and negatively associated with density, suggesting an allocation tradeoff. Bark mechanical stiffness tends to increase with density, contributing 10-70% to branch stiffness. Bark water storage increases mainly due to volume, not to differences in tissue storage capacity. Bark traits vary widely, reflecting fine modulation and coordination with other plant parts.

Julieta Rosell is a graduate of the National University of Mexico, and is a postdoctoral fellow at Macquarie University. Her research focuses on plant trait ecology (bark and wood), the evolution of plant life form and diversity, and the systematics of neotropical plants.

Wood density and its anatomical components

Kasia Zieminska[1], Don Butler[2], Sean Gleason[1], Ian Wright[1], Mark Westoby[1]
[1]Macquarie University, [2]Queensland Herbarium

Background/question/methods: Wood density (dry mass per fresh volume [g cm^{-3}]) is a key plant trait measured in ecological and forestry studies. However, it is still rather unclear how exactly wood density relates to plant ecological strategies. Presumably, the answer to this question lies in the structure of wood. The aim of our study was to describe anatomical components of wood density across a broad range of species from different climates. We measured wood density and proportions of wood tissues: fibres (walls and lumens), vessels (walls and lumens), parenchyma (rays and axial) and tracheids in branches of 24 Australian trees and shrubs. We focused on branch wood, as it is ecologically important for both hydraulic supply and mechanical support to leaves.

Results/conclusions: Wood density variation was mostly influenced by the density of wood outside vessel lumens (non-lumen density) rather than by vessel lumen proportion. Overall, non-lumen density was associated with properties of fibres, the most abundant tissue. Non-lumen density was positively correlated with fibre wall proportion (r^2=0.4, P<0.001). Fibre lumen proportion was low in high-density species and variable in low-density species. Parenchyma amount was also more variable in low-density species. Our results show wood density cannot unambiguously inform us about plant ecological strategies. This conclusion applies especially to low-density species, which have more options to build their wood than high-density species. Correspondingly, a wider range of ecological strategies may be present among low-density species.

Kasia Zieminska is a PhD candidate in the Comparative Ecology Lab at Macquarie University. She investigates plant ecological strategies determined by wood anatomical structure. She is especially interested in the links between wood density, anatomy and climate.

Seed coat dormancy in Grevillea: test of the mechanical constraint model

E Charles Morris[1], Candy Briggs[1]
[1]School of Science and Health, University of Western Sydney

Background/question/methods: Seeds of eastern Grevillea species show increased germination after treatment with smoke and heat, and have been shown to have seed coat dormancy. A number of the known mechanisms of seed coat dormancy have been demonstrated not to operate: the seed coat is permeable to water, does not contain germination inhibitors or constrain the exit of inhibitors, nor to restrict access of the embryo to oxygen. The mechanical constraint model is the last remaining known dormancy mechanism remaining. This model was tested in a series of experiments. Different parts of the seed coat were removed to test whether mechanical constraint was localised to specific areas of the coat. And partially dissected embryos, either treated with fire cues or untreated controls, were incubated over a range of water potentials to gauge the maximum thrust that the embryo could generate.

Results/conclusions: Restriction of germination was localised to a specific area of the seed coat. If the seed coat at the micropylar end of the seed was removed, germination occurred; if this area remained intact but other areas were removed, germination did not occur. In the water potential experiment, extension of the radicle was observed for partially dissected embryos treated with smoke and heat over the range -0.8–0.9 MPa whereas control embryos were unable to do so. These observations are consistent with the mechanical constraint model of seed coat dormancy.

Charles Morris and Candy Briggs work at the Hawkesbury Campus of UWS. They have investigated the control of germination in Grevillea seeds over a period of years.

Concurrent session 4D
Food webs and trophic networks

Downstairs drivers: how root herbivores shape multi-trophic communities aboveground

Scott Johnson[1]
[1]Hawkesbury Institute for the Environment, University of Western Sydney

Background/question/methods: It has been recognised for at least 20 years that aboveground and belowground insect herbivores can interact via induced changes to their shared host plants. Plant-mediated mechanisms, including changes in primary and secondary metabolites, are largely thought to underpin these interactions yet few studies have addressed both nutritional and defensive mechanisms simultaneously. Still fewer have attempted to investigate whether such interactions observed in the laboratory translate into changes in field populations of insect herbivores and their antagonists. Using a perennial woody crop, *Ribes nigrum* (blackcurrant) in laboratory and field experiments, we investigated the effects of root herbivory by *Otiorhynchus sulcatus* (vine weevil) on *Cryptomyzus galeopsidis* (blackcurrant aphid) and *Nematus olfaciens* (European blackcurrant sawfly).

Results/conclusions: Performance of aphids increased in the presence of weevils, whereas sawfly performance decreased when sharing a plant with weevils. Increased aphid performance was linked to root herbivore induced increases in the proportion of essential amino acids, whereas poorer sawfly performance resulted from reductions in leaf phosphorus. Aphids induced higher levels of secondary metabolites (specifically phenolics) in roots, but *O. sulcatus* performance was not adversely affected. Field observations intermittently reflected these interactions; plants with *O. sulcatus* had fewer sawflies, but higher numbers of aphids. Aphid population build-up increased abundance of natural enemies, which reduced aphid populations to levels equivalent or less than weevil-free plants. To our knowledge, this is the first mechanistic example of plant-mediated effects of root herbivores on different aboveground feeding guilds to be demonstrated in both laboratory and field conditions.

Scott Johnson is Senior Lecturer at the Hawkesbury Institute for the Environment, based at UWS, having joined HIE in 2011 from The James Hutton Institute in the UK. His research focuses on insect-plant ecology, especially multi-trophic interactions spanning aboveground-belowground systems.

Rodent granivory as a process limiting shrub encroachment in arid Australia: an indirect dingo affect

Chris Gordon[1], Mike Letnic[2], Ben Moore[1]
[1]The Hawkesbury Institute for the Environment, The University of Western Sydney, [2]The University of New South Wales

Background/questions/methods: Rodents are thought to have little effect on seed survival and plant recruitment in arid Australia as granivory is dependent on seed availability following sporadic rainfall events. Rodent abundance is also dependant on high rainfall events and rodents can reach extremely high densities after rain. The parallel between high seed production and high rodent numbers may lead to discrete periods of high seed predation by rodents which may affect seed bank persistence and vegetation recruitment.

We aimed to test if seed predation by eruptive rodent assemblages in the Strzelecki desert could limit recruitment of a dominant encroaching shrub species (*Dodonaea viscosa*) during episodic periods of high rodent abundance. We also tested the effects ants, birds and rodents had as seed predators. As dingoes have a positive association with rodent abundance and diversity in arid Australia, and dingoes have a negative association with encroaching shrub species in areas of the Strzelecki Desert, we also tested if dingo presence affected seed predation.

Results/conclusions: Our results showed that rodents consumed huge quantities of seed during 'boom' periods of high rodent abundance, and that dingoes were a primary determinant of seed survival via an indirect pathway. Our results also showed that rodents had a greater effect on shrub seed survival than ants or birds when in high numbers. We propose a model that incorporates temporally variable trophic effects of dingoes and rodent granivory as important determinants of vegetation abundance and shrub encroachment in arid Australia.

Chris Gordon is a PhD candidate whose thesis research is interested in understanding how top predators affect vegetation communities via indirect mechanisms of trophic control. Chris has previously worked on the ecophysiology of desert lizards and the keystone effects of dingoes in arid Australia.

Trophic relationships of the platypus: insights from stable isotopes and cheek pouch dietary analysis

Melissa Klamt[1], Jenny Davis[1], Ross Thompson[1], Richard Marchant[2], Tom Grant[3]
[1]School of Biological Sciences, Monash University, [2]Sciences Department, Museum Victoria, [3]School of Biological, Earth and Environmental Sciences, UNSW

Background/question/methods: The platypus, *Ornithorhynchus anatinus,* is endemic to freshwater ecosystems in eastern Australia. Despite considerable interest in their evolutionary history and physiology, their contemporary trophic relationships are poorly known. This is the first study to determine the diet of the platypus using stable isotope analysis (SIA). We demonstrate the utility of SIA for describing trophic relationships in this species; in combination with more traditional approaches. We applied both cheek pouch and stable isotope analyses to more accurately determine the diet of the platypus and to provide a better understanding of the role of the platypus in aquatic food webs in south-eastern Australia.

Results/conclusions: Stable isotope mixing models (SIAR) revealed that platypuses were feeding on a wide range of benthic invertebrates, particularly insects. The $\delta^{13}C$ signatures of the aquatic plants *Vallisneria spiralis, Potamogeton tricarinatus, Chara* sp. and benthic algae indicate that aquatic and not riparian plants were the predominant basal carbon sources within this food web. The similarity of $\delta^{13}C$ and $\delta^{15}N$ values recorded for the platypus, the native fish (*Galaxias* sp.) and the exotic mosquito fish (*Gambusia holbrooki)* indicate that these species are relying on the same organic resources and may potentially compete. Although cheek pouch studies are a reliable indicator of diet, the greater range of dietary benthic species revealed by SIA indicates some variation in diet over time. Some results differed between the stable isotope and cheek pouch analyses, suggesting that studies which combine both methods are likely to provide the most accurate insights into the diet of the platypus.

Melissa Klamt is a PhD student in the School of Biological Sciences and student representative for the Australian Centre for Biodiversity. Mel's Honours and now PhD research focus on the ecology of the platypus, in particular the platypuses' interaction with its environment.

Reassembling food webs in climate-changed landscapes: an experimental study

Ross Thompson[1], Giselle Perdomo[1], Paul Sunnucks[1]
[1]Australian Centre for Biodiversity, Monash University

Background/question/methods: We continue to expand our understanding of how climate change will impact on patterns of biodiversity, but we are only beginning to understand interactions with existing stressors. Climate change effects will play out on landscapes which have already been fragmented, and the interactions between these stressors are poorly understood. Using the moss-microarthropod ecological system as a model, we generated fragmented landscapes and then impacted those with extreme climate change scenarios, measuring the impacts on food web structure.

Results/conclusions: Climate change effects were profound in all parts of the moss landscape, but were most profound in isolated small fragments. The effects on individual taxa were highly unpredictable, but there was evidence for selection for smaller, disturbance-tolerant taxa. Of particular concern was that results for fragments were strongly affected by the food web of the neighbouring 'mainland' sources of colonists, and that variability in those mainlands was very large. This suggests that predicting climate change effects on fragments in the landscape may require extensive knowledge of the natural history of the available taxa and the condition of potential source environments.

Ross Thompson is an ecologist interested in understanding the rules that determine the structure of food webs, and how human impacts may challenge those rules. He primarily works in freshwater ecosystems, but occasionally flirts with terrestrial and marine ecosystems.

Assimilation of diazotrophic nitrogen into pelagic food webs

Ryan Woodland[1], Daryl P Holland[2], John Beardall[2], Jonathan Smith[3], Todd Scicluna[1], Perran LM Cook[1]
[1]Water Studies Centre, School of Chemistry, Monash University, [2]School of Biology, Monash University, [3]South East Algae Project (SEAPRO)

The fate of diazotrophic nitrogen (N_D) from planktonic cyanobacteria in pelagic food webs and the dynamics of the nutrient transfer remain poorly understood; particularly for toxic cyanophytes that are selectively avoided by most herbivorous zooplankton. Current theory suggests that N_D derived from diazotrophic cyanobacteria can enter planktonic food webs contemporaneously with peak bloom biomass via direct grazing and exudation from viable cells, or post-bloom with the remineralisation of particulate and dissolved bloom detritus. Although, the relative importance of these processes is unknown, we hypothesised that assimilation of N_D by palatable phytoplankton and subsequent grazing by zooplankton would be the primary pathway by which N_D was incorporated into the planktonic food web. Instead, in situ stable isotope measurements and grazing experiments clearly documented the rapid assimilation of N_D by multiple functional groups of plankton during a bloom of the toxic *Nodularia spumigena* Mertens in the absence of measurable grazing. We identified two distinct mechanisms in the trophic transfer of N_D from *N. spumigena* to the plankton community: a highly dynamic transfer of N_D to zooplankton that covaried with bloom biomass and bypassed other phytoplankton taxa, likely routed through bloom-associated bacteria; and a slowly accelerating assimilation of the dissolved-N_D pool by phytoplankton that was decoupled from contemporaneous variability in *N. spumigena* concentrations. These findings provide empirical evidence that N_D can be assimilated and radiated throughout natural plankton communities and yield insights into the specific processes underlying the propagation of N_D through pelagic food webs.

Ryan Woodland is a postdoctoral research fellow at Monash University. He is involved in several projects that focus on anthropogenic effects on trophic structuring in estuaries. He uses stable isotope, observational and modeling approaches to quantify ecological responses to human forcing.

Means and extremes in climate-impacted freshwater ecosystems: an experimental approach

Paula Sardina[1], John Beardall[1], Jason Beringer[2], Mike Grace[3], Ross Thompson[1]
[1]Australian Centre for Biodiversity, Biological Sciences, Monash University, [2]Australian Centre for Biodiversity, Geography, Monash University, [3]Australian Centre for Biodiversity, Chemistry, Monash University

Background/question/methods: Predicting the effects of climate change on freshwater ecosystems remains challenging despite a growing number of empirical and experimental studies. Empirical studies have generally emphasised increases in mean temperatures, when many parts of the world will be impacted by changes in frequency of climatic extremes. Here we sought to understand how realistic weather scenarios generated from regional climate models might impact aquatic food webs in south-eastern Australia. Using temperature controlled flumes we subjected river food webs to weather scenarios based on 2070 climates and measured a range of factors including algal responses, changes in invertebrate communities and measures of ecosystem function.

Results/conclusions: Food webs exposed to the climate change scenarios showed distinct responses. In particular, there were changes in invertebrate communities, driven in part by species-specific responses of warming. The dominant mayfly in the community responded to the future climate scenario by emerging at a smaller size, and by alterations in sex ratios. Other taxa showed no response. Changes in algal communities were evident, but tended to be highly variable between replicates. These results show the altered community and food web structure in aquatic systems affected by climate change, and the potential for species-specific responses to be important drivers in community-level responses.

Paula Sardina is a research fellow in the Australian Centre for Biodiversity, where she works on a range of issues relevant to freshwater ecology, including climate change, landuse change and invasion.

Concurrent session 4E
Dispersal and habitat connectivity

Dispersal inertia renders Komodo dragons unresponsive to environmental change

Tim Jessop[1], Claudio Ciofi[2], Deni Purwandana[3], David Forsyth[4]
[1]Department of Zoology, University of Melbourne, [2]Department of Animal Biology and Genetics, University of Florence, [3]Komodo Survival Program, Bali, [4]Arthur Rylah Institute for Environmental Research, Department of Sustainability

Species endemic to islands have high rates of extinction that will increase under most global change scenarios. One possible reason for the high extinction rates of island endemics is evolution of 'dispersal inertia', when individuals disperse less than ideal for population persistence. Data on the dispersal dynamics of island endemics are rare due to the logistical difficulties of conducting long-term studies of populations in archipelagos. Here we test hypotheses about dispersal in a vulnerable apex island predator, the Komodo dragon, *Varanus komodoensis*, using demographic, genetic and telemetry data collected over 10 years at ten sites on four islands in the Indonesian archipelago. Only two of 1115 marked dragons dispersed, and none between islands. Low demographic dispersal and gene flow persisted despite potential selective pressures favouring dispersal, such as high inbreeding coefficients, high population densities and low prey resources. High site fidelity, rather than poor movement capabilities, suggests past dispersal costs now limit Komodo dragon dispersal within and among islands. Strong dispersal inertia in island endemics, including Komodo dragons, will have major implications for enduring rapid environmental change. Conservation management via translocations of individuals will become increasingly important for ensuring persistence and adaptation of island endemics as rates of global change quicken.

Tim Jessop and his co-authors have combined different skills to provide an integrative approach to evaluate dispersal among and within populations of the Komodo dragon.

Nomadic movements of black swans (*Cygnus atratus*) in arid Australia following La Nina floods

Raoul FH Ribot[1], John McEvoy[1], Andy TD Bennett[1]
[1]Centre for Integrative Ecology, Waurn Ponds, Deakin University

Background/question/methods: Nomadic waterbirds of the arid interior of Australia must travel large distances to locate seasonally and spatially unpredictable water resources which are ephemeral. How they solve this navigation problem is a major unsolved puzzle of bird migration. After years of drought, two La Niña years caused heavy rainfalls and an influx of vast numbers of waterbirds into the arid interior of Australia. During this period, we deployed GPS satellite-transmitters on black swans (*Cygnus atratus*), with multiple fixes per day, to reveal their movements on an unprecedented temporal and spatial scale.

Results/conclusions: Most long distance flights, in order to find new resources, were undertaken at night, and were successfully directed to areas with recent floods. Distances of movements were found to vary substantially between night and day. The hypothesised cues used by birds to 'predict' weather and rain in distant locations will be discussed along with evidence from our study in support of these. Our findings provide new insight into the ecology of nomadic individuals and how birds can accurately locate water resources dispersed over many hundreds of kilometres in a rapidly changing environment.

Raoul Ribot is currently a research fellow at Deakin University, after he completed a PhD at the University of Bristol (UK) and MSc at the University of Groningen (Netherlands).

From farm-duck to desert nomad: how waterfowl respond to rapidly changing environments

John McEvoy[1], Raoul Ribot[1], David Roshier[1], Andy Bennett[1]
[1]Centre for Integrative Ecology, Deakin University

Background/question/methods: In dynamic and unpredictable landscapes individuals must respond to highly variable resource distributions. Understanding the behaviours associated with this response is a key issue in the ecology of arid regions. In Australia, irregular cycles of flooding and drought produce localised pulses of productivity separated by many years and interspersed with prolonged dry periods. The ecology of many birds in this system is dictated by this irregular cycle of 'boom and bust'. A one-in-twenty-year flooding event provided a unique opportunity to deploy GPS technology to track the movements of 38 individual pacific black duck (*Anas superciliosa*) during a 'boom' phase. The trajectories of these individuals were analysed using behavioural change point analysis to identify switches between sedentary and nomadic movement phases.

Results/conclusions: The initiation and cessation of long distance movements were examined in relation to local and regional scale changes in weather conditions. These data demonstrate how movement behaviour can change rapidly in relation to both local fluctuations in local weather conditions and landscape level changes in resource distribution.

John McEvoy is interested in how animals' interactions with their environment at various temporal and spatial scales influence individual and group movement decisions. He also has a strong interest in applied ecology and conservation.

Can habitat suitability modelling explain seasonal movements of brolgas in south-western Victoria?

Inka Veltheim[1,2], April Reside[3], Simon Cook[1], Michael McCarthy[2]
[1]School of Science Information Technology and Engineering, University of Ballarat, [2]Centre of Excellence for Environmental Decisions, University of Melbourne, [3]James Cook University

Background/question/methods: Drivers of movements and dispersal patterns of Australian waterbirds are poorly understood. Rainfall, availability and extent of suitable habitat, food resources and breeding requirements are considered to be important factors in determining movements. The brolga, *Grus rubicunda,* is a wetland dependant bird, occurs in northern and south-eastern Australia and moves between breeding and non-breeding areas within their annual life cycle. Seasonal movements and dispersal are thought to be driven by rainfall.

We investigated the influence of weather on intra- and inter-annual variability in habitat suitability for the brolga. We used Australia-wide historical brolga occurrence records and eight weather variables to build a model of habitat suitability. We projected the model for each month between 1950 and 2010.

Results/conclusions: We found that the area of suitable habitat in southern Australia contracted during the drier, hotter times of the year and expanded during the wetter, colder times. Movements of individual brolgas fitted with GPS satellite transmitters in 2010 supported the patterns observed in the habitat suitability model. The observed seasonal contraction and expansion appears to be primarily driven by temperature. These findings will increase our ability to predict areas of suitable habitat for this threatened species at regional scales and improve our understanding of how changes in weather-driven habitat suitability influence seasonal movements.

Inka Veltheim is a PhD student at University of Ballarat and the Centre of Excellence for Environmental Decisions at University of Melbourne. She is investigating movement ecology of brolgas, *Grus rubicunda*, in Victoria. For more information, please visit inkaveltheimresearch.wordpress.com

Is a fuelbreak a barrier to movement for smoky mice?

Phoebe Macak[1], Peter Menkhorst[1]
[1]Arthur Rylah Institute, Department of Sustainability and Environment

Background/question/methods: A network of strategic fuelbreaks has been constructed around Melbourne's forested water catchments for the purpose of reducing the risk of fire damage to the city's water supply. We investigated the impact of fuelbreaks on the movements of the threatened smoky mouse (*Pseudomys fumeus*) to see whether the breaks form a physical barrier or whether animals willingly cross. There was concern that smoky mice may not readily cross large open areas with no overhead cover. This could reduce breeding opportunities, dispersal and consequently genetic diversity and the future persistence of this small mammal.

We studied a population of smoky mice straddling a strategic fuelbreak in forest near Jamieson, north-east Victoria, in 2010-2011. Trapping on each side of the fuelbreak identified 33 individuals. Radio-tracking was used to determine more precisely where this nocturnal species travels during the night and how it uses its habitat.

Results/conclusions: Smoky mice appeared to be quite willing to cross the linear clearing presented by the strategic fuelbreak, with some animals crossing several times on the same night. One of the study animals also crossed a nearby forest track. Our results suggest that the fuelbreak is unlikely to cause long-term partitioning of smoky mouse populations that inhabited the area prior to its construction. At this stage it is not recommended that any modifications are required to facilitate crossings. However, due to the disappearance of some of the study animals whose radio-collars were found on the fuelbreak, predation is thought to be an issue that warrants further investigation.

Peter Menkhorst has been working on various aspects of smoky mouse ecology to increase what is known about its movements and habitat.

The matrix in fragmented landscapes: conceptual model and empirical challenge using a 14-year dataset

Don Driscoll[1], Sam Banks[1], Philip Barton[1], Annabel Smith[1], David Lindenmayer[1]
[1]ARC CEED, NERP EDH, FSES, ANU

Background/question/methods: In extensively modified landscapes, the matrix surrounding native vegetation has often been perceived as homogeneous non-habitat through which species might occasionally disperse to reach habitat patches. However, this simplistic concept has been substantially revised and the matrix is now well understood to have a range of complex interactions with patch-dependent species through the influence of the matrix on dispersal, food and other resources, and the abiotic environment. We present a conceptual model describing how the matrix drives changes in communities that occur in patches of native vegetation within largely modified surroundings. We then use a bird data set spanning 14 years (1998-2011) from a fragmented eucalypt woodland to examine the extent to which the conceptual model is supported.

Results/conclusions: We find that temporal changes in the matrix (establishment and growth of pine plantation on former grazing lands) have led to major changes in bird distribution with support for many of the pathways described by the conceptual model. Our results emphasise that the matrix can have an over-riding effect on the distribution of species in fragmented landscapes, more so than the effects of patch size, patch shape, or patch condition.

Don Driscoll has research interests in fire ecology, ecological theory and dispersal. He aims to understand how to conserve biodiversity in fragmented landscapes. Don and co-authors work in the vibrant Conservation and Landscape Ecology group at ANU, which has a strong focus on applied empirical ecology.

Concurrent session 4F
Community assembly, diversity and dynamics

Conservation of Carabidae in productive landscapes: understanding fine scale spatial dynamics

Chela Powell[2], Chee-Seng Chong[3], Sarina Macfadyen[4], Linda Thomson[2], Ary Hoffmann[1,3], Michael Nash[1]
[1]Department of Genetics, University of Melbourne, [2]Melbourne School of Land and Environment, Department of Forest and Ecosystem Science, University of Melbourne, [3]Department of Zoology, University of Melbourne, [4]CSIRO Entomology, Black Mountain

Background/question/methods: Reports on Australian biodiversity tend to focus on the uniqueness of our biodiversity, not the functionality of this diversity. Yet most of Victoria's landscape is cleared to differencing degrees and in private ownership, thus agriculture is an essential part of this landscape that needs to be considered when conserving biodiversity. Biodiversity value to agriculture is generally stated as providing ecosystems services to; such as pest regulation, pollination, water storage/treatment, creating favourable microclimates and nutrient cycling. Services like pollination and pest control rely on biodiversity being maintained within the local landscape adjacent to production units (Nash, 2008 #2561; Thomson, 2010 #2444). Understanding the forces driving the spatial dynamics of insect distributions in productive landscapes can provide valuable insight into their ecology, conservation and management. The spatial organisation of predatory ground beetles (Carabidae) and their interaction with ants (Formicidae) was investigated across 5 production units from eastern Australia.

Results/conclusions: Carabid spatial patterns were species dependent, with different spatial patterns observed within the same species at different times. Coexisting species were often positively associated. Formicidae were found to co-occur with Carabidae, contrary to previous hypothesis suggesting exclusion. The habitat preferences of some ants to field margins were different to that of Carabidae that tended to aggregate within the production unit. The patchy fine scale distribution and difference between regions in these patterns highlight the importance maintaining a number of species. Conservation must include productive landscapes as they are not biologically barren.

Michael Nash is currently investigating invertebrates response to climate change in the Australian alps. His background in agriculture saw him investigate predator prey dynamics between native ground beetles and exotic pests, hence his passion for conservation of insects.

Predicting the effect of climate change on community structure and function: an assessment using grassland Thysanoptera

Matthew Binns[1], David Warton[2], Heloise Gibb[3], Nigel Andrew[1]
[1]University of New England, [2]University of New South Wales, [3]La Trobe University

Predicting how an ecosystem will respond to changes in climate is important when considering how to manage an area to reduce biodiversity loss. This is especially the case in understudied groups such as Thysanoptera, that play an important role in ecosystem processes. Insect were collected from 45 sites for each season over four seasons. We then used recent developments in multivariate statistical modelling (specifically, the mvabund package for R) to predict how these Thysanoptera communities will respond to climate change. In addition, a recently developed forth corner modelling technique has been used with morphology data to determine why particular species or individuals would respond the way they do. This will also test the idea that an assessment of trait diversity within a community can be more important than the species composition. For this assessment we assessed Thysanoptera communities associated with *Themeda australis* dominated grasslands. The use of this host plant also provided the opportunity to assess the importance of ploidy in terms of structuring insect-plant interactions. Approximately 40 explanatory variables were used in the model. Almost half of these were important in explaining variation in the data, including a combination of climatic variables generated by ANUCLIM, and more accurate measurements from 150 ibutton dataloggers.

Matthew Binns is just about to complete his PhD, during which he developed an unusual fondness for thrips.

Environmental drivers of spatial patterning in mangrove tree species dominance

Beth Crase[1], Adam Liedloff[2], Peter Vesk[1], Mark Burgman[3], Brendan Wintle[1]
[1]The Centre for Excellence in Environmental Decisions, School of Botany, University of Melbourne, [2]CSIRO Ecosystem Sciences, [3]Centre of Excellence for Risk Analysis, School of Botany, University of Melbourne

Background/question/methods: Many mangrove communities form distinct bands parallel to the shoreline with each dominated by a single tree species. However, the determinants of mangrove species distribution and dominance across the intertidal zone are not well understood. We aimed to quantify the relationship between species' dominance and the hydroperiod (defined as the duration of inundation in a year), soil salinity and the salinity of inundating water for three dominant species: *Sonneratia alba*, *Rhizophora stylosa* and *Ceriops tagal*. Two hundred sites were surveyed within an extensive (20,000 ha), largely intact mangrove forest in northern Australia. We related species dominance to the explanatory variables by applying boosted regression tree models (BRTs), a statistical modelling approach able to automatically capture interactions and nonlinear relationships between variables.

Results/conclusions: The dominance of all three species was most strongly influenced by the hydroperiod, followed by soil salinity. The salinity of inundating water was the least informative variable. Ecological space, determined by gradients in hydroperiod and soil salinity, was partitioned between the three species with little overlap. As anticipated changes in sea level will alter the hydroperiod, our findings are critical for global forecasting of future distributions of mangrove communities, and for the design of mitigation and adaptation measures.

Beth Crase is a tropical botanist interested in spatial analysis and statistical modelling within landscape ecology and biogeography, with a particular focus on forecasting the impacts of sea level rise on coastal plant communities.

Microclimate and plant species density is altered in small forest fragments: not how you may expect

Brad Farmilo[1], John Morgan[1]
[1]Department of Botany, La Trobe University

Background/question/methods: Habitat fragmentation is one of the most pervasive threats to global biodiversity. Not only does fragmentation cause small and isolated populations of species, it often results in changes to the local climate (microclimate), which may further exacerbate the loss of species. We use the Wog Wog Habitat Fragmentation Experiment to investigate the response of understorey plant species density (the number of plant species within a standardised area) to habitat fragmentation at multiple spatial scales ($1m^2$, $16m^2$, $144m^2$). In addition, we collected data on microclimate (light, moisture) for use as a possible explanation for the density patterns observed.

Results/conclusions: We found that small fragments experience the greatest change in species density and microclimate compared to continuous (unfragmented) forest condition. Small fragments were more shaded and not as dry as continuous forest. These microclimatic changes corresponded with increasing species density at small spatial scales, within small fragments. Such results contradict the view that predicts a higher probability of population extinction in smaller fragments. This research shows plant populations have the capacity to persist in small fragments and this may be due to matrix-induced changes in microclimate. Therefore, with appropriate management, small fragments can be important resources for native species conservation.

Brad Farmilo has a research interest in conservation biology and increasing our understanding of how fragmented landscapes operate, and is currently conducting a PhD on the internal dynamics of plant populations in shrinking natural habitat.

Potential impacts of climate change on insect communities: a transplant experiment

Sabine Nooten[1], Lesley Hughes[1], Nigel Andrew[2]
[1]Department of Biological Sciences, Macquarie University, [2]Centre for Behavioural and Physiological Ecology, Zoology, UNE

Current and future climate change will have profound impacts on species interactions and communities, leading to disruptions of present day plant-insect communities. We used a multi-species transplant experiment to investigate the potential effects of a warmer climate on insect community composition and structure. Eight native Australian plant species were transplanted outside their native range into a climate approximately 2.5°C (mean annual temperature) warmer than their native range. Subsequent insect colonisation was monitored for 12 months. We compared the insect communities on transplanted host plants at the warmer sites with control plants transplanted within the species' native range. Comparisons were also made among transplanted plants at warmer sites and congeneric plant species native to this area. We found that the morphospecies composition of the colonising Coleoptera and Hemiptera communities differed markedly between transplants at the control compared to the warmer sites. Differences in community structure, as described by the distribution of different feeding guilds, were also found. However, the structure of the herbivorous insect community showed a higher level of consistency between plants at control and warm sites. There were marked differences in community composition and feeding guild structure, for both herbivores and non-herbivores, between transplants and congenerics at the warm sites. These results suggest that as the climate warms, considerable turnover in the composition of insect communities may occur, but the structure of insect herbivore communities may retain elements of their present day structure.

Sabine Nooten has been studying climate change impacts on plant-insect communities as part of a PhD project since 2008. Sabine is especially interested in the dynamics of plant-insect interactions.

Integrating ants into the ecological community: does conserving plant communities adequately conserve invertebrates?

James Schlunke[1], Dieter Hochuli[1]
[1]School of Biological Sciences, University of Sydney

Background/question/methods: Current biodiversity legislation focuses on conserving unique assemblages of plant species (the 'ecological community'). By conserving representations of all plant community types, we hope to also conserve the breadth of unquantified cryptic taxa including invertebrates, however this assumes congruence between underlying invertebrate taxa and vegetation 'units'. The structure of ant communities is influenced by multiple factors, including intraspecific dominance interactions, which may be mediated by habitat traits. Integrating effects of plant community composition, fine and broad-scale habitat structure and patterns of species turnover (beta-diversity) on ant assemblages is crucial to evaluating current conservation strategies. We surveyed ant and plant community composition at three spatial scales (metres, hundreds of metres, tens of kilometres) in a north-south transect. Ants were sampled using 1280 pitfall traps arranged in 4x4 grids over eighty 20x20m quadrats. We recorded plant community composition at quadrat level, and habitat variables at each pitfall trap.

Results/conclusions: We found that species turnover for ant species was higher than for plant species, with nMDS ordination revealing a strong spatial influence on similarities amongst ant assemblages. Plant assemblage composition showed only weak spatial correlation. Dominant Dolichoderine ant species were drivers of assemblage differences, with very little overlap in distributions despite being the most abundant species found. A multivariate GLM showed interactive effects of habitat variables and plant species composition in driving ant assemblage composition. These results indicate that conservation of ant communities requires consideration of spatial arrangement in addition to the plant assemblage composition of habitat.

James Schlunke is a PhD Candidate at the University of Sydney, studying community ecology of invertebrates.

Concurrent session 5A
Attitudes and perception of landscapes and ecology

Nature's classroom: blending citizen science and education to bring ecological research to primary students

Dieter Hochuli[1], Melissa Slarp[1]
[1]School of Biological Sciences, The University of Sydney

Background/question/methods: Disengagement with nature is one of the major barriers to developing an ecoliterate community. An emerging culture of sheltering children from perceived risks has inspired the 'No child left inside' movement, creating opportunities for children to explore the natural world. We developed a program where primary school students in years 3 to 6 could participate in ecological research. This program builds upon ecological research identifying how ant assemblages and myrmechochory could be used to describe the ecological integrity of remnant bushland. We created learning resources supporting multiple key learning areas in the 3-6 curriculum to prepare children for a 2-hour excursion. In their local environment (native bushland or parks), students surveyed ants and seed dispersal using baited traps and seed trays.

Results/conclusions: Students readily engaged with the ant system and the learning resources that were developed. Satisfaction derived from the field component of the work was a vital link to encouraging children to participate in this citizen science initiative, which built upon the latent fascination many children have for nature. The learning resources targeting multiple key learning areas were central to the success of the program, as teachers were able to 'tick multiple boxes' efficiently when planning lessons. These resources were seen as a vital link to fostering awareness of the local environment as well as the nature of ecological research. Importantly, the program provided an opportunity to generate data from previously unsurveyed areas. Although only common ants were recorded, data generated supported our previous work identifying how ant functional groups respond to urban disturbance.

Dieter Hochuli runs the insect ecology lab at the University of Sydney. Work in his group focuses on identifying the mechanisms driving invertebrate responses to environmental change, primarily in urban ecosystems.

The role of public education initiatives in changing attitudes and behaviours associated with urban habitat and biodiversity loss

Charlotte Taylor[1], Sara Johnson[2], Holly Parsons[2], Kate Ravich[2], Judy Christie[3]
[1]University of Sydney, [2]Birdlife International, [3]Sydney Catchment Management Authority

Background/question/methods: Loss of biodiversity, and habitat degradation, remain key ecological problems in urban areas, despite the presence of sustainable conservation initiatives at local, national and global levels. Considerable effort has also been made to provide educational information for the public, but relatively little evaluation of the effects of such education has been published in Australia. This project investigated the extent to which public education affects attitudes, behaviour and understanding of environmental issues and ecological processes which affect bird populations in urban areas. We used a mixed methods survey and interview protocol to collect quantitative and qualitative data from 500 members of the public and from a matched control group of 500 members of an environmental interest group.

Results/conclusions: Significant differences between the two groups were observed in their understanding of the interdependency of humans and the natural world, and in their ability to articulate an appropriate definition of biodiversity. Although both groups correctly identified current threats to biodiversity, and the problems associated with habitat loss, and both demonstrated similar attitudes to taking responsibility for making change, these differences were not significant. Given matched demographic samples for education, gender and age these results highlight the need for targeted education which focuses on ecological misconceptions, provides unambiguous messages linking anthropogenic actions with biological networks and motivates individuals to take responsibility for their environment. We are currently trialling initiatives with social media to integrate ecological concepts into online discussions, and working with environmental educators and the media to develop common educational themes.

Charlotte Taylor's research focuses on integrating urban ecology, scientific literacy and biodiversity education. Current research projects are investigating how complex biological concepts can be communicated using virtual 3D and online environments.

The values and preferences of city residents for peri-urban landscapes: implications for biodiversity conservation

Christopher Ives[1], Dave Kendal[2]
[1]School of Global, Urban and Social Studies, RMIT University, [2]Australian Research Centre for Urban Ecology, Royal Botanic Gardens Melbourne

Background/question/methods: With cities expanding at unprecedented rates into fringing agricultural land, there is a need to understand the range of non-market benefits peri-urban landscapes provide to city residents. Drawing on theories of human values and attitudes, we surveyed Melbourne residents in order to answer two questions: (1) what values do people assign to peri-urban agricultural land? and (2) are these assigned values related to personal underlying values or landscape preference?

Results/conclusions: Many values assigned to peri-urban agricultural land were identified and grouped via principal components analysis into three categories: multifunctionality, food production and native biodiversity. Preferences for photographed peri-urban landscapes formed four groups: extensive agriculture, intensive agriculture, trees and plantations. Native grasslands were preferred least. The structure of underlying personal values resembled the literature on environmental value orientations. Many relationships between values and preferences were observed, with assigned values most strongly related to preference and acting to mediate correlations between underlying values and landscape preference. Biospheric underlying values were correlated strongly with assigned values for native biodiversity, yet these were not significantly correlated with preference for extensive landscapes (containing native grasslands). This suggests that peri-urban landscapes may not be perceived as containing high levels of biodiversity or may not be aesthetically pleasing. Separation of survey items about environmental protection (within multifunctional assigned values) from native biodiversity assigned values implies that the urban public distinguishes native biodiversity from anthropocentric notions of 'nature'. Policies should therefore promote a diversity of peri-urban landscapes and look for synergies between biodiversity conservation and other landscape functions.

Chris Ives is a researcher at RMIT and is interested in biodiversity conservation and environmental policy in urban environments. He received his PhD from Macquarie University (2012) where he studied urban riparian corridors and has worked recently at Melbourne University on issues of urban spread.

Concurrent session 5B
SYMPOSIUM: Identifying refugia for biodiversity

Environmental refuges from disease-driven amphibian extinctions: patterns and processes protecting frogs from extermination in the periphery of their distribution

Robert Puschendorf[1], Ross Alford[1], Conrad Hoskin[1]
[1]School of Marine and Tropical Biology, James Cook University

Background/question/methods: Chytridriomycosis, caused by the fungus *Batrachochytrium dendrobatidis* (Bd), has been linked to extirpations and extinctions of amphibian species across the globe. The pathogen thrives in cool, moist environments, and high mortality rates have commonly occurred during outbreaks in amphibian populations in high-elevation tropical rainforests. In Australia several high-elevation species, including two out of the five torrent frog species (*Litoria lorica, Litoria nyakalensis*), were believed to have gone extinct during chytridiomycosis outbreaks in the 1980s and early 1990s. Here we investigate the unknown status of peripheral populations of torrent frogs in high elevation-dry forest and compare their abundance and disease status to the adjacent rainforest sites where amphibian populations have suffered well documented declines and even extirpations due to chytridiomycosis. We use a variety of field and laboratory techniques to accomplish this.

Results/conclusions: *Litoria nannotis* in the dry habitat had significantly higher pathogen prevalence than those in the wet habitat, but were five times more abundant. We also discovered a previously unknown population of *L. lorica* and a population of the waterfall frog (*L. nannotis*) further downstream, both present at high abundance and with high prevalences of Bd infection. No individuals of either species showed clinical signs of disease, and they remained abundant during surveys over the following 4 years. We present a new hypothesis for how amphibians and this otherwise lethal pathogen can coexist, and discuss the conservation implications of our findings.

Rob Puschendorf is interested in disease ecology and evolution and the influence of environmental factors on host-pathogen interactions, especially on dynamics of *Batrachochytrium dendrobatidis* across habitats in Costa Rica and Australia.

Identifying refugia for terrestrial biodiversity across Australia

April Reside[1], Cassandra James[1], Jeremy VanDerWal[1], Ben Phillips[1], Justin Welbergen[1], Lauren Hodgson[1], Stephen Williams[1]
[1]Centre for Tropical Biodiversity and Climate Change, James Cook University

Background/question/methods: Refugia are habitats that promote species persistence in the face of climate change. Therefore, they provide useful targets for conservation and management strategies that aim to reduce the worst impacts of anthropogenic climate change. Localised refugia within the landscape will be especially critical in regions predicted to experience high climatic instability. Climatic stability is increasingly recognised as a key component of refugia, yet the identification of areas that combine relative future climatic stability with high biodiversity values has so far been challenging. Here we address this challenge by integrating several metrics of climatic stability and species distribution modelling of terrestrial vertebrates, enabling us to identify broad-scale climate change refugia for Australian terrestrial biodiversity.

Results/conclusions: We show that for medium- and severe-future climate scenarios, species from parts of coastal Northern Territory and South Australia will have to move more than 1000 km to stay within two standard deviations of current temperature by 2085. For some parts of south-west Western Australia, no areas in Australia will remain within two standard deviations of current temperature by 2085. These impacts will be compounded with severe drying projected for the south-west. We further identify the refugia where species are required to move the least to remain within current climatic limits; and highlight strategies for identifying localised refugia in areas that have the greatest predicted landscape-scale instability.

April Reside is a post doc at JCU working on a NCCARF-funded project looking at refugia for terrestrial biodiversity. The project is a collaboration between JCU, CSIRO, Griffith University and Curtin University in WA. The project is run parallel with the NCCARF-funded freshwater refugia project.

Evolutionary refugia and ecological refuges: key concepts for conserving arid zone freshwater biodiversity under climate change

Jenny Davis[1], Alexandra Pavlova[1], Ross Thompson[1], Paul Sunnucks[1]
[1]School of Biological Sciences, Monash University

Background/question/methods: Refugia have been suggested as priority sites for conservation under climate change because of their ability to facilitate survival of biota under adverse conditions. We considered information on past climatic, geological and hydrological conditions, and the biogeography and phylogeography of extant aquatic species, to identify the refugia that have enabled freshwater biota to persist in the Australian arid zone. We assessed the likely future persistence of these refugia by considering where local temperature regimes and hydrological processes are decoupled from regional processes.

Results/conclusions: We propose that distinguishing between evolutionary refugia (sites that have persisted over millennial timescales) and ecological refuges (sites that persist on yearly to decadal timescales) is a key concept for climate adaptation planning to conserve arid zone freshwater biodiversity. Evolutionary refugia were characterised as groundwater-dependent habitats supporting vicariant relicts and short-range endemics. They are likely future refugia because their water source (groundwater) is decoupled from local rainfall. However, their biota is extremely vulnerable to changes in local conditions because population extinctions cannot be rescued by dispersal from other sites. Conservation planning requires a high level of protection for specific sites and their groundwater resources. Ecological refuges were identified as predominantly surface water dependent habitats with biota supported by contemporary gene flow over a range of scales, depending on the dispersal traits of individual taxa and hydrological connectivity. These systems are vulnerable to changes in the regional climate because they have little thermal or hydrological buffering. Accordingly, conservation planning must focus on protecting dispersal processes, rather than specific sites.

Jenny Davis holds the chair of Freshwater Ecology in the School of Biological Sciences at Monash University. Her research interests include invertebrate community ecology, ecosystem resilience, feedback mechanisms, regime change and the impacts of multiple stressors on shallow aquatic ecosystems.

Does late Pleistocene climate stability predict within-species diversity for herpetofauna in Australia's eastern mesic arc?

Dan Rosauer[1], Craig Moritz[1]
[1]Ecology, Evolution and Genetics, Australian National University

Areas which maintained a greater degree of climate stability through the intense climatic cycles of the last 120k years, and particularly since the last glacial maximum (LGM, 21kya) have been found to retain significantly more within-species diversity than adjacent less stable areas where species show less internal diversity, consistent with a post-LGM expansion from more stable refugia.

If more stable areas, where occupation has been more continuous, represent centres of phylogenetic endemism, then predicting and confirming their locations may be valuable both to understand the current distribution of diversity, and as an input to informed conservation.

The stability-diversity relationship has been demonstrated for Brazil's Atlantic Forest and in the Australian Wet Tropics, but not yet more broadly within Australia. Here we use phylogeographic data for a range of frog and reptile taxa, and a temporal series of paleo-climate models for the last 120k years, to investigate the degree to which the stability-diversity relationship holds more broadly for the herpetofauna of Australia's mesic east coast biome. We assess the degree of spatial concordance of such patterns between taxa. These refugial areas should be places which display reliable productivity through good and bad years, as well as high paleo-climate stability relative to other areas.

We present initial results from this analysis quantifying the stability-diversity relationship. We also consider the issues involved in extending the approach to Australia's monsoonal tropics to identify, and ideally predict, refugial areas which now represent centres of phylogenetic diversity and endemism.

Dan Rosauer is a postdoctoral fellow at the ANU. He likes to surf the boundary between biogeography, biodiversity informatics and nature conservation. After completing a PhD at UNSW, and a postdoc at Yale, he has returned to work on Australia's monsoonal tropics.

Collapse and recovery of an avifauna: have south-eastern Australia's bird communities recovered from a decade of drought?

Dale Nimmo[1], Jim Radford[1], Andrew Bennett[1]
[1]School of Life and Environmental Sciences, Deakin University

Background/question/methods: During the recent severe droughts that gripped south-east Australia for a decade, the plight of avifaunal communities in many regions became dire. This was exemplified in north-central Victoria where drought, compounding the effects of habitat loss, resulted in a documented 'collapse' of the region's avifauna. South-eastern Australia has since experienced above-average rainfall for 2 years, spelling the end of the 'big dry'. Here, we ask 'is the collapse ongoing, or have the rains offered a reprieve?' We use data on bird communities from 300 sites throughout a ~20 500 km^2 study area in north-central Victoria, collected at the beginning (2002-03), during (2006-07), and after (2011-12) the drought. Hierarchical models and Bayesian logistic regression were used to determine the extent to which the region's avifauna has recovered post-drought, and to explore spatial patterns of decline and recovery.

Results/conclusions: The local extirpation of woodland birds during drought has an element of predictability, with extinctions being less likely in more continuous forests and in riparian zones. Sites in which species were locally abundant at the beginning of the drought also had a lower probability of local extirpation during drought. The drought-breaking rains have halted the decline of many species, although some are experiencing ongoing decline. Based on these results, we identify practical measures to enhance the resilience of biodiversity in fragmented landscapes when exposed to environmental shocks.

Dale Nimmo is a conservation biologist interested in how species and communities respond to broad-scale disturbances.

Do refugia provide the key to resilient landscapes?

Louise Gilfedder[1], Oberon Carter[1]
[1]Department of Primary Industries, Parks, Water and Environment

Ecological refugia include places that are predicted to remain climatically stable, relative to surrounding areas; places where time-stands-still, so to speak. The capacity for such places to cope with or avoid contemporary threats is not well understood. What are the major threats to refugia? What assumptions can be made about the capacity for refugia to avoid or cope with threats? Are mapped refugia a useful way to identify 'resilient' places, or are refugia simply a spatial expression of some expected response of the landscape to global change—a response which may or may not be realized? The authors' present approaches used to identify terrestrial refugia in Tasmania, and posit that refugia do provide an effective no-regrets adaptation strategy to nature conservation in Tasmania in the face of global change. Some examples of potential policy and management responses are also presented.

Background/question/methods: Do refugia provide an effective no-regrets adaptation strategy to nature conservation in Tasmania in the face of global change? Work is under way to develop a process to identify and map glacial refugia and contemporary refuges, and to develop and implement related planning and policy approaches. The layers are to be used as the authoritative source of information for conservation planning. The scope of this project is to review the current information on the mapped extent and distribution of refugia in Tasmania, to develop a process to identify and map glacial and contemporary refugia, and to develop and implement related planning and policy approaches.

Results/conclusions: The fire refugia layer has been produced which is a combination of four new spatial layers: (1) topographic fire protected areas, (2) island refugia, (3) montane fire refugia and (4) cloud forest refugia. These component layers indicate the likely distribution of fire refugia, i.e. places that are subject to much lower fire frequency than the surrounding landscape.

Louise Gilfedder is a senior conservation scientist at the Tasmanian Department of Primary Industries, Parks, Water and Environment, where she leads the Natural Systems Resilient to Climate Change project. She also works at the University Tasmania as a knowledge broker at the Landscape and Policy Hub.

Concurrent session 5C
Environmental stressors

Chronically ill sleepy lizards *Tiliqua rugosa* in Australia's cereal cropping landscapes

Anita Smyth[1,2,3], Elizabeth Smee[4,5], Stephanie Godfrey[6], Mathew Crowther[5], David Phalen[5]
[1]CSIRO, [2]Future Farm Industries CRC, [3]TERN Eco-informatics, The University of Adelaide, [4]The University of Adelaide, [5]The University of Sydney, [6]Flinders University

Background/question/methods: Intensive agricultural practices alter animal habitats which places unprecedented stress on organisms. Stress affects physiological health and if widespread amongst individuals, it can alter population responses. Over time, environmental stress develops into sustained overstimulation of an organism's coping functions which leads to chronic stress or serious sub-lethal stress. In the end, it causes death or decreases longevity and reproduction. We studied the body condition and haematology of two sleepy lizard *Tiliqua rugosa* populations in relatively intact native vegetation (baseline sites) and cropping landscapes (severe sites) to assess lizard health in severely modified landscapes and make inferences about habitat quality and farm management.

Results/conclusions: We randomly collected data from a total of 119 individuals (baseline site: n=30 adults; severe sites: n=75 adults, 14 young) from sites in seven landscapes. Unlike the baseline sites, the health of lizards at the severe sites was significantly compromised, showing haemolytic anaemia. Differences in the percentage of polychromatophilic red blood cells, packed cell volume and absolute and differential blood cell counts clearly showed lizard health was alarmingly poor for almost 50% of our study animals in these sites. Habitat complexity of severe sites was reduced but it did not appear to influence lizard health. Instead, exposure to pesticides that can potentially act as toxins seemed to be the most likely cause of haemolytic anaemia. The same cause could also be affecting other wildlife in the ecosystem, farm animals and possibly humans. Our findings have serious implications for pest management on cereal farms.

Dr Anita Smyth was a senior research scientist with CSIRO specialising in terrestrial ecology. She is now facilitating open access to ecological data for AEKOS at the Eco-informatics Facility of the Terrestrial Ecosystem Research Network based at The University of Adelaide.

Persistent organic pollutants in Australian white ibis (*Threskiornis molucca*) eggs of eastern Australia

Camila Ridoutt[1], Richard Kingsford[2], Anthony Roach[3], Alan Yates[4]
[1]NSW Department of Primary Industries, [2]University of New South Wales, [3]NSW Office of Environment and Heritage, [4]National Measurement Institute

Background/question/methods: Persistent organic pollutants (POPs) degrade environments, affecting wildlife. Such pollutants accumulate in birds, affecting reproduction by interfering with biogeochemical pathways, reducing shell thickness and reproductive behaviour. We examined whether selected POPs, polychlorinated dibenzo-p-dioxins (PCDD), polychlorinated dibenzofurans (PCDF), polychlorinated biphenyls (dl-PCBs), identified polybrominated diphenyl ethers (PBDEs) and organochlorine pesticides (OCPs), varied in concentration in eggs (n=34) of Australian white ibis (*Threskiornis molucca*), collected from urban, peri-urban and inland sites within eastern Australia. High resolution gas chromatography and high resolution mass spectrometry (HRGC/HRMS) were used for chemical analyses. We also measured egg traits (n=219) in different regions to examine if differences related to potential exposure to pollutants.

Results/conclusions: Total PCDD, dl-PCB and PBDE levels were between seven and nine times higher at urban sites compared to inland sites and also significantly greater than peri-urban sites. Contrastingly, total PCDF concentrations were significantly higher at inland sites compared to urban and approximately four times higher than at peri-urban sites. Furan data were highly skewed, due to the presence of one particularly high furan congener, 2,3,7,8-PeCDF, detected from an egg in the Macquarie Marshes, an inland site which may be potentially linked to manufacturing by-products of pesticides and fungicides. Patterns in egg traits also reflected the location of colonies; eggs were substantially smaller in size, weight and volume at urban sites, compared to peri-urban and inland sites. Factors such as smaller sized eggs have been associated with reduced chick survival and therefore urban bird colonies may experience a risk of lower breeding success.

Camila Ridoutt completed a Bachelor of Environmental Science (Hons 1st)/Arts in 2011. She worked as a research assistant in the Australian Wetlands and Rivers Centre until she gained her current position as a Graduate Officer with NSW Department of Primary Industries.

Detecting ecological consequences of pollution in marine environments

Allyson O'Brien[1,2], Michael Keough[1,2]
[1]Centre for Aquatic Pollution Identification and Management, [2]Department of Zoology, University of Melbourne

Background/question/methods: Biological stress responses in individual species or populations are used as indicators of pollution across a range of different environments. Using community-level effects of pollution as an indicator of environmental stress is less common, despite this being the question of most concern to environmental managers. We developed an experimental approach to detect the effects of pollution on communities using field-based mesocosms. Here, we present data from the first large-scale trial of the experimental approach across four intertidal mudflats in Port Phillip Bay and Western Port, Victoria. Mesocosms containing defaunated sediments from the four sites, which varied in background levels of heavy metal pollutants, were transplanted and buried in sediments of the same four sites. After six weeks, macrofauna that had recolonised the sediments were sampled as well as sediment characteristics (grain size, pH, organic content, redox potential) and metal concentrations (Pb, Cu, As, Cd, Cr, Cu, Ni, Pb and Zn).

Results/conclusions: There were strong differences in the composition of the communities between sites but also differences between communities found in the mesocosm sediments, irrespective of site. Macrofauna communities associated with sediments derived from the site with the highest metal concentrations were significantly different from the other sediments across all sites. Results suggest this experimental mesocosm approach can be used more broadly at different sites as an indicator of community-level effects of polluted sediments. This experimental approach is now being adapted to investigate responses to specific pollutants and provide ecologically relevant assessments of pollution in marine environments.

Allyson O'Brien is a Postdoctoral Research Fellow at The University of Melbourne. Her research interests focus on linking community ecology and ecotoxicology to provide useful outcomes for managers of marine and estuarine environments.

Stormwater limits distribution of platypus in an urban landscape

Elizabeth Martin[1], Chris Walsh[1], J Angus Webb[1], Melody Serena[2]
[1]University of Melbourne, [2]Australian Platypus Conservancy

Background/question/methods: The platypus (*Ornithorhynchus anatinus*) is reportedly sensitive to catchment urbanisation but the primary mechanism limiting its distribution in urban freshwater habitats has not been identified. We created distributional models for three platypus demographic classes, including adult females (which are exclusively responsible for raising young), adult males (which are more mobile than females), and first-year juveniles, using live-trapping data collected in Melbourne, Victoria, Australia. We tested if distributions of the three demographic classes were better predicted by catchment urban density (total imperviousness, TI), by urban stormwater runoff (catchment attenuated imperviousness, AI), or by stream size (catchment area, CA). Two variants of each predictor variable were developed, one accounting for mobility and one not.

Results/conclusions: Female distribution was most plausibly predicted by AI (accounting for mobility), with a steep decline in detectability from 0 to 10% AI. Male distribution was equally plausibly predicted by AI and TI (both models accounting for mobility), with a less steep and more uncertain decline with imperviousness than females. Juvenile distribution was most plausibly predicted by CA (accounting for mobility), but AI and TI (accounting for mobility) were nearly equally plausible predictors. Platypus populations in urban areas are likely to be affected adversely by urban stormwater runoff conveyed by conventional drainage systems, with adult females more limited by runoff-related impacts than adult males or juveniles. Urban platypus conservation efforts have generally focused on restoring riparian and in-stream habitats on a local scale. This is unlikely to protect platypus from adverse impacts of urban stormwater runoff, which is most effectively managed at the catchment scale.

Liz Martin completed a Bachelor of Science in Ecology at the University of Melbourne and is now studying a Master of Science with the Centre of Excellence for Environment Decisions also at Melbourne. Liz is interested in modelling landscape ecology to inform conservation.

Lichen *Usnea inermis* as a biomonitor of atmospheric heavy-metals in the Collie coal basin, south-western Australia

Meenu Vitarana[1], William Stock[1], Andrea Hinwood[1]
[1]Centre for Ecosystem Management, Edith Cowan University

Background/question/methods: Measuring atmospheric heavy-metals pollution is logistically difficult, expensive and time-consuming, making routine monitoring unfeasible. Biomonitoring using a specific species of moss, lichen or higher plant is an alternative, cost-effective approach. In this study, the fruticose lichen, *Usnea inermis* was investigated for its use as a biomonitor to determine heavy-metal pollution in the Collie coal basin, south-western Australia. Samples were collected in triplicate from thirty-six study sites over two sampling campaigns in spring and autumn (wet and dry seasons) along an identified pollution gradient, including nine unpolluted sites. Lichen thalli were analysed for the metals As, Cd, Cr, Cu, Pb, Mn, Hg, Ni and Zn, using inductively coupled plasma mass spectrometry (ICP-MS).

Results/conclusions: Significant negative correlations between metal concentrations and increasing distance from the closest pollution source were observed for all metals except Mn in the spring campaign, while As, Hg and Ni showed the same trend in the autumn campaign. Elevated As levels were observed for five sites in the spring campaign (11.02, 10.00, 8.22, 7.18, 5.87 ugg^{-1}), with three sites located close to the open-cut coal mines and one site near a coal-fired power station. Spatial distribution maps for all metals revealed high concentration peaks around one of the coal-fired power stations in the area, with dispersion patterns corresponding to the dominant wind direction for the area. Higher concentrations were also observed in the vicinity of the alumina refinery for Cd, Cr and Hg. These results indicate that *Usnea inermis* is a useful biomonitor capable of elucidating spatial trends in heavy-metal dispersion from industrial activities in the Collie coal basin.

Meenu Vitarana is from Sri Lanka, holding a degree in Zoology and a Masters in biotechnology. Her childhood interest in lichens led to the opportunity to study these fascinating symbionts as biomonitors under a PhD in Environmental Management. She received the ESA Student Research Award in 2011.

Changing rainfall patterns affect the composition and functioning of a temperate grassland ecosystem

Sally Power[1,2], Ellen Fry[2], Sarah Pierce[2], Pete Manning[3]
[1]Hawkesbury Institute for the Environment, University of Western Sydney, [2]Imperial College London, UK, [3]Newcastle University, UK

Background/question/methods: Climate models predict that the amounts and frequencies of rainfall episodes will change as the earth becomes warmer, resulting in more extreme climates in the future. Drought experiments have demonstrated negative effects on a wide range of ecosystem processes. However, the size of effects will depend not only on the magnitude and timing of rainfall episodes, but also on plant community characteristics such as life history, rooting depth and water use efficiency. We established a field experiment to evaluate the effects of changing rainfall patterns on the composition and functioning of a temperate grassland. Rainfall treatments included: 1) summer drought/winter addition, 2) spring+summer drought and 3) high variability summer rainfall. The role of plant traits and trait diversity was also investigated by establishing trait group/diversity treatments.

Results/conclusions: The effects of rainfall manipulation varied according to plant trait group. Communities dominated by perennial species experienced lower ecosystem CO_2 exchange rates during the summer, and higher rates during winter, compared to ambient rainfall plots, whereas those dominated by annual species were unaffected. Prolonged (spring+summer) drought reduced nutrient turnover rates and availabilities, but had limited effects on the plant community. In contrast, the high variability rainfall treatment had no significant effects on microbial-driven processes, but resulted in plant dieback and reduced diversity. Overall, we found that plant community composition and the precise nature of precipitation change are crucial determinants of grassland responses.

A/Professor Sally Power is an ecosystems ecologist with a particular interest in the impacts of global change on terrestrial systems. She is currently involved in projects investigating the impacts of nitrogen deposition, ozone, drought and elevated CO2 on heathland, grassland and forest ecosystems.

Concurrent session 5D
Predation and predator–prey interactions

Predation modifies larval amphibian communities in urban ponds

Andrew Hamer[1], Kirsten Parris[2]
[1]Australian Research Centre for Urban Ecology, Royal Botanic Gardens Melbourne, [2]School of Botany, University of Melbourne

Background/question/methods: The introduction of fish to ponds can impact on amphibian populations through subsequent predation on eggs and larvae. Predation rates are expected to be higher in permanent ponds where fish persist than in ephemeral ponds. While these relationships have been examined in relatively natural freshwater ecosystems, they have not been explicitly considered in urban landscapes. We assessed relationships between the occurrence and relative abundance of native tadpoles and the density of predatory non-native fish and predatory aquatic invertebrates in urban ponds, and examined how these relationships were influenced by pond hydroperiod and aquatic vegetation.

Results/conclusions: Larvae of only three out of six frog species detected during the study were captured at ponds containing fish. We found an important negative effect of predatory fish on the mean relative abundance of tree frog (*Litoria* spp.) larvae. We also found that predatory invertebrates had an important negative effect on larval abundance. The abundance of tree frog larvae was higher in more ephemeral ponds where predatory fish were generally absent. Our results suggest that while models of amphibian distribution along pond-permanence gradients may be suitable for understanding factors that structure larval amphibian communities in natural areas, their applicability to urban ecosystems may be reduced by the modified hydrology of urban ponds, which tend to be largely permanent. To conserve urban amphibians, we recommend the removal of exotic fish from urban ponds, planting aquatic vegetation, and protecting or restoring ephemeral wetlands in urban areas.

Andrew Hamer is an Ecologist at the Australian Research Centre for Urban Ecology. His research is directed towards understanding the drivers that underpin how amphibians and freshwater turtles respond to urbanisation. He is currently researching broad-scale trends in amphibian and turtle populations in the face of increasing urbanisation and the behaviour of Australian frogs at road-crossing structures.

The role of feral cats in small mammal declines in northern Australia: experimental evidence

Anke Frank[1], Chris Johnson[1], John Woinarski[2], Michael Lawes[2], Sarah Legge[3], Alaric Fisher[4], Ian Radford[5], Chris Pavey[6]
[1]University of Tasmania, [2]Charles Darwin University, [3]Australian Wildlife Conservancy, [4]Department of Natural Resources, Environment, the Arts and Sport, NT, [5]Department of Conservation, WA, [6]CSIRO

Background/question/methods: Predation by feral cats is considered to have contributed significantly to historical extinctions in a large set of Australian mammals. Current dramatic declines of small mammal populations in northern Australia raise concerns about another wave of extinction. The role of cats in this current decline has been doubted as they have been present for at least 100 years, and there is little data about their ecology in northern Australia. We investigated the potential role of feral cats by establishing two pairs of enclosures at Wongalara Sanctuary, Northern Territory. For each enclosure, fences were constructed that allowed cat entry into half of the area, and excluded cats from the other half. In every enclosure, we introduced native pale field-rats (*Rattus tunneyi*). Rats were then monitored using radio-tracking and live-trapping, while cats have been monitored using camera traps and searches for tracks and scats inside and outside the enclosures.

Results/conclusions: Two weeks after cats entered the accessible half of one enclosure no rats could be tracked or trapped, whereas rat numbers have been stable in the inaccessible half since their release in April 2012. In contrast, there has been no evidence of cats in the accessible half of the other enclosure. Camera trapping indicates that there is lower cat activity and slightly more dingo activity around this latter enclosure. We are currently investigating evidence for top-down control of cats by dingos through more intensive camera trapping around and away from the enclosures, combined with small mammal trapping across the property.

Anke Franke has been a Postdoctoral Fellow at the University of Tasmania since 2010, investigating the role of feral cats in the current dramatic small declines. Previous research concentrated on the impact of livestock grazing on native mammals and reptiles in arid Australia (PhD, The University of Sydney, 2010).

Perceived predation risk by brushtail possums (*Trichosurus vulpecula*): the use of direct and indirect cues

Valentina Mella[1], Clare McArthur[1], Peter Banks[1]
[1]School of Biological Sciences, The University of Sydney

Fear is a complex behaviour with many potential triggers and has a pervasive and powerful influence on when and where animals feed, and on what and how much they eat. Perceived predation risk can come from indirect cues, such as characteristics of the environment or from more direct cues of predator presence, such as urine. This study tested the effects of perceived predation risk on feeding behaviour of free-ranging brushtail possums (*Trichosurus vulpecula*) in four different field experiments using direct (predator odours) and indirect (illumination and feeder location) cues of predation.

Background/question/methods: The study aimed to understand which type (or combination) of predation cues can influence foraging behaviour of wild possums. Specifically we quantified giving-up-density (GUD), using the amount of food left behind in an inedible matrix at artificial food patches, as a measure of diminishing benefits of feeding at a certain patch.

Results/conclusions: Wild brushtail possums did not alter foraging patterns in response to predator odours. However, indirect cues of predation, in the form of feeder location ('high feeders' vs 'ground feeders'), had a consistently significant effect on foraging behaviour, with GUDs at 'high feeders' lower than at 'ground feeders'. This study identifies ground feeding as risky and contributes to the understanding of brushtail possums' perception of predation risk.

Valentina Mella's interests are primarily in predator-prey relationships in mammals and the effects of predation risk on behaviour. Valentina studied anti-predator responses of a variety of Australian prey species and is currently focusing on how personality shifts the foraging response of herbivores to predation risk.

Conservation with bite: understanding and applying predators' ecological functions

Euan Ritchie[1]
[1]School of Life and Environmental Sciences, Deakin University

Background/question/methods: There is increasing recognition of the important roles predators perform in regulating ecosystems and sustaining biodiversity worldwide. In Australia, we have suffered substantial economic and biodiversity losses through the effects of predators—most notably cats and red foxes—and over-abundant herbivores.

Based on my own research and that of collaborators, I aim to:

1. Provide a synthesis of knowledge on Australian predators including their ecological roles, interactions and functions.
2. Highlight the importance of predators to rangeland management, pest control and biodiversity conservation.
3. Suggest ways to advance the use of predators as conservation and management tools.

Results/conclusions: I show that the impacts of invasive predators and over-abundant herbivores could be reduced by a new and more integrated predator management philosophy. The presence of dingoes is clearly linked with suppression of fox and kangaroo populations at local and regional scales, with associated benefits for native prey and vegetation. The relationship between dingoes and cats, and cats and foxes, appears more complex, with behavioural effects (spatial and temporal differences in activity patterns of interacting species) being more important than is currently appreciated.

Based on the reviewed evidence, I propose two controversial suggestions for enhanced ecological management and restoration, both of which focus on recreating lost interactions, rather than imposing traditional command-and-control management:

1. We should objectively assess if maintaining the dingo barrier fence is economically and environmentally warranted.
2. We should urgently begin trialling reintroductions of native predators into Australian ecosystems.

Euan Ritchie is a Lecturer in Ecology at Deakin University. Euan applies ecological theory with good doses of field work to seek solutions to the challenges of conserving biodiversity.

Concurrent session 5E
Dispersal and habitat connectivity

The effect of planning for connectivity on a network of roadside reserves

Pia Lentini[1,2], Philip Gibbons[2], Josie Carwardine[3], Joern Fischer[4], Michael Drielsma[5], Tara Martin[4]
[1]School of Botany, The University of Melbourne, [2]The Fenner School of Environment and Society, The Australian National University, [3]CSIRO Ecosystem Sciences, [4]Faculty of Sustainability, Leuphana University Lueneburg, [5]New South Wales Office of Environment and Heritage

Background/question/methods: Although the concept of connectivity in conservation is now decades old, it remains both poorly understood and defined. Some argue that metrics known to have a strong relationship with biodiversity (such as habitat quality and area) should take precedence in conservation planning. However, many heavily fragmented landscapes are characterised by features such as streams and hedgerows which are inherently linear, so for these strategic planning that enhances both representation and connectivity may be possible with little effect on the cost, or area and quality of the reserve network. We assessed how alternative approaches for accounting for connectivity affect planning outcomes for linear habitat networks, using the stock route network as a case study. Our planning objective was to represent vegetation communities across the network at a minimal cost. We ran scenarios with a range of representation targets: 10, 30, 50 and 70% of the original extent of each vegetation community in the linear remnants and nearby protected areas, using three different approaches for accounting for connectivity (boundary length modifier, euclidean distance, and landscape value).

Results/conclusions: We found that decisions regarding the specific target and connectivity approach used may affect the siting of reserve systems: at conservation targets ≥50% networks designed using the Euclidean distance and landscape value connectivity approaches consisted of a greater number of small reserves. Hence, by maximising both representation and connectivity, these networks compromised on larger contiguous areas. However, targets this high are rarely employed in real-world conservation planning, so concerns regarding undue costs of connectivity appear unwarranted. Approaches for incorporating connectivity into the planning of linear reserve networks which take into account not only the spatial arrangement of reserves, but also the characteristics of the intervening matrix, highlight important sections that 'link' the landscape, and which may otherwise be overlooked.

Pia Lentini is a postdoctoral researcher with the University of Melbourne's Quantitative and Applied Ecology Group,. She is currently focusing on planning for the long-term viability of urban microbat populations, and also the efficacy of conservation corridors in fragmented landscapes.

Evaluating the effectiveness of road crossing structures for arboreal mammals: is use evidence for effectiveness?

Kylie Soanes[1,2], Rodney van der Ree[1], Peter Vesk[2], Mick McCarthy[2]
[1]Australian Research Centre for Urban Ecology, University of Melbourne, [2]Quantitative and Applied Ecology Group, University of Melbourne

Background/question/methods: Millions of dollars are spent worldwide on wildlife crossing structures attempting to mitigate the impacts of roads on animal populations. However the effectiveness of these structures is largely unknown, as monitoring programs evaluating population level impacts are rarely conducted. We use before-after-control-impact (BACI) population monitoring to evaluate the effectiveness of crossing structures for the squirrel glider (*Petaurus norfolcensis*), a threatened arboreal mammal, along a highway in SE Australia. Remote-sensing cameras, personal integrated transponder scanners and BACI radio-tracking were used to determine the impacts of mitigation on squirrel glider movement. Mark-recapture surveys were conducted BACI to determine changes in population size and survival rates as a result of mitigation.

Results/conclusions: We found that installing crossing structures increased highway crossing by squirrel gliders while unmitigated sites remained a barrier to movement. Multiple individuals of both sexes and all age classes were detected crossing the mitigated highway, suggesting that some level of functional connectivity is provided. However, the impact of the highway on movement was only partially mitigated relative to non-highway (control) sites. Preliminary analysis shows that squirrel glider populations have declined at sites where the highway was recently constructed, even though crossing structures are present and used by squirrel gliders. Further analysis of population density and survival rates is currently under way. Our results suggest that monitoring the use of crossing structures by wildlife may be insufficient when inferences about population level impacts are required.

Kylie Soanes is a PhD student with the Australian Research Centre for Urban Ecology and the Quantitative and Applied Ecology Group at the University of Melbourne. Her research investigates the effectiveness of road crossing structures for arboreal mammals and the methods we use to evaluate them.

From metapopulations to meta-food-webs: spacial community ecology in the arid zone

Clarissa Barbosa[1], Jenny Davis[1], Jayne Brim Box[2], Glenis McBurney[2], Ross Thomson[1]
[1]School of Biological Sciences, Monash University, [2]NRETAS, Northern Territory Government

Background/question/methods: Local communities are influenced by the fluxes of species across the landscape. Understanding local patterns of species composition and trophic structure requires adopting a metacommunity approach, which combines community dynamics and spatial ecology. Metacommunity studies to date have focused mainly on how dispersal and connectivity affect the diversity of communities, rather than on food-web structure. We tested hypotheses about the effects of dispersal limitation, habitat connectivity and ecosystem size on the diversity and food-web structure of freshwater metacommunities in Central Australia. Freshwater systems in the arid zone present an opportunity to investigate metacommunity processes on large-scale natural systems with strong barriers to dispersal. We sampled 10 sites across the West McDonnell and George Gill ranges in the Northern Territory in January 2012 for aquatic invertebrates, water quality and habitat characteristics. Food-webs will be assembled using gut-content and stable isotope analyses.

Results/conclusions: It's expected that more isolated communities will have lower species richness and a higher percentage of specialist species, whereas more connected communities will have longer food chain lengths and higher functional diversity. Most sites had transparent waters (<1.2NTU), with pH between 6.50-9.18 and low total phosphorus (0.01-0.06mg/L). There was high variation in electrical conductivity (0.070-8.850mS/cm), in total nitrogen (0.19-0.96mg/L) and in water depth (1.68-12.95m). This work will contribute to a greater understanding of how spatial processes interact to maintain diversity and to generate structure in communities. This information will help inform how increasing landscape degradation and fragmentation, as well as the landscape-scale spread of invasive species, may influence biodiversity.

Clarissa Barbosa is a freshwater ecologist who has experience working in aquatic ecosystems of the Brazilian savanna ('Cerrado'). At present she is a PhD student at Monash University, studying how spacial processes influence diversity and structure within communities.

Patching up the divide: population dynamics of rainforest mammals in a fragmented landscape

Katrien Geurts[1], Miriam Goosem[1], Susan Laurance[2], Sarah Kerr[2], Robyn Wilson[1], Steve Turton[1]
[1]School of Earth and Environmental Sciences, James Cook University, [2]School of Marine and Tropical Biology, James Cook University

Background/question/methods: In the wet tropics bioregion of north Queensland, rainforest restricted species are threatened by habitat fragmentation and further degradation by climate change. Suitable habitat will contract when temperatures increase. For endemic upland species dispersal to highland refuges will be imperative for their continued existence. We investigated the influence of patch size, vegetation structure, isolation distance and surrounding landscape matrix on population dynamics, movements and genetic variation. Non-flying mammals were surveyed by spotlighting, mark recapture and DNA sampling in continuous rainforest, remnants close to continuous forest and fragmented patches.

Results/conclusions: Initial results show that abundance, sex ratio and body condition of mammals are similar in small patches and large patches. Species composition appears more variable, which may indicate different levels of sensitivity to fragmentation effects. From these preliminary results it seems that small fragments can act as valuable habitat for some rainforest species. However, it is possible that these tolerant species could suffer from inbreeding effects in the long term. Therefore trapping surveys are continuing and DNA samples are currently under analysis.

Results showing less gene flow between patches than between continuous rainforest sites would provide an incentive for building corridors and revegetating small patches to maintain them as stepping stones and habitat in the landscape. If varying distances between populations show different degrees of isolation this would assist in estimating an optimal corridor length. Overall this information should contribute to design the landscape for higher connectivity, which will accommodate successful dispersal to climate change refugia.

Katrien Geurts is a PhD student in Environmental Science and has obtained an international postgraduate scholarship from James Cook University. For her Master's degree in biology in Belgium, Katrien researched an invasive fruit fly species in Tanzania. After that she worked for six months in a Belgian veterinary lab.

Factors influencing the dispersal of tree species in a fragmented landscape: are roadside environments useful?

Claire Coulson[1], Peter Spooner[1], Ian Lunt[1]
[1]Charles Sturt University

Background/question/methods: In fragmented agricultural landscapes, roadside environments provide refuge for native species and threatened ecosystems, and so are important for the conservation of biodiversity. Due to their linear nature, and frequency of disturbance events from road management activities, roadsides are often threatened by plant invasions. Two contrasting models have been proposed to explain invasive plant patterns and processes in relation to roads: (1) where roads act as conduits for the invasion of plants into adjacent ecosystems, or (2) where roads act as repositories for invasion of plants from adjacent ecosystems. However few studies have focused on vertebrate dispersed tree species, where habitat preferences of the dispersing animals, availability of fruiting trees, and substrate factors may influence patterns of recruitment in relation to roadsides. We examined the stand structure, habitat and spatial attributes of populations of invasive species Schinus molle, and native species Brachychiton populneus in roadside remnants in southern NSW, where anecdotal evidence suggests these species are being dispersed into roadsides from adjacent paddock trees. We investigated: (a) what factors influence successful colonisation of these species into roadside remnants, (b) what is the relationship between paddock trees and recruitment into roadside remnants, and (c) what factors influence subsequent dispersal of these species within roadsides?

Results/conclusions: Results from a combination of field based and spatial analyses will be discussed. Knowledge of plant dispersal mechanisms in roadsides has important implications for conservation management, particularly in the context of a changing climate, as roadsides may provide vital corridors for the movement of species.

Claire Coulson recently completed an Honours project at Charles Sturt University. After several years working in environmental management she returned to study to gain a better understanding of ecological processes, hoping to better inform management. She found more questions than answers.

Seed banks of physically dormant species: season- versus fire-related dynamics and climate change

Mark Ooi[1], Tony Auld[2], Andrew Denham[2]
[1]Institute for Conservation Biology, University of Wollongong, [2]Office of Environment and Heritage, NSW

Background/question/methods: Understanding the mechanistic effects of climate change on species key life-history stages is essential for predicting ecological responses. In fire-prone regions, seed bank persistence between fires allows recovery after fire, and maintains plant populations in the long term. For physically dormant species, seed bank persistence depends on the maintenance of dormancy which is controlled primarily by temperature. We tested the dormancy thresholds of physically dormant shrub species to current and future projected summer conditions to assess seed bank resilience between fires. We then developed a conceptual framework depicting the selective pressures of fire, particularly fire frequency, on physically dormant seed traits to place the seed bank dynamics of species along a response scale, ranging from those tightly bound to seasonal cues to those bound to fire.

Results/conclusions: We found that soil temperature increases related to projected future summer conditions can cause seed bank decay between fires. This mechanism could increase extinction risk of physically dormant species and population modelling for one species, *Acacia suaveolens*, showed that this occurred for even relatively small decreases in annual seed bank survival. There were distinct functional groups identified based on seed bank dynamics, highlighting potential arguments for adaptation to fire for some species but not others. These functional groupings could allow better prediction of extinction risk from this mechanistic response to climate change.

Mark Ooi's work encompasses the broad themes of disturbance ecology and global change biology, particularly how changes to the environment can impact upon life-history traits and populations. This work is applied to understanding ecological issues, including maintaining biodiversity and climate change.

Concurrent session 5F
Temporal patterns in community assembly

Intrinsic time-dependence in the diversity-invasibility relationship

Graeme Clark[1], Brian Leung[2], Emma Johnston[1]
[1]University of New South Wales, [2]McGill University

Background/question/methods: Contradictory patterns in the diversity-invasibility relationship have intrigued ecologists for many years. Experiments testing the relationship generally find it to be negative, but field surveys usually find it to be positive. This conundrum has become known as the 'invasion paradox', and several explanations have been offered. Most propose that the paradox is driven by differences in spatial scale, but this is challenged by field surveys that find a positive relationship across all spatial scales. Here we propose that the invasion paradox may be partially driven by differences in temporal scale, since experiments generally consider invasion on shorter time scales than surveys. We present a conceptual model of how temporal scale may affect the diversity-invasibility relationship, and test the logic with a field experiment and simulation model.

Results/conclusions: Results show that the relationship begins negative and moves to positive under a wide range of scenarios, providing an alternate explanation for the invasion paradox.

Graeme Clark is a postdoctoral ecologist at UNSW with a variety of research interests, including biological invasions, disturbance ecology and climate change ecology. He predominantly works in marine systems, but enjoy tackling questions and theory of broad ecological significance.

Arrival order of native functional groups does not affect invasibility of planted dune communities

Tanya Mason[1], Kris French[1], Dianne Jolley[2]
[1]Institute for Conservation Biology and Environmental Management, School of Biology, [2]School of Chemistry, University of Wollongong

Background/question/methods: Different arrival orders of native plant functional groups to a site may affect final community structure. Arrival order may then indirectly influence community resistance to invasion. We present the results of a mesocosm experiment where we constructed coastal dune communities and monitored biotic and abiotic responses to different arrival orders of native plant functional groups. We simulated a single invasion event by bitou (*Chrysanthemoides monilifera* ssp. *rotundata*), a dominant exotic shrub of coastal communities. We then compared the planted communities with unplanted mesocosms. We evaluated the prediction that plantings with simultaneous representation of grass, herb and shrub functional groups at the beginning of the experiment would more completely use available resources and therefore limit exotic invasion than staggered plantings. Staggered plantings in turn would sequester more resources and offer greater invasion resistance than unplanted mesocosms.

Results/conclusions: Contrary to our predictions, there were few effects of arrival order on abiotic variables for the duration of the experiment and arrival order did not affect final community invasibility. All planted communities had similar responses to each other and supported significantly more invader germinants and significantly less invader abundance than unplanted mesocosms. Native plantings may have a nursery effect during the invader germination and establishment phase and a competitive function during the invader juvenile and adult phase. While grass, herb and shrub functional group plantings will not prevent invasion in restored communities, they may suppress invader biomass.

Tanya Mason is a plant community ecologist. Her previous research (University of Wollongong) looked at invader interactions with native plant biodiversity and resistance of native communities to weed invasion. Her current research (UNSW) focuses on the vegetation, biogeography and conservation status of upland swamp communities.

Changes in bird assemblages and their habitats in response to a changing climate

Joanne Bennett[1], James Thomson[1], Christine Connelly[1], Rohan Clarke[1], Shaun Cunningham[1], Ralph Mac Nally[1]
[1]Australian Centre for Biodiversity, School of Biological Sciences, Monash University

Background/questions/methods: Human-induced climate change and habitat alteration are key threats to biodiversity. The ways in which climate change interacts with other major threats to biological populations is not well understood. By 2070, southern Australia may experience a 1–5°C temperature increase compared to the present, a 10% decrease in rainfall in all months and an increase in the frequency and severity of extreme droughts. The box-ironbark forests of Victoria are a fragmented and highly modified landscape that experienced a 13-year drought, and is a system in which to study the interaction between climate change and habitat change. I have measured vegetation and bird assemblages in exactly the same ways as was done prior to the long drought to enable estimates of change.

Results/conclusions: There have been substantial shifts in vegetation, with loss of shrub cover, canopy cover and increased tree death. The bird assemblages differed markedly, with reductions in species already considered to be of conservation concern and increases in generalist, large-bodied and behaviourally dominate species. Bird species richness significantly decreased, but total abundance increased. Climate change appears to be mediating change in the bird assemblages through effects on vegetation. As these processes are global issues, this work could inform approaches to effective management of vegetation at landscape and regional scales worldwide.

Joanne Bennett is a PhD candidate at the Australian Centre for Biodiversity located in the School of Biological Sciences, Monash University. Her project investigates changes in bird assemblage structure in central Victorian forests in response to a changing climate.

Effects of successional age on community composition and above-ground biomass in tropical Australia

Miriam Goosem[1], Susan Laurance[2]
[1]Centre for Tropical Environmental and Sustainability Science, Earth and Environmental Sciences, James Cook University, [2]Centre for Tropical Environmental and Sustainability Science, Marine and Tropical Biology, James Cook University

Background/question/methods: Many tropical rainforests have been cleared and subsequently abandoned as agriculture becomes unviable. Although secondary forests often regenerate in these abandoned sites, they are considered to be a poor substitute for the original forest, lacking both high species richness and exceptional carbon storage. We investigated tropical tree diversity and carbon sequestration in regrowth rainforests of the Atherton Tablelands, far north Queensland, along a chronosequence of successional forest, varying in age from <5 years to >50 years. Our boundaries were limited to 35km^2 to minimise variation in macroclimate, topography and potential biota. We identified and measured all trees 10cm diameter at breast height (DBH) within plots of 50m x 10m at 20 sites and also all trees 2.5cm DBH within sub-plots of 50m x 3m. We analysed the influence of successional age and dominant tree species on carbon storage and community composition.

Results/conclusions: Initial analyses suggest that both tree species diversity and carbon sequestration are influenced not only by age but also by canopy dominant species. Tree species diversity also appears to be affected by an interaction between isolation and dominance in the upper storey. As the project progresses, environmental factors likely to be causing barriers to regeneration of later successional species will be further examined, together with means of reducing those barriers. Parameters of interest include landscape configuration, abiotic features such as soil condition and nutrient status and biotic interactions that influence seed dispersal and seedling recruitment.

Miriam Goosem is a Principal Research Fellow at James Cook Uni, funded by an ARC Linkage grant concerning improving biodiversity and carbon storage in rainforest regrowth. Her research interests involve mitigating human impacts in rainforest ecosystems. She lectures in environmental impact assessment.

Long-term studies: detecting and understanding trends in biodiversity

David Keith[1,2], David Lindenmayer[3], Andrew Lowe[4], Jeremy Russell-Smith[5], Neal Enright[6], Barry Fox[1], Greg Guerin[4], David Paton[4], Mark Tozer[2], Colin Yates[7]
[1]University of NSW, [2]NSW Office of Environment and Heritage, [3]Australian National University, [4]University of Adelaide, [5]Northern Territory Bushfires Commission, [6]Murdoch University, [7]WA Department of Environment and Conservation

Background/question/methods: Understanding directions, rates and causes of recent trends in biodiversity is vital to planning conservation actions. State of Environment Reports turn to map statistics and aggregated indices to infer general trends, while empirical data are considered too patchy or inconsistent to contribute to an overview. Using examples from Australian heathlands, we asked what further insights on the status of biodiversity can be gained from available empirical studies. We reviewed a selection of long-term ecological experiments of 10-30 years duration. We aimed to identify major drivers of ecosystem dynamics, determine trends in different biota and diagnose causes of change.

Results/conclusions: The studies were continental in coverage and identified land clearing, fire regimes, climate processes and disease as major influences on heathland dynamics. Fire regimes are the most ubiquitous driver, but the mechanisms and nature of fire-driven changes vary among biota and across the continent. Land clearing caused severe historical losses of biodiversity in the south-west and continues to threaten coastal heathlands. Plant disease is driving the most rapid recent declines, primarily in southern Australia. Observed sensitivities of heathland biota to climatic factors signal potential losses of diversity under future climates. All of the studies advanced understanding of heathland dynamics. Concordance between studies with varied approaches suggests robustness of inferred trends. We conclude that long term ecological studies are under-utilised in conservation reporting and planning. Further investment in them will greatly strengthen capacity to detect and interpret trends in biodiversity. Similar insights could not be achieved with any certainty by short cut methods.

David Keith has a joint appointment at the University of NSW and the Office of Environment and Heritage (NSW). His research interests include long term studies of both ecosystems and populations, and their application to conservation of biodiversity

Concurrent session 6A
SYMPOSIUM: Forest transition in a changing climate

Australia's forests and climate change: from impact assessment to adaptation

Sarah Boulter[1], Frank Stadler[1]
[1]National Adaptation Climate Change Research Facility

By using a common vulnerability assessment framework (i.e. sensitivity, exposure and adaptive capacity); the National Climate Change Adaptation Research Facility (NCCARF) commissioned a major assessment of the vulnerability of Australia's forests under climate change scenarios. The project considered both extant published research, policy and legislation as well as interviews with key stakeholders. NCCARF and its research partners determined the impacts of climate change on biophysical and socio-economic aspects of Australia's forests, options for adaptation, knowledge gaps and future research gaps. It highlighted the complexities inherent in predicting the impact of interacting environmental changes. For example, while growth trials at a pot scale show increased atmospheric CO_2 will likely improve growth or productivity, at a stand scale, the variability associated with species-level variation along with nutrient and water availability, make it much more difficult to predict the outcome of increased CO_2.

A regional scale assessment was also carried out using an agro-ecological classification of Australia to understand forest vulnerability to climate change within each of 10 regions. This comparative assessment highlighted not only those areas at greatest risk, but also areas of potential benefit from changing conditions. The ultimate outcome of the assessment is the identification of nine key policy directions for managing Australia's forests into the future.

Sarah Boulter is a Research Fellow with the National Adaptation Climate Change Research Facility. In this role, she works on the policy communication and research aspects of climate change adaptation. Frank Stadler is a Research Coordinator at the facility.

Tree growth in Australia's eucalypt forests: what does macroecology tell us about future trends?

Lynda Prior[1], Grant Williamson[1], Sam Wood[1], David Bowman[1]
[1]University of Tasmania

Background/question/methods: Climate models unanimously predict increasing temperatures around the globe, accompanied by variable and often uncertain changes in rainfall patterns. It is not clear how these changes will influence tree growth. We investigated current patterns of tree growth in Australia's eucalypt production forests to quantify how generic tree growth varies in response to climate, and thereby predict the likely consequences of climate change on individual tree diameter growth and stand basal area increment. We assembled long-term datasets supplied by forestry agencies in five states and analysed responses to temperature, rainfall and rainfall seasonality, controlling for tree size and stand basal area. In sum, the dataset was based on >800,000 records from ~275,000 trees in nearly 2800 plots spanning a gradient in mean annual rainfall from 550-2100 mm, and in mean annual temperature from 6 to 22°C.

Results/conclusions: Tree diameter and stand basal area growth rates were both correlated more strongly with mean annual temperature than mean annual rainfall, although data were highly variable. Modelled diameter growth rates were maximal in areas with mean annual temperature around 10 to 12°C, increased with rainfall up to about 2000 mm, and decreased with rainfall seasonality. Similar trends were evident for stand basal area increment. These findings strongly suggest that future tree growth in most Australian forests will decrease in response to increasing temperatures, and are likely to slow further where mean annual precipitation declines.

Biography not available at time of printing.

Modelling changing tree distribution around Perth in a changing climate

Jerome Chopard[1,2], Michael Renton[1,2], Erik Veneklaas[1,2]
[1]Centre of Excellence for Climate Change Woodland and Forest Health, [2]University of Western Australia, School of Plant Biology

In a recent worldwide review, Allen et al (2010) showed the occurrence of forest mortality related to drought. In Western Australia, species have evolved to adapt to drought conditions and nutrient poor soils. While the soil composition will not change in the near future, global climate models all predict less water for the south-west corner of Western Australia. These new conditions imply that the actual observed envelope of species physiological traits cannot be used to predict the repartition of the vegetation in a near future (Pearson 2003).

We revisit a simple old model from Sperry et al (1998) to estimate the chances of survival of species from a water point of view. The model integrates a detailed soil water transfer with the hydraulic architecture of the tree to compute tree transpiration according to environmental conditions. Contrasting strategies to uptake water (tree size, root density and spread, leaf water potential) are ranked according to their long-term (one year) efficiency in regards to edaphic (clay vs sand) and climatic conditions (average year vs dry year).

When superimposed on a map of actual repartition of species in woodlands around Perth, this approach provides a plausible estimate of what the landscape will look like according to climate predictions for the near future.

Background/question/methods: Woodlands in south-west Western Australia are composed of specific drought adapted species. All global climate models predict even less rain in this particular region. Will the trees survive? How the species composition will be affected by this trend? We use a model to rank different physiology strategies according to their efficiency to sustain plant transpiration.

Results/conclusions: The model emphasises the role of roots in water limited systems in particular root/leaf ratio and root density when the overall size of the tree does not play a preponderant role. While the estimation of belowground parameters is difficult in the field, the model successfully predicts the observed evolution of a Jarrah forest during a severe dieback event.

Jerome Chopard has a PhD on multi-scale modelling of water uptake by trees, a Post-doc on computing mechanics of meristem cells to model growth, and a Post-doc on modelling adaptation of tree to changing water conditions in Western Australia

Extreme drought and heat triggers severe dieback in multiple, dominant canopy species in south-western Australia

Katinka Ruthrof[1], George Matusick[1], Giles Hardy[1]
[1]Centre of Excellence for Climate Change, Woodland and Forest Health, Murdoch University

Background/question/methods: Ecosystems in Mediterranean climate regions are projected to undergo considerable changes as a result of shifting climate, including from extreme drought and heat events. Ensuing forest dieback and mortality are emerging as global concerns. Although Mediterranean-type forest (MTF) ecosystems are considered to be resilient to drought, we observed sudden forest collapses in two regionally significant MTFs in Western Australia (the Northern Jarrah Forest and Tuart woodland). Remote sensing and field investigations were undertaken to characterise the extent and severity of canopy dieback and tree mortality, as well as the associations between canopy health and potential predisposing site factors.

Results/conclusions: In both of these MTFs, canopy dieback was found to be concentrated in distinct areas and was affected between February and March 2011. Tree foliage rapidly discolored and died over this period. A relatively shallow soil profile and extreme drought and heat in 2010-2011 are thought to predispose water-shedding sites to drought-triggered canopy dieback during extended periods of dryness. These results suggest MTFs, once thought to be resilient to climate change, are susceptible to sudden and severe forest collapse when key thresholds are reached. Tracking forest health changes in response to severe disturbance is an important key to deciphering past and future vegetation change.

Katinka Ruthrof is a plant ecologist whose work focuses on revegetation, fire ecology, population dynamics and invasive species. Her research focuses on facilitating regeneration of degraded woodlands and forests, in addition to improving rehabilitation techniques for disused limestone quarries.

Impacts of large scale drought deaths in Western Australia's northern jarrah (*Eucalyptus marginata*) forest

Giles Hardy[1], George Matusick[1], Katinka Ruthrof[1]
[1]Centre for Climate Change, Woodland and Forest Health, Murdoch University

Background/question/methods: Devastating forest damage resulting from extreme drought and heat is increasingly reported from around the world. In late 2010 and early 2011, due to abnormally dry conditions (less that 50% rainfall) and mean maximum temperatures of 1 to 1.5°C above average, large areas of canopy collapsed in the northern jarrah (*Eucalyptus marginata*) forest in the south-west of Western Australia (SWWA). Monitoring plots within and outside the damaged sites were established to determine (a) where the damage occurred, (b) what species were affected and to what severity, and (c) to examine relationships between damage and topography, soil type, stocking, stand structure, and the presence of the introduced soil-borne plant pathogen *Phytophthora cinnamomi*. In addition, how the plots changed over time was followed with regards to tree response, secondary pests and fuels.

Results/conclusions: Approximately, 16,800 ha of forest was shown to have collapsed. Approximately 50% of the collapse sites were associated with shallow soils. Marri (*Corymbia calophylla*), jarrah, *Banksia grandis* and *Allocasurina fraseriana* were shown to be sensitive to drought. Many trees died, whilst others developed epicormic or coppice shoots. Large numbers of *Phorocantha semipunctata* were observed to attack stressed trees and contribute to tree deaths. It is likely major structural changes are likely to occur in the jarrah forest with the predicted drying and warming climate in this region. Detailed findings and the implications of this forest collapse will be discussed.

Professor Giles Hardy is the Director of the Centre for Climate Change, Woodland and Forest Health. He is interested in how abiotic and biotic diseases impact on ecosystem function and health.

Mapping tree damage caused by extreme drought and heat using a remote sensing approach

Niels Brouwers[1], Ricky van Dongen[2], George Matusick[1], Greg Strelein[2], Giles Hardy[1]
[1]Centre of Excellence for Climate Change, Woodland and Forest Health, Murdoch University, [2]Department of Environment and Conservation, Western Australia

Background/question/methods: Forest ecosystems and dominant tree species have increasingly showed signs of decline around the world related to changes in climate. The south-west of Western Australia (SWWA) has been no exception. In 2010 and early 2011, the SWWA received 50% less rainfall compared to the long-term average, and experienced multiple heatwaves resulting in localised tree crown dieback in the Northern Jarrah Forest region. Indicating (and predicting) where in the landscape the declines occurred is important to adequately direct management resources and inform future planning. This research reports on efforts undertaken to accurately map the areas where damage occurred using a remote sensing approach. Multiple maps were produced indicating affected areas based on changes in foliage 'greenness' using two Landsat TM scenes captured at different dates. A sensitivity analysis of the adopted remote sensing approach and an accuracy assessment was performed using ground validation data.

Results/conclusions: Four change maps were produced using different scene combinations and 'greenness' indexes. The preliminary results indicate that: (i) the adopted remote sensing approach shows good potential for accurately mapping the affected areas, and (ii) NDVI is a good 'greenness' index to use in this process. More work is currently under way and the results will be presented.

Niels Brouwers is a Postdoctoral Research Fellow at the Terrestrial Ecology group in the School of Environmental Science at Murdoch University. He is specialised in forest and landscape ecology.

Flooding, salt, grazing and thinning affect regeneration dynamics of river red gum (*Eucalyptus camaldulensis*) forests of the Murray River

Gillis Horner[1,2], Ralph Mac Nally[1], Shaun Cunningham[1], Patrick Baker[1], James Thomson[1]
[1]Monash University, [2]GHD

Background/question/methods: Riverine ecosystems already under stress from river regulation and water extraction are now experiencing a chronic, additional stress through climate change. Forest dieback due to reduced flooding and salinisation, is likely to be exacerbated by climate change-induced droughts. We used a 42-year growth dataset to examine the effects of initial stand density on mortality, tree growth and structure of floodplain forests. We also conducted a field experiment to investigate which factors influence seedling survival.

Results/conclusions: River regulation, grazing and salinisation have created conditions that are unfavourable for seedling regeneration and adult survival. We showed that a dramatic increase in mortality in the high-density river red gum stands coincided with a steep temporal gradient of drying (imposed by a warming climate, river regulation and reduced groundwater availability), while mortality remained little changed in lower-density treatments. Early thinning also had a pronounced effect on forest structure, tree growth, habitat and aboveground carbon storage rates. Seedling survival is also likely to be a critical process limiting population viability of dominant floodplain tree species in many water-limited river basins. We showed that flooding produced an eight-fold increase in seedling survival, yet the positive effects of flooding largely were nullified by grazing and sediment salinity.

My results highlight the importance of initial stand density and seedling survival as key determinants influencing the development of floodplain forests. I recommend that managed flooding and early thinning of developing stands be considered as part of a broader management strategy to enhance forest regeneration, carbon storage and wildlife habitat.

Gillis Horner completed his undergraduate degrees at the University of Adelaide. He recently completed his PhD at Monash University on the ecological dynamics of river red gum forests of the Murray River. He has over 17 years experience working on Qld, Vic and NSW catchments of the Murray-Darling Basin

Eucalyptus Free-air CO2 enrichment ('FACE') and how atmospheric CO2 is affecting Cumberland Plain biodiversity

David Ellsworth[1], Teresa Gimeno[1], Kristine Crous[1], Oula Ghannoum[1], Matthias Boer[1]
[1]Hawkesbury Institute for the Environment, University of Western Sydney

Background/question/methods: Global atmospheric CO_2 concentrations are rising at a rate reaching nearly 2% pa and as $[CO_2]$ is enriched, a stimulation of leaf net photosynthesis and the ecosystem carbon cycle is expected. Stimulation of photosynthesis and plant growth and C storage by elevated [CO2] has large potential offsetting effects on further increases in atmospheric [CO2], but on the other hand there is evidence of saturation in this response particularly due to nutrient limitations. A *Eucalyptus* Free-air CO2 enrichment ('FACE') has been established in a *Eucalyptus* woodland in the Cumberland Plain of western Sydney, and [CO2] within FACE plots has been raised by 90ppm over the past few months. We ask whether understory grasses and overstory trees in this forest system respond similarly to elevated [CO2], to understand whether species dynamics may be affected in a future, higher-CO2 atmosphere. Both mature *Eucalyptus tereticornis* trees and the native C3 grass understory species *Microlaena stipoides* were studied to understand if these species respond similarly to elevated CO2.

Results/conclusions: Leaves of mature *Eucalyptus tereticornis* trees showed a strong photosynthetic enhancement in elevated [CO2] of 5 micro-mol CO2 m-2 leaf s-1, or +26% though a small stomatal response to [CO2] was observed. The dominant grass (*Microlaena*) showed a smaller photosynthetic response to [CO2] of +15% but large reductions in stomatal conductance. Thus, the balance of ecosystem water-use has been altered by elevated [CO2], with implications for how Australian forests and biodiversity may change in a future, higher-CO2 atmosphere.

Professor David Ellsworth is a plant eco-physiologist at the University of Western Sydney's Hawkesbury campus in Richmond, NSW. He has worked on FACE experiments involving woody perennial species for nearly 20 years. He is among the highly-cited scientists in Australia in ecology and environment.

Concurrent session 6B
SYMPOSIUM: Linking Indigenous and Western ecologies

Can modern science be akin to TEK? Case studies: linking cultural knowledge and park management

Rebecca Phillips[1]
[1]Vic Parks

The connection Aboriginal people have to their Country is built upon evolutionary interrelationships and lifecycles. It is evident the landscape has shaped their culture and their culture has shaped the land. This is why traditional ecological knowledge (TEK) is so important in understanding the story of Country and for advancing the study of phenology for improved management of that land.

Both TEK and phenology are dependent and built upon observations of ecological timing in a specified area. In addition, both utilise key species of interest that are influenced by climate or signify a seasonal change. The differences include: the timescale of recorded knowledge; how environmental and astronomical observations are interpreted through different languages, cultural values, world views, law and society. The methods of accumulating that knowledge is contrasting to oral histories, songs, dance and art rather than written data and modern technologies, such as carbon dating. By aligning and combining knowledge and resources through engaging TEK holders with environmental scientists and modern technology is being explored through seasonal calendars. This approach is avoiding the flaws of intellectual property rights by assisting Aboriginal people to assert control over the use of TEK while at the same time activating it in the delivery of joint management.

Rebecca Phillips is the Traditional Ecological Knowledge Coordinator for Vic Parks and has written several papers on the importance and value of traditional ecological knowledge.

Working on Country

Ray Ahmat[1]
[1]Vic Parks

Working on Country (WoC) Program is funded by the Federal government Caring for our Country Program.

The WoC is in conjunction with Parks Victoria and Yorta Yorta Nation Aboriginal Corporation (YYNAC) on a co-management agreement to support the YYNAC aspiration on their custodian landscapes.

The program supports working on country activities such as pest and weed management as well as ecological monitoring project and cultural heritage site protection on country.

Background/question/methods: Give people an understanding on a project that can show working relations with the government land manager and the Aboriginal community.

Results/conclusions: Sustaining the environment for future generations to come.

Ray Ahmat is the Indigenous Ranger program coordinator for the River Red Gum District and Yorta Yorta Aboriginal Nation in northern Victoria

Bunuba business on Bunuba country

Clive Aiken[1], Dave Dolman[2]
[1]Bunuba Rangers, Darlngunaya Pty Ltd, [2]Kimberley Science and Conservation Strategy, Department of Environment and Conservation

Background: In the remote central Kimberley region of Western Australia, Bunuba Peoples asked themselves 'how can we create new opportunities for our people to continue to practice and teach land management across country? The Aboriginal land council is unable to meet our needs and the State government already has staff to run the gazette Parks and Reserves on our country'.

Method: Bunuba draw on their long-standing business acumen as cattle station owners and develop themselves as land management contractors where traditional relationships to country, successful ventures in the pastoral industry and generational relationships with the Department of Environment and Conservation in the region, are their purchasable skills.

This is not a story of just one more Indigenous ranger group on the Australian landscape, but a story of an independent group of traditional owners establishing a very unique Australian small business where through fee-for-service the State government and others contract them for land management services.

Through their business relationships, Bunuba have seen their families return to country; employment and training given to Bunuba people; an emerging Bunuba leader is further enhancing his skills, knowledge and contributions; tourism ventures are being planned; the threats of feral animals and weeds are being tackled head on and fire regimes and ecological monitoring utilise both-ways knowledge and methods.

Results: Clive Aiken, Ranger Coordinator, will share the first twelve months of their working experiences presenting a story that is the living practice of Indigenous and western ecologies working together.

Clive Aiken is a Bunuba man. As coordinator of the Bunuba Rangers, he has continued his grandfather's work in creating a formal partnership with the Department of Environment and Conservation. He has developed and guided an active team of Rangers and an annual land management works program across Bunuba country.

Cross-cultural research for managing *Allosyncarpia* rainforest patches of the Arnhem plateau

Jeremy Freeman[1], Jeremy Russell-Smith[2], Dean Yibarkuk[1]
[1]Charles Darwin University, [2]NAILSMA

Background/question/methods: Traditional owners of the Arnhem Plateau have identified isolated rainforest patches as a focal conservation target. Dominated by the large, endemic *Allosyncarpia ternata* tree these rainforests are both culturally and ecologically significant. Management planning delineated key knowledge gaps including mapping suitable for on ground works, identification of priority management sites based on cultural-ecological inputs and resolving between two contested theories of *Allosyncarpia* condition. Many scientists and land managers assert that the loss of the indigenous burning regime created larger, hotter fires across the landscape, thus causing contraction of *Allosyncarpia* patches. Other researchers claim there is a landscape wide expansion of *Allosyncarpia* resulting from elevated CO_2 and rainfall. The implications for land management of either theory are critical. To definitively determine *Allosyncarpia* trend and condition this latest research analysed 60 years of aerial photos at 40 sites across the Arnhem Plateau, classifying canopy cover over three time periods. It also conducted extensive on ground surveys.

Results/conclusions: New mapping greatly reduced the previously established extent of *Allosyncarpia* and identification of priority areas has focused on ground works and aided in acquiring new funding. Desktop and field data analysis revealed that most isolated patches are degraded by fire. Patches which aerial photo analysis suggests are 'expanding' are in fact sites recovering from dieback, with new canopy consisting of regrowth. These findings demonstrate that fire is a dominant factor in Northern Australia and reinstatement of a traditional fire regime is required to protect isolated *Allosyncarpia* patches.

Jeremy Freeman is a PhD candidate at CDU working on his thesis on cross cultural monitoring on Indigenous managed lands, using case study ecosystems from the Arnhem Plateau. He has a background in spatial information science and has worked in the university, government and private sectors.

Cultural mapping and freshwater turtle monitoring in Githabul country

Doug Williams[1], Nicholas McClean[2]
[1]Githabul Working on Country Program, [2]Australian National University

Freshwater turtle diving has been identified as a unique cultural practice among Northern Rivers aboriginal groups, providing a regular source of bush food for Githabul people, a forum for promoting cooperation, social cohesion and family bonding within the community, and a source of cultural identity. Here we present ongoing work mapping and recording cultural heritage places and practices in Githabul country (in the Border Ranges in NE NSW) with a particular focus on turtles. Doug Williams discusses traditional culture and the place of mapping in demonstrating the strength of traditional relations to land, while Nick McClean presents the work of the Githabul Rangers, monitoring freshwater turtle numbers and habitat, and recording turtle diving techniques. Our combined approach fits into broad program development that aims to promote Githabul culture within current collaborative land management agreements, providing the basis for Githabul led cultural heritage and wildlife conservation initiatives.

Background/question/methods: This project was developed through a pilot project investigating Githabul cultural heritage management options in 2010. This was a collaboration between the Australian National University and Githabul Working on Country program. During and since this process, key members of the Githabul community expressed a desire for focused work at the interface of cultural heritage and environmental management, to address the causes of turtle decline. The project has been included in the Githabul Rangers draft scope of works for 12/13. Oral history and cultural mapping work has established not only the importance of turtle diving among Githabul, but also the general decline in turtle numbers. Today, many of the main river channels are suffering from siltation and bank erosion, and this habitat loss combined with regular take among Northern Rivers Aboriginal communities, has placed increasing pressure on freshwater turtle populations. The project work focuses on determining the cultural and ecological significance of freshwater turtles. Working with elders in the Githabul community, rangers record oral history interviews about the role of turtle diving in community life, record sacred sites at selected turtle diving sites, monitor turtle numbers in these places, and map the broad extent of turtle diving and related food harvesting places in Githabul country. This information will provide the first data set to be stored in a cultural heritage database currently under development by Githabul Working on Country. In later stages of the project, a focus will be on using the skills and knowledge acquired to identify a small number of sites as Githabul cultural places, to be protected and managed by Githabul Rangers in line with Githabul community priorities. This will contribute to a broader program of site protection and management, that is an identified priority of Githabul Working on Country.

Conclusions/results: As the project outlined above is currently under way there have not been specific results/conclusions written up. However these are expected to be delivered before December 2012.

Doug Williams is a Senior Custodian of the Githabul Nation. Doug is presently chair of the Githabul Nation Aboriginal Corporation and Cultural Officer for the Githabul Working on Country Program. Doug works with the Githabul Ranger Team and wider community on a range of cultural knowledge projects

Indigenous knowledge is fundamental to management of Indigenous owned Australia: case study from Arnhem Land

Emilie Ens[1], Emmanuel Namarnyilk[1]
[1]Centre for Aboriginal Economic Policy Research, Australian National University

Twenty-three per cent of Australia is Aboriginal owned land under statutory authority and this figure is increasing as more native title claims are heard and won in the courts. Most of this land is in remote parts of the country where there is a wealth of Indigenous culture, knowledge and interest in managing country for natural, cultural and socio-economic values. Concurrently, remote parts of Australia are relatively less well understood by western scientists and less controlled by non-Indigenous land managers compared to urban and regional areas. Therefore, Indigenous knowledge systems and action is essential in these areas. In this presentation we will demonstrate the opportunities for supporting Indigenous land management in remote Australia through recognition of the fundamental value of Indigenous knowledge which has been built up over millennia of Indigenous control, use and management. Further, recognition of the importance of building socio-ecologically sustainable management practices that draw on use of Indigenous and non-Indigenous knowledge is discussed using examples from Arnhem Land. Ecological entities we will discuss include wetlands, plants and frogs.

Emilie Ens and Emmanuel Namarnyilk have been working together in Arnhem Land for four years. We have been studying how Indigenous and non-Indigenous knowledge/methods can be used to manage remote Aboriginal owned land, including Emmanuel's ancestral country in western Arnhem Land.

Concurrent session 6C
Ecological genetics

Species boundary delimitation of the genus *Pelargonium* (L'Her. ex Aiton) in Australia

Chong Ren Ong[1], Niccy Aitken[1], Justin Borevitz[1], Brendan Lepschi[2], Adrienne Nicotra[1]
[1]Research School of Biology, Australian National University, [2]Australian National Herbarium

Background/question/methods: The genus *Pelargonium* in Australia is an evolutionarily recent group believed to have arrived from Africa via long distance dispersal approximately 5 million years ago. The current taxonomy of the Australian *Pelargonium* recognises 8 species on the basis of habit, vegetative and floral characters. However, different populations of *P. australe* exhibit substantial morphological variation that remain constant in cultivation under similar conditions, whereas *P. littorale* and *P. inodorum* are difficult to distinguish by morphology alone. The aim of this study was to improve species delimitation and explore the driving forces leading to differentiation within the Australian *Pelargonium* by combining morphometric analysis, crossing experiments and a genotyping by sequencing (GBS) method to phyogenetic analysis. Morphometric analysis consisted of both landmark-based geometric morphometrics (GMM) as well as a traditional morphometric analysis based on 67 morphological characters. We performed two sets of crossing experiments within the widespread *P. australe* and *P. inodorum*/*P. littorale* complexes. Phylogenetic relationships were analysed based on multilocus SNP markers of 59 Australian populations and 4 African outgroups derived through GBS.

Results/conclusions: Preliminary analysis of the morphometric data demonstrates that the current circumscription of *P. australe* is a complex of four morphologically distinct entities. *Pelargonium littorale, P. inodorum* and *P. helmsii* are morphologically very similar while *P. rodneyanum*, *P. havlasae* and *P. striatellum* form a disjunct grouping of three separate clusters. Results will complement ongoing research targeted at understanding trait evolution from an ecological and genetic basis as well as the role of phenotypic plasticity in speciation within the Australian *Pelargonium.*

Chong Ren Ong is an honours student in the Research School of Biology at ANU with interests in plant evolution and systematics.

Urbanisation results in genetic isolation of endangered bird population inhabiting saltmarsh remnants

Richard Major[1], Andrew King[1], Georgina Cooke[1], Rebecca Johnson[1], Jaynia Sladek[1]
[1]Australian Museum

Background/question/methods: Urbanisation represents the most extreme form of matrix transformation and it is expected to severely restrict dispersal of animals, both because of the structural unsuitability of the novel habitat as well as through mechanisms associated with human activity such as disturbance by motor vehicles. Urban development tends to be most intense in coastal zones and has been a major cause of decline of the coastal saltmarsh endangered ecological community. The aim of this study was to determine whether isolation by urbanisation represents a significant threat to the listed endangered population of a saltmarsh-dwelling bird, the white-fronted chat. DNA was extracted from feathers from 78 individuals from five sites, including two saltmarsh remnants within 15 km of Sydney CBD and three sites up to 500 km distant. Eighteen microsatellite markers were used to compare genetic structure and measure genetic variability between populations.

Results/conclusions: The two populations surrounded by intensive urban development were genetically distinct from each other despite being separated by less than 20 km. They were also distinct from more continuous populations to the north, south and west of Sydney, which themselves showed negligible genetic differentiation. The two endangered populations had low levels of genetic diversity reflected in the number of alleles and heterozygosity. Interestingly, two immigrants were detected in one of the isolated populations but despite multiple nesting attempts, they have failed to effect genetic rescue. This study demonstrates that the urban matrix can represent a significant barrier to movement of even highly vagile species such as birds.

Richard Major is a research scientist in the Australian Museum's terrestrial vertebrate section, with special research interests in the ecology of birds in fragmented landscapes.

The genetic structure of an endangered amphibian in an urban landscape

Claire Keely[1,2], Joshua Hale[1,2,3], Kirsten Parris[1], Geoff Heard[1], Jane Melville[2], Andrew Hamer[4]
[1]School of Botany, The University of Melbourne, 2Department of Sciences, Museum Victoria, [3]Department of Zoology, The University of Melbourne, [4]ARCUE, c/o School of Botany, University of Melbourne

Background/question/methods: Urbanisation is a leading cause of species extinctions worldwide and is considered a major threat to global biodiversity. Recently proposed urban growth boundaries will increase the extent of Melbourne, Australia by an additional 40,000 hectares. The endangered growling grass frog (*Litoria raniformis*) will be directly impacted by Melbourne's urban expansion over the next few decades. Remnant populations of this frog occur throughout the proposed urban growth areas, and the species is known to be sensitive to habitat fragmentation caused by urbanisation. We assessed the genetic structure of remnant populations of *L. raniformis* across Melbourne's urban fringe. Tissue samples were collected from 270 individuals across the south-west, west and south-east regions of the city, and combined with a further 179 samples obtained previously from northern Melbourne. Haplotype composition and diversity were determined by sequencing a fragment of the mitochondrial gene, COI.

Results/conclusions: In total, 23 distinct haplotypes were represented. Shared haplotypes and low levels of diversity were observed between populations distributed across Melbourne's north. In contrast, populations in the south-east were composed largely of unique haplotypes and showed the greatest level of diversity. Information acquired during this project will be integrated into models of metapopulation viability for *L. raniformis* around Melbourne, and used to inform decisions concerning reserve design, translocations and re-introductions.

Claire Keely is currently undertaking a PhD through The University of Melbourne and Museum Victoria. Her research is focused on the conservation genetics of the endangered growling grass frog, *Litoria raniformis*, in an urban environment. For more information http://cckeelyresearch.wordpress.com/

Inbreeding and outbreeding depression in *Stylidium hispidum*: implications for mixing seed sources for ecological restoration

Siegy Krauss[1], Kristina Hufford[2], Erik Veneklaas[3], Louisa Cockram[3]
[1]Kings Park and Botanic Garden, [2]University of Wyoming, USA, [3]University of Western Australia

Background/question/methods: The benefits of composite rather than local seed provenances for ecological restoration have recently been argued, largely on the basis of maximising evolutionary potential. However, these arguments have downplayed the potentially negative consequences of outbreeding depression once mixed provenances interbreed. In this study, we compared intraspecific F1 hybrid performance for four populations of *Stylidium hispidum*, a species endemic to south Western Australia. To test for outbreeding depression, we conducted controlled pollinations and assessed germination and survival to 6 months for three cross categories (within population crosses, short- and long-distance F1 hybrids) for paired sites (3-10km apart) distributed within two genetically differentiated regions (120km apart). Reciprocal transplant trials with F1 progeny were established for 18 months within initial source populations to further assess outbreeding depression through survival, growth, flowering and seed production.

Results/conclusions: For germination and survival, we found strong evidence for outbreeding depression in long-distance crosses, and inbreeding depression for within population crosses, relative to short distance crosses. For *in situ* survival and growth, we found evidence for a long-distance cross advantage over both short-distance and within-population crosses. Final seed production results will be presented. Cumulative results however identify an intermediate outcrossing distance (here, equivalent to 10km) in this species. These results are considered in light of the evolutionary consequences of mixing seed sources for biodiversity restoration.

Siegy Krauss heads up the Conservation Genetics lab at Kings Park and Botanic Garden in Perth, Western Australia. Here, molecular tools are being applied to issues and questions underpinning better conservation and ecological restoration of our unique native flora.

How sensitive are genetic estimators of population structure at detecting fragmentation?

Bernd Gruber[1], Aaron T Adamack[1]
[1]Institute for Applied Ecology, University of Canberra

Background/question/methods: There is an ongoing debate how to analyse data from genetic markers such as microsatellite when studying a species' population structure. Meirmans & Hendrick (2011) recently reviewed three estimators of genetic differentiation: F_{st}, F'_{st} and D. In their conclusions they recommended reporting all three estimators in future studies of population structure, but favoured the use of F'_{st}, as 'in most cases F'_{st} would be the best choice […] as it is most suited for inferences of the influence of demographic processes such as genetic drift and migration on genetic population structure'. They primarily based their conclusion on studying the theoretical properties of the indicators having classical approaches in mind.

We tested the sensitivity of these estimators of genetic differentiation for detecting population fragmentation using a landscape genetic approach. The ability of the three estimators to detect population fragmentation caused by a landscape feature that acts as a barrier to gene flow was tested for varying levels of sampling effort and time spans in which the barrier was effective (e.g. the construction of a road).

Results/conclusions: Our simulations showed that the three estimators performed similarly with regards to sampling effort, but performed quite differently in their sensitivity to recent fragmentation events. Our results suggest that researchers should exercise caution when developing their sampling design for future population structure studies to ensure their design is capable to detect causes of population structure.

Bernd Gruber's main research interest is how genetic data can be used to infer population processes and to inform the management and conservation of threatened species. He is currently employed as an Assistant Professor and lectures various subjects such as biometry, GIS and ecological modelling.

Estimating the population history of an endangered bird, the helmeted honeyeater

Peter Selwood[1], Alexandra Pavlova[1], Katherine Harrisson[1], Neil Murray[2], Bruce Quin[3], Peter Menkhorst[4], Leo Joseph[5], Graham Stone[6], Ian Smales[7], Paul Sunnucks[1]
[1]Monash University, [2]La Trobe University, [3]Department of Sustainability and Environment, [4]Arthur Rylah Institute for Environmental Research, DSE, [5]CSIRO, [6]University of Edinburgh, [7]Biosys

Background/question/methods: The helmeted honeyeater (*Lichenostomus melanops cassidix*) is a highly endangered subspecies of the yellow-tufted honeyeater (*L. melanops*). It possesses a distinct colour demarcation in the nape of adults, larger crest and weight and longer body length than the other subspecies and has generally been characterised by high site fidelity and habitat specificity. It is unclear whether the helmeted honeyeater is a unique and independently evolving lineage, as it could potentially represent a severely bottlenecked population of the yellow-tufted honeyeater. We tested this using microsatellite genotypes and mitochondrial and nuclear sequences of several hundred individuals spanning the entire range of the yellow-tufted honeyeater. Population genetic, approximate Bayesian computation (ABC) and coalescent techniques were used to elucidate the demographic history of the species complex, with particular focus on if and when the helmeted honeyeater diverged from the other subspecies.

Results/conclusions: Analysis of genetic data revealed that helmeted honeyeater was genetically differentiated from the other subspecies, although the genetic variation of helmeted honeyeater was only a subset of that present in the other subspecies. Coalescent and ABC estimates based on DNA sequence data indicated that helmeted honeyeater diverged from its closest subspecies in Pleistocene, with some gene flow occurring since divergence. These estimates may be seen as consistent with the conservation priority given to the helmeted honeyeater. Recent observed hybridisation between the helmeted honeyeater and neighbouring populations from another subspecies can be seen as continuation of historic gene flow, as long as this hybridisation remains at 'natural' low levels.

Peter Selwood completed his Bachelor of Science (Science Scholar Program) at Monash University. He completed his honours project on the demographic history on the helmeted honeyeater under the supervision of Dr Paul Sunnucks and Dr Alexandra Pavlova.

Success and failure of invasions: does genetic variation matter?

Sara Ohadi[1], Rebecca Ford[1], Peter Ades[1], Roger Cousens[1]
[1]Melbourne School of Land and Environment, University of Melbourne

Background/question/methods: The introductions of species to new environments may not always result in self-sustaining populations. Founder populations may be lacking sufficient variation to cope with the novel environmental conditions in the new habitat. Therefore, rapid adaptation and plasticity in ecological traits may be their only prospect for survival and establishment, unless some additional variation to the invader population alleviates the bottlenecks. Here, the success and failure of two congeneric invasive species, *Cakile maritima* and *Cakile edentula*, has been studied to find out about the role of variation in the success/failure of either species. These two species have invaded coastal habitats of Australia sequentially, where the invasion of the latter species (*C. maritima*) has displaced the first species (*C. edentula*). High variation (genetic and phenotypic) in *C. maritima* was hypothesised to be conducive to its better establishment compared to *C. edentula*. To determine the extent and pattern of variation within and among populations of both species, 29 populations (a total of 548 samples) were collected from Western Australia, South Australia, Victoria, New South Wales, Queensland, Tasmania and Lord Howe Island. Samples were genotyped with eight simple sequence repeat (SSR) markers for evaluating the genetic diversity and structure within and between species.

Results/conclusions: Microsatellite analysis revealed higher genetic diversity and allelic richness for *C. maritima*. The number of detected alleles varied substantially between the two species, where *C. maritima* and *C. edentula* populations had 77 and 58 alleles, respectively. Although a high level of inbreeding was found for both species, the inbreeding coefficient was lower for *C. maritima* (Fis: 0.45), which is an out-crosser, than in the inbreeding *C. edentula* (Fis: 0.65). The geographical pattern of the genetic structure of *C. maritima* suggested that genetic variation in *C. maritima* has been derived from multiple sources. In contrast, all the populations of *C. edentula* were genetically similar, despite being geographically isolated. These results underpin the potential role of genetic diversity in the relative success of invasions by *Cakile* species.

Sara Ohadi is a PhD student at the department of Geography and Resource Management, University of Melbourne. In her PhD project she is looking at how variation can contribute to success of invasions. Using molecular techniques, she is trying to reconstruct the invasion history of two coastal invaders Cakile spp.

Mechanisms of response to novel environments in genetically depauperate invasive Japanese knotweed

Christina Richards[1], Massimo Pigliucci[2]
[1]Department of Integrative Biology, University of South Florida, [2]Philosophy Program, Graduate Center, City University of New York

Background/question/methods: Given that the invasion process often entails population bottlenecks, it is surprising that many invasives appear to thrive even with low levels of sequence-based genetic variation. A growing number of studies have found that many plant invaders are successful, and can even colonise new habitats with low DNA sequence based diversity. Among these are the Japanese knotweeds, which are expanding into novel coastal habitats on the north-east coast of the United States with only a few genotypes. Using reciprocal transplants across three habitats, we described patterns of phenotypic response to different environments, measured phenotypic differentiation, and assessed degree of local adaptation with ANCOVA and path analysis.

Results/conclusions: Habitats elicited significant differences in leaf area, succulence, number of leaves, height and biomass, and in relationships among traits. Path analysis revealed differences in selection among habitats by modelling the relationship among traits and fitness (total biomass). Also, plants from different populations maintained persistent phenotypic differences: marsh plants had greater leaf area, total number of leaves, were taller and had greater biomass than plants from the beaches and roadsides. In contrast, plants from the roadside had greater survival. Our results did not generally support the hypothesis of local adaptation (i.e. 'home site advantage'), but the patterns of selection and differentiation suggest that these populations could be in the process of adapting. Since these populations consist of few genotypes, our findings suggest that natural selection may be able to favour individuals based on the availability of non-genetic sources of heritable phenotypic variation in these environments.

Christina Richards is an assistant professor in the Department of Integrative Biology at the University of South Florida in Tampa, FL, USA. Her research incorporates genomics and epigenetics tools into ecological experiments to understand how organisms respond to stressful and changing environments.

Concurrent session 6D
Extremes of interactions: parasitism to mutualism

Ecological interactions between hosts and parasites: *Salmonella* slyly slinks among sixty social sleepies

Michael Bull[1], Stephanie Godfrey[2], David Gordon[3]
[1]Flinders University, [2]Murdoch University, [3]Australian National University

Background/question/methods: Conventional models of host-parasite dynamics suggest equal exposure to infection by all members of a population. In reality, the exposure of individual hosts will depend on the mechanism of transmission, and for many parasites social networks in host populations could determine host-parasite dynamics. However, empirical support for social networks as pathways for disease transmission, particularly for indirectly transmitted parasites, is lacking for many wildlife populations. We constructed the social network in a population of Australian sleepy lizards (*Tiliqua rugosa*). Data loggers on each of 60 lizards recorded GPS locations every 10 minutes of every day through the 120 day lizard activity season. We deduced social contact from the proximity of pairs of lizards in synchronised location records, and used the frequency of contacts to derive weighted network edges between pairs of lizards. We found multiple genetic strains of the enteric bacterium *Salmonella enterica* within the population.

Results/conclusions: Pairs of lizards that hosted the same bacterial genotypes were more strongly connected in the social network than were pairs of lizards that did not. In contrast, there was no significant association between spatial proximity of lizard pairs and shared bacterial genotype infections. These results provide strong correlative evidence that bacterial infections are passed around the social network, rather than that adjacent lizards are picking up the same infection from some common source. They provide a foundation for new understanding of host-parasite dynamics and for the control of exotic pathogens that threaten wildlife populations.

Michael Bull has been studying sleepy lizards and their parasites for 30 years. His ESA membership exceeds 30 years and he believes he has attended every ESA meeting since 1980, regularly talking about a long-term lizard project. He is currently Managing Editor of the society's journal Austral Ecology.

Invader-invader mutualism influences entry and establishment of other alien species in rainforest on Christmas Island

Luke O'Loughlin[1], Peter Green[1]
[1]Department of Botany, La Trobe University

Background/question/methods: The 'invasional meltdown' hypothesis posits that the ability of some species to invade intact ecosystems may be contingent on mutualism between primary invaders altering recipient communities to facilitate secondary invaders. This may occur via changes that allow alien species to either enter the system (true-entry) or significantly increase in numbers (population-release) and become invasive. On Christmas Island, mutualism between invasive yellow crazy ants and honeydew-secreting scale insects has led to population explosions of both, dramatically altering the rainforest understory by causing the local extinction of omnivorous red crabs. We tested the hypothesis that by deleting crabs, the ant-scale mutualism facilitates the secondary invasion of rainforest by a variety of non-native landsnails, either by creating enemy-free space or by augmenting habitat resources. We sampled the landsnail fauna across 20 replicate sites in four forest states, characterised by the density of crabs and ants.

Results/conclusions: Of 18,084 landsnails, 83.8% in 18 species were exotic. The smallest of these, *Georissa* spp. (1mm), were present at all sites, but showed a strong trend towards greater abundance in states where crabs were locally extinct ($F=3.13$, $p=0.06$). A larger species (*Achatina fulica*, >40mm) was absent from both forest states where crabs were abundant, and occurred at 60% of sites in the two states where crabs were absent ($X^2=8.44$, $p=0.038$). These data suggest that mutualism between primary invaders does facilitate secondary invasions, but the mechanism is size dependent; creation of enemy-free space for large species (true-entry), and habitat augmentation for small species (population-release).

Luke O'Loughlin completed a B. Conservation Biology and Ecology (Hons) in 2009. His previous researched focused on shrub encroachment, both in terms of invasion and habitat restoration. Began his PhD studies looking at interactions between invasive species on Christmas Island in 2011.

Plant-parasite stable polymorphisms: a simple but overlooked solution?

Ryan Sharp[1,2], Femke van den Berg[1], Michael Shaw[2], Frank van den Bosch[1]
[1]Rothamsted Research, [2]University of Reading

Background/question/methods: The gene-for-gene (GFG) relationship states that for each gene coding for pathogen virulence there is a matching gene in the host coding for resistance. The GFG model implies an evolutionary arms race between plant and pathogen, but stable polymorphisms (whereby genes are maintained indefinitely) have still been observed.

Many studies have tried to identify what causes these polymorphisms in GFG systems by testing various specific and complex factors. We hypothesise that stable polymorphisms can be caused just by incorporating some simple epidemiology, i.e. density-dependence and coinfection.

Epidemiological models have been investigated before but have also incorporated other factors known to generate stable polymorphisms (e.g. perenniality and polycyclic disease), thus the effect of density-dependence remains unclear. Coinfection is a factor that is inherent at some level in all plant-pathosystems but is also a factor largely overlooked.

A discrete-time dynamical system was developed representing the GFG dynamics between an annual host plant and a monocyclic pathogen. The model was then analysed to determine whether co-evolution under density-dependence and different modes of coinfection leads to stable polymorphisms.

Results/conclusions: We found that: the density dependence inherent in all real world systems can account for the stable polymorphisms found in some plant-pathosystems; the mode of coinfection can greatly affect the evolutionary outcome, e.g. modes favouring the avirulent pathogen yield more stable polymorphisms. More complicated mechanisms are therefore not needed.

Many studies inadvertently incorporate a number of factors that yield stable polymorphisms simultaneously; our work elucidates this problem and allows us to suggest platforms for future research.

Ryan Sharp is a PhD student at Rothamsted Research, where he develops and applies models of plant-pathogen interactions. Recent work includes: how temporal heterogeneity affects pathogen emergence; control of emerging resistant pathogen strains; and, causes of plant-parasite stable polymorphisms.

The mycorrhizal facilitation hypothesis

Louisa Armstrong[1], Kris French[1]
[1]Institute for Conservation Biology and Environmental Management, University of Wollongong

Background/question/methods: Invasive exotic plants are a major threat to the environment and the economy and it is important to understand their methods of invasion and how to manage and control them. We propose that vesicular arbuscular mycorrhizae advantage invasive plants and facilitate invasion, particularly in low nutrient habitats. Root colonisation by vesicular arbuscular mycorrhizae was assessed for 29 coastal plant species. Of these, eleven were native species, ten were invasive exotic species, and the remaining eight were non-invasive exotic species. Four of the ten invasive exotic species are weeds of national significance.

Results/conclusions: Overall, invasive exotic plant species were found to have 12-15% higher mycorrhizal colonisation rates than native and non-invasive exotic species. Individually, the six highest colonisation rates were found in the roots of invasive species, including the four weeds of national significance. These results provide support for the hypothesis that mycorrhizae facilitate invasion and suggest that invasive plants may utilise mycorrhizae more than native or non-invasive exotic species within low nutrient environments. The data also suggests that non-invasive exotics could be hindered by their lower levels of vesicular arbuscular mycorrhizae.

Louisa Armstrong obtained her BSc (Hons), majoring in Biological Sciences, from the University of Wollongong. She is currently completing her PhD at UOW researching the interactions between Australia's Weeds of National Significance and vesicular-arbuscular mycorrhizae.

Rapid population turnover of the mistletoe *Korthalsella rubra* (Viscaceae) during drought

Jennifer Taylor[1], Emilie Lesseguince[1], Chris Simpson[2], Murray Ellis[2]
[1]School of Arts and Sciences, Australian Catholic University, [2]Population Analysis and Modelling, NSW Office of Environment and Heritage

Background/question/methods: Some species of mistletoe in the Viscaceae have been well studied due to their negative effects on commercially important plants. However, the 16 species of Viscaceae in Australia have received little ecological attention. Hence we know little about the interactions of these species with their hosts or their ecological role in the environment. Two factors influencing effects of mistletoes on their host are the density of mistletoe and longevity of the relationship between host and mistletoe. In this study we explored these two factors in the Viscaceous mistletoe, *Korthalsella rubra*. We monitored the growth and survival of juvenile and mature *K. rubra* on *Geijera parviflora* hosts growing on the plains in central-western New South Wales over a 100 day period.

Results/conclusions: *Korthalsella rubra* density per host varied from 0 to >2000 individuals per host plant. Turnover of plants was relatively rapid under the drought conditions during our study, with an average of 33% of marked individuals dying within a 100 day period. Mortality was four times higher in adult than seedling plants but was unrelated to the health of the host. Hence this mistletoe would require a high recruitment rate to maintain the population. Recruitment occurred primarily within a short distance of an infected plant, and favoured larger plants (minimum height 1.6m). This pattern is unlike the dispersal pattern seen in mistletoes where birds eat the fruit, and indicate that dispersal in highly fragmented landscapes may be compromised.

Jennifer Taylor is a Senior Lecturer in Environmental Science at ACU. Her research examines effects of disturbance on woodlands and forests. This work is part of a collaborative project with NSW Office of Environment and Heritage examining community dynamics of woodland birds in central-western NSW.

Associations between shrubs, sap-suckers, and dominant ants in semi-arid Australia: beneficial for plants and herbivores?

Nyree Weichel[1], José Facelli[1], Richard Glatz[2]
[1]Ecology and Evolutionary Biology, University of Adelaide, [2]SARDI, Adelaide

Background/question/methods: Associations between ants, sap-suckers, and plants are often mutualistic, but environmental conditions can change costs and benefits to partners. Consistent differences in environmental conditions might cause functional differences: partner outcomes might depend on biome. Such associations are common across Australia, where the shrub *Acacia victoriae* and membracids of genus *Sextius* are widespread. *Sextius* sp. and various Margarodidae and lycaenid larvae frequently colonise *A. victoriae* in semi-arid southern Australia. Small black ants of genus *Iridomyrmex* (SBIs) trail among shrubs, attending the sugary-exudate producing herbivores (SEPHs).

A field experiment and survey investigated effects of naturally occurring and manipulated densities of SEPHs/*Sextius* sp. on shrub fitness and other arthropods, assessing factors determining SEPH densities. The field survey examined effects of slope-aspect, an aridity gradient, on soil, shrub fitness, SEPHs, and other arthropods.

Results/conclusions: SEPH/*Sextius* presence on *A. victoriae* depended on SBI presence. *Sextius* density was linked to soil and leaf nutrient levels and shrub growth rate. *A. victoriae* growth was reduced by exclusion of *Sextius*. On shrubs with naturally high SEPH/*Sextius* densities, growth and seed production was higher, folivory was lower, and assemblages of small arthropods were different. Parasitoid wasp densities were associated with SEPH/*Sextius* densities, possibly indicating a two-way relationship that strongly regulates arthropod assemblages. Slope-aspect affected many parameters. Results were consistent with the possibility of adaptiveness of the shrub-SEPH-SBI interaction to semi-arid conditions.

This study is the first to investigate the association between these taxa, warranting further research into association dynamics, its adaptiveness to aridity, and its affects on the broader community.

Nyree Weichel was a completing PhD candidate at the time of submission. She is interested in plant-arthropod interactions and mutualisms.

Drivers of population-level effects of parasites and parasite virulence: life-history meets meta-analysis

Maggie Watson[1,2]
[1]School of Animal and Veterinary Sciences, Charles Sturt University, [2]School of Environmental Sciences, Charles Sturt University

Background/question/methods: A central goal of population ecology is to identify factors controlling population dynamics. In wild populations, predation and competition are well-studied, with a few theoretical and empirical investigations focusing on the effects of parasites. Population regulation by parasites has been identified in red grouse *Lagopus lagopus scoticus*, svalbard reindeer *Rangifer tarandus platyrhnchus* and soay sheep *Ovis aries*; unfortunately, these examples represent managed populations, and therefore may not reflect true effects of parasites on wild populations. Thus, the question still remains—are parasites significant drivers of population-level effects and what host life-history traits drive observed parasite virulence?

Results/conclusions: A meta-analysis of 43 experimental studies (37 avian, 6 mammalian) of the costs of parasites to population-level measures of natural, free-ranging hosts revealed an overall effect size, *d* (difference between experimental and control groups) of 0.37—comparable to some measures of predation and competition. However, the taxonomically small pool of host species studied leads to the conclusion that these results may only be applicable to short-lived, colonial, hollow or ground dwelling/nesting, temperate-living avian and mammalian hosts. Further analyses revealed key determinants of the effects of parasites were host life-span and parasite type rather than the previously suggested drivers of virulence—latitude, host density or host demography.

Maggie Watson has just completed her PhD on the effects of parasites in the crested tern. She is currently teaching ornithology subjects at Charles Sturt University, and hopes to continue research into parasites, developmental stress and immune system priming.

Passive facilitation: an overlooked component of tree-grass interactions in a semi-arid grassland

Victor Resco de Dios[1]
[1]Hawkesbury Institute for the Environment, University of Western Sydney

Background/question/methods: The stress gradient hypothesis (SGH) posits that the intensity of facilitation increases with that of environmental stresses. Important refinements on SGH have been made over the last few years. However, these more recent refinements have not yet considered how temporal demographic fluctuations influence tree-grass interactions across stress gradients. Here we test how the intensity of competition and facilitation of C4 grasses over seedlings of the woody legume *Prosopis velutina* change across a gradient in water availability, in a 4-year study where grass density naturally and dramatically diminished over the last 2 years. The study was conducted at the Santa Rita Experimental Range rainfall manipulation facility, in the Sonoran Desert (Arizona, USA). The gradient in water stress was created by either increasing or decreasing 50% of the long-term summer and winter mean precipitation across 2 sites with contrasting soil textures in a fully factorial design.

Results/conclusions: We observed a dramatic shift in the sign of plant interactions from first two years (with grasses physiologically active) to the last two years of the experiment (with grasses physiologically dead). Grass competition prevented significant woody recruitment in the first two years, regardless of the water treatment. However, grasses facilitated woody recruitment during the last two years of the experiment. In these years when facilitation occurred, its intensity was decoupled from rainfall and no clear relationship between facilitation and the intensity of stress was observed. Grass facilitation during the last two years was due to the amelioration of the soil water balance by the grass litter. These results highlight the importance of passive interactions, that is, microsite alterations driven by the remains past organisms. Moreover, our results indicate that the complexity embedded within ecological systems may be too high to be captured by simplistic general hypotheses.

Dr Victor Resco de Dios is a scientist interested in understanding the processes regulating changes in land cover and their effect on biosphere-atmosphere interactions

Concurrent session 6E
Spatial processes: causes and consequences

Land clearance not dieback continues to drive tree loss in a Tasmanian rural landscape

Kerry Bridle[1], Lynda Prior[2], Gregor Sanders[2], Scott Nichols[2], Rowan Harris[2], David Bowman[2]
[1]Tasmanian Institute of Agriculture, UTAS, [2]School of Plant Science, UTAS

Background/question/methods: Tree cover has declined markedly since European settlement in the agricultural areas of Australia due to land clearing and natural and stress-induced senescence of remnant trees combined with widespread regeneration failure. These decreases in tree cover have seldom been quantified on a landscape scale, but are important in understanding losses in carbon storage and biodiversity across large areas of the continent. We used historical aerial photography and satellite imagery to study changes in tree canopy cover in the southern Tasmanian Midlands, one of the oldest agricultural regions in Australia. Tree cover at 1000 random sites was assessed from imagery captured on four occasions between 1947 and 2010.

Results/conclusions: Tree cover was stable between 1947 and the 1970s, but decreased from 33% in the 1970s to 21% in 2010. The decrease appeared driven by transition from some cover to no cover, rather than from more cover to less cover, because sites with tree cover in 2010 showed little net change during the study period. Statistical modelling showed soils derived from igneous rocks lost more cover than did the less fertile sedimentary soils, and contrary to expectations if drought was the cause of cover loss, sun-exposed north-facing sites did not lose more cover than south-facing ones. We argue that these temporal and spatial patterns of tree cover change are consistent with tree clearing rather than loss of remnant isolated trees due to drought-induced dieback.

Kerry Bridle is an ecologist at the Tasmanian Institute of Agriculture. She has worked on several RDC projects including Land, Water and Wool and the national Grain and Graze biodiversity project. Her research interests include understanding and assessing the impacts of farmers' decision making on natural resources, particularly native vegetation.

Investigating environmental and disturbance gradients on vegetation heterogeneity: is measurement type important?

Ingrid Stirnemann[1], Wade Blanchard[1], Philip Gibbons[1], David Lindenmayer[1]
[1]Fenner School of Environment and Society, The Australian National University

Background/question/methods: All landscapes are spatially heterogeneous, and the degree and scale of heterogeneity influence the distribution and abundance of species in an ecosystem. Ecological gradients play a vital role in driving spatial heterogeneity of vegetation within a landscape. For example, topography and fire regimes are likely to strongly influence variation in the total cover and configuration (i.e. the spatial arrangement) of vegetation structure. Most studies of vegetation heterogeneity have compared total cover across sites, but fewer have examined how ecological gradients influence variation in vegetation within sites. Accounting for within-site heterogeneity may provide a more comprehensive picture of the effect of environmental and disturbance gradients on spatial vegetation structure. In this study we examined the response of vegetation structure to topography and fire regimes (interval and intensity) and investigated if two different measures of heterogeneity (total cover and within-site configuration) described the response in the same way. We measured vegetation structure at 96 sites within Jervis Bay Territory where a range of vegetation types occur (heath, woodland, forest).

Results/conclusions: Generalised linear modelling showed that fire interval explained significant variation in total cover, while fire intensity explained significant variation in vegetation configuration. Elevation was an important driver of vegetation cover, but not configuration. Our results show that combining different measures of vegetation heterogeneity can provide a more comprehensive understanding of ecosystem structure than a single method used alone. Importantly, different ecological gradients described vegetation structure in different ways, thus our findings provide a guide for effectively measuring heterogeneity for landscape ecology studies.

Ingrid Stirnemann is a PhD student interested in landscape ecology. She is currently investigating efficient ways to measure vegetation heterogeneity and the influence of heterogeneity on birds and mammals.

Climatic drivers of wildfire occurrence and extent in semi-arid south-west Australia

Alison O'Donnell[1], Matthias Boer[1], Lachlan McCaw[2], Pauline Grierson[1]
[1]School of Plant Biology, University of Western Australia, [2]Science Division, Department of Environment and Conservation, WA

Background/question/methods: Changes in climatic patterns may drive shifts in the frequency, extent and intensity of wildfires and subsequent changes in the composition, structure, diversity and functioning of ecosystems in fire-prone regions. We investigated the climatic drivers of wildfire patterns in fire-prone semi-arid shrublands and woodlands of south-west Australia. We used superposed epoch analysis (SEA) to determine whether wildfire occurrence and extent were related to regional climate and/or broad-scale drivers of regional climate, including the El Niño southern oscillation (ENSO), the Indian Ocean dipole, atmospheric blocking in the Southern Ocean, and the southern annular mode.

Results/conclusions: Fires occurred during dry and hot conditions typically associated with the El Niño phase of ENSO, while fires tended not to during cool and wet conditions. However, years of major fire extent (i.e., 1,000 km^2 burnt) tended to occur during drought conditions that followed wet and cool conditions in spring and summer of the preceding year. These wet and cool periods were typically associated with the presence of blocking highs in the adjacent Southern Ocean. We hypothesise that high rainfall in spring and summer favours the growth of ephemeral plants while subsequent drought conditions promote fuel drying, resulting in continuous and highly flammable fuel beds capable of sustaining larger fires. As climatic extremes are expected to increase in intensity and frequency in the future, it is likely that the occurrence of extensive wildfires in semi-arid south-west Australia will also increase, potentially driving changes in the distribution and composition of fire-sensitive woodland communities.

Alison O'Donnell's research focuses on the role of climate, vegetation and topography on broad-scale spatial and temporal patterns of wildfires in semi-arid south-western Australia. Her research interests include landscape ecology, biogeography and dendrochronology.

Enhanced flower production in resource-rich urban landscapes explains avian nectarivore abundance

Adrian Davis[1], Richard Major[2], Charlotte Taylor[1]
[1]University of Sydney, [2]Australian Museum

Background/question/methods: The prolific flowering of street-tree plantings has been proposed as a partial explanation of the success of large-bodied nectarivores in Australian urban landscapes. Many non-endemic trees have been planted for their flowering aesthetics and may produce a greater number of flowers than endemic species as well as having a longer flowering period. Additionally, the urban heat island effect as well as an increased availability of water may produce more frequent or prolonged flowering in urban environments. This study aimed to compare flower production and length of the flowering period of *Angophora costata*, *Eucalyptus pilularis* and *Corymbia gummifera* in street-scapes, remnant bushland and undisturbed forest, and to determine whether flower productivity predicted nectarivore abundance. Twenty of each of the three species of tree were selected from each of the three habitats within Sydney, NSW. Trees were monitored for 12 months and flowers were counted from photographs taken weekly from the commencement of flowering until flowering had finished. The relative abundance of all nectarivorous species was determined from counts made during each survey.

Results/conclusions: All three species produced significantly more flowers and flowered for longer in street-scapes than in remnants and undisturbed forest. Differences in flower productivity between remnants and undisturbed forest varied amongst species. The rate of flowering significantly and positively predicted nectarivore abundance. This study provides strong support for the contention that the high abundance of large-bodied nectarivores in urban landscapes is in part due to resource richness associated with human land use.

Adrian Davis is currently completing his PhD in the School of Biological Sciences at the University of Sydney with his research focusing on the distribution and abundance of parrots within Sydney and their utilisation of and competition for resources.

Nest site selection and productivity: implications for the mao, an endangered honeyeater

Rebecca Stirnemann[1], Murray Potter[1], Ed Minot[1], David Butler[1]
[1]Ecology Group, PN624, Massey University, New Zealand

Background/question/methods: Interactions between the landscape, immigration and mortality influence local population dynamics and ultimately determine the persistence of a population. For a species such as Samoa's endangered honeyeater the Mao *Gymnomyza samoensis,* it is critical to clarify those factors affecting its productivity and its sensitivity to changes in habitat at different scales. This study focuses on how habitat fragmentation and land use change influence Mao reproductive success by combining data from monitored pairs with results from an experiment studying the depredation of artificial nests. Reproductive success of twelve pairs was monitored over the 2011 breeding season. In forest sites, three pairs out of eight successfully fledged a single chick. In contrast, the four Mao pairs which attempted to breed in the plantation sites did not successfully fledge any chicks. The fates of 144 artificial Mao nests were monitored in altered and primary forest habitats in sites where Mao breed. The effects of territory selection were assessed at two different scales: (1) the position of the territory within the landscape, and (2) the microhabitat positioning of the nest.

Results/conclusions: Results from the experiment show that the position of a territory within the landscape was a significant predictor of nest disturbance by rats. We conclude that it is unlikely that territories in or near to plantations contain viable Mao populations, whereas populations in unfragmented forest sites are likely to be sources in most years. Nevertheless, with increased fragmentation and further changes in land use, nest predation is likely to increase. That would have consequences for not only the Mao, but other forest species in Samoa which currently depend on source populations for their continued survival.

Rebecca Stirnemann is interested in how life history traits of tropical birds differ from temperate models. She is currently doing research into the ecology of the endangered Mao in Samoa as part of a PhD through Massey University.

Fallen logs as resource traps in degraded chenopod shrublands

Alexandra Bowman[1], José Facelli[1]
[1]The University of Adelaide

Background/question/methods: While numerous studies focus on heterogeneity created by living plants and animal diggings in arid lands, little information exists on the patterns and roles of heterogeneity created by fallen logs, and how they change with grazing regime. We studied differences in soil nutrient content and soil seed bank associated with the presence of fallen logs in the long ungrazed Koonamore Vegetation Reserve and adjacent heavily grazed South Lake paddock in the chenopod shrublands of South Australia. We studied soil properties associated with pre-existing fallen logs of unknown age, and others known to persist for up to 78 years.

Results/conclusions: Logs acted as traps for soil nutrients and seeds. Organic carbon and total nitrogen were higher in soils associated with logs. Both nutrients were also higher inside the reserve than in the degraded paddock. Propagule number and species richness were higher next to logs than in open spaces and viable seeds were in much greater abundance next to logs in the degraded paddock than any other site. Logs in this system create patches that differ in properties from other patches present in the system (i.e. created by perennial plants, depressions, or diggings). Logs act as resource traps which may enhance the diversity of the system, but the patterns depend on the grazing affecting the site. Because they may act as foci of recovery of degraded systems, their management and preservation should be incorporated into management schemes.

Alexandra Bowman is a PhD candidate in The School of Earth and Environmental Sciences at The University of Adelaide. Her studies are focusing on the ecological effects of fallen logs in chenopod shrublands of South Australia.

Beyond species richness: testing concordant patterns of species and genetic diversity in Indo-Pacific marine fauna

Jude Keyse[1], Eric Treml[2], Jonathan Rhodes[1], Cynthia Riginos[1]
[1]University of Queensland, [2]University of Melbourne

Background/question/methods: The pattern of decreasing species richness of tropical marine taxa with distance from the Coral Triangle is well known and supported by data from numerous studies. A concordant pattern has been suggested in genetic diversity, with support from a few taxa, however this concordance has not been explicitly tested. In fact, little is known of the patterns in genetic diversity in the region, despite this level of diversity having important implications for the sustainable future of marine species.

Genetic diversity data is often published in studies of the phylogeography or population genetics of a single or few species. These 'free' data can be used to answer questions on a larger scale than the scale of their constituent parts, yet use of these data carries with it certain caveats. Data mining involves extensive searching and data entry, and the disparate sampling strategies of original studies result in a patchy coverage. However, this technique allows meta-analytical approaches to answering some of the 'big questions' in marine biogeography, such as whether genetic and species diversity show concordant patterns of hotspots. Our research combines genetic diversity data from 111 studies focusing on marine animals in the Indo-Pacific to answer this question.

Results/conclusions: Initial results indicate that the gradients of genetic diversity do not match established patterns of species diversity. Indeed, the Coral Triangle does not appear to be a hotspot of genetic diversity, and our preliminary analyses have identified unexpected hotspots in areas peripheral to the Coral Triangle.

Jude Keyse is currently halfway through a PhD looking at the correlation between species and genetic diversity in Indo-Pacific marine fauna and which environmental factors might help explain these patterns of diversity. Jude is interested in biogeography and phylogeography of marine organisms and keen to relate the work to applied conservation science.

Concurrent session 6F
Conservation planning and management

Biodiversity modelling to identify priorities for conservation and restoration in human-modified landscapes of the eastern Amazon

Jim Thomson[1], Jos Barlow[2], Erika Berenguer[2], Joice Ferreira[3], Toby Gardner[4], Alexander Lees[4], Ralph Mac Nally[1], Edward Game[5]
[1]Australian Centre for Biodiversity, Monash University, [2]Lancaster University, UK, [3]Embraba, Brazil, [4]University of Cambridge, UK, [5]The Nature Conservancy

Background/question/methods: One of the greatest challenges facing the development of sustainable management systems in human-modified landscapes lies in maintaining ecological resilience and the long-term persistence of native biodiversity across multiple landuse mosaics. We use systematic conservation planning tools to identify priority conservation areas and priority areas for regeneration on degraded land in regions of the eastern Amazon. Extensive spatial data on bird, invertebrate and tree biodiversity were coupled with a range of GIS and remote sensing data to model species distributions and biodiversity patterns across a range of landuse types and forest conditions. Models were used to map biodiversity across a 2 million hectare region of the eastern Amazon (Paragominas municipality) under current, and possible future, landuse scenarios. The resulting maps were used as inputs to Zonation systematic conservation planning software, which was used to identify priority areas for conservation or restoration. We also included indicators of socio-economic condition to inform multiple-objective landscape planning.

Results/conclusions: We developed high resolution spatial priorities for conservation and restoration in a human-modified region of the Amazon, based on integrated biodiversity and socio-economic data. We explore the sensitivity of conservation planning results to the taxonomic group(s) and modelling methods used as inputs.

Jim Thomson is a research fellow at the Australian Centre for Biodiversity, Monash University. He is a quantitative ecologist with broad interests in freshwater and landscape ecology, conservation biology, and statistical modelling.

How well is long-term biological monitoring informing the management of Australia's marine protected areas?

Prue Addison[1], Jan Carey[1], Mark Burgman[2]
[1]School of Botany, University of Melbourne, [2]Australian Centre of Excellence for Risk Analysis, University of Melbourne

Background/question/methods: In 1991 the Australian government implemented a strategy to establish a National Representative System of Marine Protected Areas (NRSMPA), as a commitment to marine biodiversity conservation. This strategy included an aspiration to regularly monitor, evaluate and report on the performance of Marine Protected Areas (MPAs). Twenty years on, the NRSMPA protects approximately 10% of Australia's waters, and some significant long-term biological monitoring programs associated with nearshore MPAs now exist. The purpose of our study was to assess how these long-term monitoring programs are being used to evaluate the management effectiveness of Australia's MPAs. To do this, we conducted a comprehensive review of the scientific and government literature and consulted key Australian MPA scientists and managers. We reviewed all biological monitoring programs associated with nearshore MPAs, which are current and have been running for more than five years.

Results/conclusions: The level of data analysis and frequency of reporting varies dramatically between Australia's long-term MPA monitoring programs. This is influenced in part by who conducts the monitoring (scientists vs managers), and how the monitoring is funded. We found very little documented evidence of the use of long-term monitoring results for the evaluation of the management effectiveness of Australia's MPAs. In fact only the Great Barrier Reef Marine Park formally uses long-term monitoring data to evaluate management effectiveness. Our review demonstrates that long-term monitoring results are not being used to their full potential for MPA management evaluation. We discuss the implications of this in relation to the public perception of conservation management, and the potential for adaptive management which is an aspiration of many conservation agencies.

Prue Addison is conducting her PhD research, investigating the utility of control charts as a decision-making tool for improved Marine Protected Area management. Prue's research is supervised by Dr Jan Carey and Prof Mark Burgman, and is conducted in association with Parks Victoria.

Development of assemblage models to assist conservation planning and prioritisation across Victoria

Graeme Newell[1], Matt White[1], Bronwyn Price[1], Canran Liu[1], Peter Griffioen[1], Natasha Maclean[2], David Parkes[2]
[1]Arthur Rylah Institute for Environmental Research, Department of Sustainability and Environment, [2]Department of Sustainability and Environment

Planning and prioritising conservation efforts requires the compilation of considerable volumes of data. Bringing together species information in meaningful ways has presented challenges in applied conservation planning for decades, particularly when issues such as depletion, rarity, sampling effort/biases, taxonomy are addressed. Previously we have developed spatially prioritisation products based on species distribution models (>500 vertebrate taxa). Limitations to this approach are rapidly exceeded when accommodating vascular plants (>3700 taxa) and other species. This led us to develop assemblage models from native flora data (30,423 quadrats; 3228 plant taxa), with information from terrestrial fauna distributions (i.e. quadrat locations intersected 494 pre-existing SDMs; >70% probability coded as present). Several analytical methods were investigated and self-organising maps (Matlab) were found to express the most useful products. From a 100 SOM array, 98 useful assemblages were identified. Locations were used to extract values from 18 environmental layers with data on soil radiometrics, climate and terrain. Random forest models (500 ensembles: R software) of assemblages were developed incorporating background pseudo-absence information stratified by environmental space. Assemblages were spatially expressed as mapped surfaces (75m resolution). Seventeen assemblages of aquatic systems were developed using a similar process. Both terrestrial and aquatic assemblage models were compiled along with point data for 777 rare/threatened taxa with site-specific requirements. Analyses of these surfaces together with condition and connectivity information were conducted with Zonation to form views of spatial priorities for conservation across Victoria. Rarely have these approaches been taken applied at this scale with a view to integration in Government conservation policy and programs.

Background/question/methods: Equitable evaluation of the distribution of flora and fauna at large spatial scales for prioritising conservation management.

Results/conclusions: A new method was developed to integrate available data for flora and fauna into simple spatial products.

Graeme Newell is part of a team of research ecologists, spatial modellers and policy analysts working in the area of conservation management for the Victorian Government.

The utility of backcasting for developing conservation policy: modelling conservation interventions in urban fringe environments

Ascelin Gordon[1]
[1]RMIT University

Background/question/methods: In many regions governments have implemented policies to reduce the impacts of anthropogenic activities on biodiversity. It can be difficulty to assess whether these policies achieve their goals for reasons such as temporal delays and a lack of resources to collect appropriate data. Thus it can be challenging to determine how best to improve existing conservation policies. Here we quantitatively demonstrate 'backcasting' as a useful and underutilised approach for policy development within a conservation context. Backcasting involves setting a future target state, and then determining pathways to reach it. The approach is demonstrated with a case study involving the Cumberland Plain Woodland (CPW) ecological community, which faces multiple threats from the growth of Sydney. Utilising a predictive model that tracks the area of CPW over time, the impact of threat reduction policies can be assessed.

Results/conclusions: By running our model over 10,000 times varying all policy relevant inputs simultaneously, we are able to determine regions of the 'policy parameter space' that allow a target area of CPW to be retained. We show how a statistical classification tree analysis on model outputs can be used to classify regions of the policy parameter space into a useful set of policy options. We then define six sets of policy rules that are each predicted to retain at least 60% of the current CPW distribution in 50 years time. This approach allows the trade-offs between multiple policy relevant parameters to be understood and can also incorporate the cost and uncertainty associated with different policy options.

Ascelin Gordon's research focuses on interdisciplinary problems in conservation science. His current research focuses on developing modelling approaches for understanding the impacts of environmental policies on biodiversity values in the landscape. He also has interests in conservation planning and spatial prioritisation and market based instruments for conservation on private land.

Continent-wide risk assessment for the establishment of non-indigenous species in Antarctica

Steven L Chown[1], Dana M Bergstrom[2], Aleks Terauds[2]
[1]School of Biological Sciences, Monash University, [2]Australian Antarctic Division, DSEWPC

Background/question/methods: Invasive alien species are among the primary causes of biodiversity change globally, with the risks thereof broadly understood for most regions of the world. They are similarly thought to be among the most significant conservation threats to Antarctica, especially as climate change proceeds in the region. However, no comprehensive, continent-wide evaluation of the risks to Antarctica posed by such species has been undertaken. Here we do so by sampling, identifying, and mapping the vascular plant propagules carried by all categories of visitors to Antarctica during the International Polar Year's first season (2007–2008) and assessing propagule establishment likelihood based on their identity and origins and on spatial variation in Antarctica's climate. For an evaluation of the situation in 2100, we use modelled climates based on the IPCC Special Report on Emissions Scenarios Scenario A1B.

Results/conclusions: Visitors carrying seeds average 9.5 seeds per person, although as vectors, scientists carry greater propagule loads than tourists. Annual tourist numbers (~33,054) are higher than those of scientists (~7,085), thus tempering these differences in propagule load. Alien species establishment is currently most likely for the Western Antarctic Peninsula. Recent founder populations of several alien species in this area corroborate these findings. With climate change, risks will grow in the Antarctic Peninsula, Ross Sea, and East Antarctic coastal regions. Our evidence-based assessment demonstrates which parts of Antarctica are at growing risk from alien species that may become invasive and provides the means to mitigate this threat now and into the future as the continent's climate changes.

Steven L Chown has recently moved from South Africa to Monash University as Professor and Head of Biological Sciences. Most of his work is in ecology, physiology and conservation biology, with a major emphasis on their integration. He has an internationally awarded record of contributions to Antarctic science and policy.

The contributions of cost, management efficacy and demography to efficient management of invasive plants

Yvonne Buckley[1], Natalie Kerr[1], Peter Baxter[2]
[1]Environmental Decisions Group, University of Queensland, [2]CARM, University of Queensland

Background/question/methods: Traditional elasticity analysis of plant population matrix models has provided some guidelines for how to manage invasive plants. However, the recommendations from these models do not take the cost or efficacy of management into account, potentially limiting their applicability in real management contexts. We collected efficacy and cost data for the management of >15 invasive plant species where demographic matrix models were available and applied an economic sensitivity analysis to determine the relative roles of efficacy, cost and demography for determining appropriate management practices for reducing invasive plant population growth rate.

Results/conclusions: We found that the ranking of management practices from simple elasticity analyses did not align well with the rankings from the economic sensitivity analysis indicating that the addition of data on cost and efficacy was useful in determining appropriate management strategies. We compared management strategies according to different management objectives including: the largest reduction in population growth rate per dollar spent (economic sensitivity analysis), the largest achievable reduction in population growth rate (efficacy analysis) and the cost of reducing population growth rate below replacement. We highlight how cost, efficacy and demography can be used together with appropriate management objectives to aid budget determination for invasive management as well as appropriate management strategies. We discuss the limitations of these approaches in data-poor situations and the continuing goal of comparative plant ecology to contribute generalities to aid in management of invasive plant species.

Yvonne Buckley is a quantitative ecologist, an Australian Research Fellow in the School of Biological Sciences and CI in both the ARC Centre of Excellence in Environmental Decisions and the NERP hub for Environmental Decisions. Her group works on both fundamental and applied plant ecology.

Concurrent session 7A
SYMPOSIUM: Australian phenology

Southern Hemisphere phenology: is it changing and what are the main drivers of change?

Lynda Chambers[1], Res Altwegg[2], C Barbraud[3], Phoebe Barnard[2], Linda Beaumont[4], Rob Crawford[5], Lesley Hughes[4], Marie Keatley[6], Valeria Ruoppolo[7], Matt Low[8]
[1]CAWCR, Australian Bureau of Meteorology, [2]South African National Biodiversity Institute, [3]CEBC, CNRS, France, [4]Macquarie University, [5]Department of Environmental Affairs and Tourism, South Africa, [6]University of Melbourne, [7]Aiuká Consultoria em Soluções Ambientais Ambientais and International Fund for Animal Welfare, [8]Swedish University of Agricultural Sciences, Sweden

Background/question/methods: Previous analyses of phenology and species' responses to climate change have indicated a paucity of published studies from southern and tropical regions. Here we conduct a comprehensive review to determine:

- the extent of phenological knowledge in the southern hemisphere, identifying knowledge gaps;
- if consistent signals of change are seen across countries, hemispheres and taxa;
- the relative role of drivers (such as temperature, rainfall and human pressures) of phenological change;
- likely implications of phenological change, including what this tells us about adaptive capacity.

Results/conclusions: Considerable information on southern hemisphere phenology has been published. However, significant variability, by location and taxa, exists in the availability of this information. For example, the majority of long-term (>10 years in length) studies are of birds and plants in Australia. Long-term records from some regions are uncommon, including South Pacific island nations, equatorial Africa and some South American countries. Birds and plants were the most reported taxa; very few studies included mammals, reptiles, amphibians or invertebrates. In the Antarctic and subantarctic studies were largely restricted to marine mammals and seabirds. A preliminary analysis using data from Australia/New Zealand suggests most species did not exhibit significant temporal trends in phenology but, when trends were observed they were more likely to be towards earlier events. The principle drivers of variability and trends in southern hemisphere phenology also varied by location and species, e.g. seabirds were more often influenced by ocean temperature and sea-ice extent than air temperature and precipitation, common drivers for terrestrial species.

Dr Lynda Chambers specialises in climate impacts on flora and fauna, including building southern hemisphere networks and capability, such as ClimateWatch (www.climatewatch.org.au). She is on the NCCARF Terrestrial Biodiversity Steering Committee and member of the International Phenology Commission. She has contributed to various IPCC reports and the National Marine Report Card.

Pyrus phenology in South Australia: life in a hot, dry climate

Fran MacGillivray[1], Andrew Lowe[1], Jennifer Gardner[2], Irene Hudson[3]
[1]School of Earth and Environmental Sciences, University of Adelaide, [2]Waite Arboretum, University of Adelaide Waite Campus, [3]School of Mathematical and Physical Sciences, University of Newcastle

Background/question/methods: A 44-year replicate dataset (1967-2010) of 112 *Pyrus* (pear) trees growing at the Waite Arboretum in Adelaide provided a unique resource for investigating the flowering phenology of non-native, deciduous species subject to identical climatic conditions. Multiple linear regression was used to investigate minimum temperature and rainfall as drivers of phenology at the genus and species levels; boxplots and one-way ANOVA identified similarities and differences among and between species and individual trees.

Results/conclusions: Peak flowering occurred in each month from May to October. The longest range for a single tree was 122 days; the shortest, 19 days. A highly significant response of the genus to the coldest mean minimum monthly temperature (Tm) (β=-7.13 ±1.21; P=0.000) represents an advance of around 7 days for each °C increase in Tm. The month in which this minimum temperature occurred was also highly significant (β=11.69 ±1.84; P=0.000); for each month earlier in the year Tm occurred, peak flowering advanced approx. 11½ days. Exposure to summer temperatures above 38°C initiated an additional, unseasonal flowering event in the immediate weeks following. Specific rainfall patterns had a further substantial influence, with autumn flowering episodes frequently triggered by breaking rains following a period of extended drought. *Pyrus* respond to the climatic extremes encountered in southern South Australia with extreme variation in flowering phenology and an associated, potentially high, economic cost to the horticultural industry. The various species and cultivars have their own distinctive constraints and triggers, uniquely influenced by genotype.

Irene Hudson on Editorial Board of Climatic Change, co-editor of 2010 book, Hudson & Keatley 'Phenological Research: Methods for Environmental and Climate Change Analysis'. On Scientific Advisory, ACERA, UniMelb. Invited author of chapter in 2011 Encyclopedia of Climate and Weather OUP.

Analysis of long-term flowering records for river red gum and black box in a flooding forest

Marie Keatley[1], Leon Bren[1], Irene Hudson[2]
[1]Department of Forest and Ecosystem Science, University of Melbourne, [2]School of Mathematical and Physical Sciences, University of Newcastle

Background/question/methods: Red gum (*Eucalyptus camaldulensis*) and black box (*E. largiflorens*) are co-occurrers in the Barmah Forest, Victoria. This forest, located on the River Murray, has a variable flooding regime but typically is inundated to a depth of about 1m in late winter and early spring. This flooding is viewed as vital for forest health. Red gum tends to occupy areas of higher flooding frequency and duration than black box, but both are capable of withstanding long periods of inundation. Of particular interest was whether there was any link between flooding and flowering. The analyses (singular spectum analysis, and regression) used a thirty-nine year (1934-73) monthly flowering observation record. Flowering was quantified by assigning a rank value (ranging from 0 to 5) producing a discrete time series. The flooding sequence was characterised by using published flow records and a simple model of flooding percentage as a function of peak flow developed in previous studies.

Results/conclusions: Both the red gum and black box had an annual cycle with peak flowering centred around December. Typically for black box, flowering would start around August and continue until February the following year. In contrast, red gum had a very well-defined but short period of flowering in December/January. The year to year invariance of red gum flowering in December was striking; as such it can be viewed as a relatively constant annual 'pulse'. We could find no evidence of flooding influencing timing of flowering and a small influence of flooding perhaps decreasing the magnitude of flowering. There was a small tendency in both species for a heavy flowering year to be followed by a less heavy year, but both species usually flowered every year Based on these analyses it seems that the annual flowering cycle of both species is not affected by the presence or absence of flooding, and the magnitude of flowering is hardly affected. Although forest health may be influenced by flooding, this does not influence flowering.

Marie Keatley is an ecologist with a strong interest in the development and application of statistical methods in phenology. She is also interested in the history of, and drivers for, undertaking phenological observations in the Australian context.

Climatic effects on growth phenology of co-occurring eucalypts

Deepa Shree Rawal[1], Sabine Kasel[1], Marie Keatley[1], Craig R Nitschke[1]
[1]University of Melbourne

Background/question/methods: Plant phenological events are interlinked and are directly influenced by environmental conditions. Seedling growth stage is one of the vulnerable stages with low stress resistance but high environmental stress. Faster seedling growth rates enhance competitive ability and survival that leads to long-term success. This study has been designed to compare the growth phenology of co-occurring eucalypts *E. obliqua, E. radiata* and *E. sieberi* under different environmental conditions. Seedling growth phenology was examined via potted plants placed in a series of three glasshouses, one tunnel (and one 'outside' treatment) set at differing temperature and moisture (well-watered; water-stressed) regimes. Measured growth responses include fortnightly height and above ground biomass for one year.

Results/conclusions: Repeated measure analysis indicated significant ($P<0.05$) temperature, moisture and interaction effects on height for all species. Reduction in height was most distinct at the outside treatment under water stressed conditions during summer. Height growth ceased for 68% of *E. obliqua;* 67% of *E. radiata* and 71% of *E. sieberi* under water stressed conditions during summer when temperatures averaged 24.4°C (maximum 48.6°C). The study demonstrated that these three co-occurring eucalypts exhibited similar height growth phenology. Summer temperature with an average of 25°C reduced growth and spring seasonal temperature average of 19°C increased growth. Moreover, the species tested may be susceptible to environmental change as upward shift in temperature reduced the growth.

Deepa Shree Rawal is a PhD student at University of Melbourne with a research area related to the prediction of plant distribution pattern using phenological tools under environmental change scenario.

The effect of current and past seasonal climate on eucalypt flowering: identifying early/late flowering years

Irene Hudson[1], Marie Keatley[2], Shalem Yiner Lee[3]
[1]School of Mathematical and Physical Sciences, University of Newcastle, [2]Department of Forest and Ecosystem Science, University of Melbourne, [3]Adelaide University

Background/question/methods: Historical flowering records (1940-1971) of four Eucalypt species from the Havelock Forest Victoria were analysed using GAMLSS. The aims of the study were to: investigate non-linear responses of flowering to seasonal climate at the time of peak flowering, the preceding season and two seasons prior; quantify the competing effects of seasonal temperature (minimum, maximum) and rainfall; establish climatic thresholds for flowering; establish climate profiles identifying early and late flowering years. A multivariate across species analysis was also performed to test for significant species differences in how current and past seasonal climate impact flowering.

Results/conclusions: For each species (*Eucalyptus leucoxylon E. tricarpa, E. microcarpa*, *E. polyanthemos*) rainfall has a non-linear opposite influence to temperature at current and 2 seasons prior to peak flowering. Rainfall is seen as a surrogate for soil moisture, impacting bud development and subsequent flowering. In *Eucalyptus leucoxylon,* warmer nights during peak flowering season, and warmer summer nights, when buds are first noticed, are conducive to flowering. Cooler nights are indicated by a negative temperature relationship in Autumn, when flowering commences and budding peaks. A drier summer, two seasons prior to peak flowering, when buds first occur, benefits flowering. GAMLSS found an upper threshold of 80mm above which buds may abort, and a lower minimum temperature for the season of peak flowering of 8.6°C. In *E. leucoxylon* warmer winters are associated with years of earlier flowering and cooler autumns with later flowering years. Climate impacts are shown to be species specific with distinctive triggers/timing. Seasonal climate lags align with the six month cycling from positive to negative temperature and rainfall influence determined by wavelets.

Irene Hudson on Editorial Board of Climatic Change, co-editor of 2010 book, Hudson & Keatley 'Phenological Research: Methods for Environmental and Climate Change Analysis' (wrote 9 chapters). On Scientific Advisory, ACERA, UniMelb. Invited author of chapter in 2011 Encyclopedia of Climate and Weather OUP.

Methods matter: implications of phenological method selection for impacts and adaptation in fruit tree flowering

Rebecca Darbyshire[1], EWR Barlow[1], Leanne Webb[2], Ian Goodwin[3]
[1]The University of Melbourne, [2]CSIRO, [3]The Victorian Department of Primary Industries

Background/question/methods: Potential shifts to flowering phenology in managed fruit tree orchards may have significant influence on production into the future. It has often been commented that with spring warming, as a result of anthropogenically induced climate change, flowering will advance with adverse impacts such as increased frost risk and interruption to pollination processes, are likely to ensue. To qualify such assertions a reliable climate-phenology model must be developed and then applied to projected climate conditions. To date, neither the use of a phenological model nor assessment under climate perturbed conditions have been quantified in Australia for pome fruit and few examples are available internationally. In part the difficulty of such an assessment resides in the initial determination of an adequate climate driven phenology model. Authors often use different approaches to consider historical trends in pome fruit flowering phenology with the literature mixed on appropriate model choice.

Results/conclusions: To investigate repercussions of methodological selection, results of projected changes to phenology conditions for pome fruit in Australia from two commonly utilised methods were compared. The models consider were a springtime only approach and a sequential winter chill and spring warming model. Projected changes to flowering were constructed using the two methods according 1, 2 and 3°C increases to average global temperatures. The results show differing impact outcomes, notable flowering advancement and minimal change. These differences are important, especially when providing growers with adaptation pathways. These divergent results for the same analysis with different methods highlight that development of greater understanding of biophysical processes should not be neglected in the rush to develop climate change impact statements and adaptation plans.

Rebecca Darbyshire is in her final year of her PhD project which considers temperature-phenology relationships in pome fruit trees in Australia and the implications of future climate change on these linkages.

Concurrent session 7B
SYMPOSIUM: Linking Indigenous and Western ecologies

Firesticks: Aboriginal fire to enhance biodiversity, connectivity and resilience

Oliver Costello[1], Ian Ross[2]
[1]Nature Conservation Council of NSW, [2]Minyumai Indigenous Protected Area

Firesticks aims to support Aboriginal communities in the promotion and protection of their natural and cultural values in relation to land and fire management. Firesticks will achieve this by identifying and communicating cultural values to land owners and managers, allowing them an understanding of ways to respect and protect these values. The NCCNSW lead Firesticks project is funded by the Australian Government's Clean Energy Future Biodiversity Fund and will use fire to enhance ecosystem resilience by improving habitat condition and connectivity through natural regeneration. Firesticks partner organisations Willows Boorabee Indigenous Protected Area (IPA); Wattleridge (IPA); Minyumai (IPA); Jali (IPA); Gugin Gudduba Local Aboriginal Land Council (LALC); Ngulingah LALC; Casino Boolangle LALC; NSW Rural Fire Service (RFS); Office of Environment and Heritage (OEH); University of Technology, Sydney (UTS) and the Nature Conservation Council of NSW (NCCNSW) will work together to build community and organisational capacity to engage and manage natural and culture values through integrating contemporary and Aboriginal knowledge and practice. Enabling and empowering Aboriginal and non-Aboriginal communities to work collectively towards resilient landscapes. Working within cultural corridors in northern NSW this project will empower Aboriginal communities to facilitate the participation in, practice of, and transfer of knowledge on traditional and contemporary sustainable fire management across Aboriginal and non-Aboriginal owned land. This project will develop and pilot an Aboriginal fire management training program that provides landholders and land managers with the skills and knowledge to collectively participate in fire management.

Oliver Costello comes from Bundjalung country on the Northern Rivers of NSW. Oliver is the Firesticks Project Coordinator at the Nature Conservation Council of NSW and a Visiting Fellow at Jumbunna Indigenous House of Learning (University of Technology Sydney). Ian Ross is a Bandjalang man from Northern Rivers of NSW and is the Coordinator/Administration support for Minyumai Indigenous Protected Area.

Establishment of an Indigenous-driven tropical ethnobotany centre

Gerry Turpin[1,2]
[1]Australian Tropical Herbarium, [2]Department of Science, Information Technology, Innovation and the Arts

Background/question/methods: There is currently no ethnobotany centre in Australia dedicated to Indigenous Australian knowledge of plants. Traditional Owners from across the wet tropics bioregion and Cape York Peninsula, together with scientists, herbarium specialists and policy-makers interested in ethnobotany from geographic locations across south-east Queensland, the Northern Territory and the Australian Capital Territory were invited to attend a workshop. The purpose was to consider whether a tropical Indigenous ethnobotany centre would be a good way of supporting Indigenous peoples' knowledge about the cultural use of plants. Participants identified that establishment of an ethnobotany 'centre' could be a valuable means of supporting Traditional Owners in the conservation, management and communication of their ethnobotanical knowledge.

Results/conclusions: Traditional Owners at the workshop identified that the ethnobotanical centre should be:

1. Indigenous-driven and based on respect for Indigenous knowledge, law and culture;
2. Based on Indigenous governance and protocols;
3. A leader in the protection of Indigenous intellectual property and recognition of Indigenous knowledge-holders;
4. Linked to sustainable economic development, education and training;
5. Started by pilot partnership projects initiated by Traditional Owners; and
6. Supported by an effective communication strategy.

Gerry Turpin has been working with the Queensland Herbarium, Brisbane, and more recently with the Australian Tropical Herbarium, Cairns for over 22 years. Gerry was previously involved in the Qld regional ecosystem mapping project and is currently establishing an Indigenous Tropical Ethnobotany Centre (TIEC)

Integrating traditional ecological knowledge with land management activities: understanding ecological response to climate change in the Great Sandy Desert

Sonia Leonard[1], G MacLaren[1], P Murray[2], Annette Kogolo[3]
[1]University of Melbourne, [2]Ngurrara Ranger Program, [3]Warlu Jilajaa Jimu Indigenous Protected Area

The impacts of climate change on desert ecosystems in north-western Australia are poorly understood. Indigenous communities have long observed and recorded the phenology of these systems through traditional knowledge systems. Traditional ecological knowledge (TEK) paradigms have high levels of complexity that help explain the changing relationships between cycles of inter-annual weather patterns, water availability and the subsequent response of flora and fauna in the landscape. TEK used by Indigenous Protected Area (IPA) and ranger programs identifies bio-temporal indicators and cultural keystone species that provide a basis for developing detailed phenological monitoring and evaluation programs. Ngurrara people of the Great Sandy Desert have initiated a two-year research program uses Indigenous seasonal calendars to develop tools and associated methodologies that allow the application of TEK to understanding the impacts of climate change on the fragile ecosystems at both macro and micro scales.

The project combines western science with TEK through the installation of a remote research station on Lake Pirnirni near Kulku community approximately 390km south east of Broome. The weather station and water monitoring equipment is operated by the Ngurrara Working on Country ranger program in conjunction with the Warlu Jillija Jumu IPA. Indigenous rangers are starting to document responses of bio-temporal indicators and how historically Ngurrara people adapted to these changes. TEK of seasonal cycles and socio-ecological systems will be important in identifying culturally appropriate land management strategies in response to climate change.

Sonia Leonard is a research fellow (Indigenous Dimensions of Climate Change) at the University of Melbourne, investigating the effectiveness of climate change mitigation and adaptation tools for Indigenous communities. She has extensively worked with Indigenous people across Northern Australia over the last decade to investigate the integration of traditional knowledge and western science to develop climate change monitoring and evaluation tools for Indigenous managed estates. Sonia was a writing group member of the National Climate Change Adaptation Research Facilities team that produced the Australian Indigenous Communities National Adaptation Plan in 2011.

Working for warru: an update on the reintroduction of black-footed rock wallaby (*Petrogale lateralis*) to the Anangu Pitjantjatjara Yankunytjatjara lands, South Australia

Simon Booth[1], Eric Abbott[1], Thomas Tjilya[1], Rachel Barr[1], Rebecca West[1], Matthew Ward[1], John Read[1]
[1]Anangu Pitjantjatjara Yankunytjatjara—Land Management

Background/question/methods: 2007 saw the first translocations of warru (*Petrogale lateralis*) pouch young off the APY (Anangu Pitjantjatjara Yankunytjatjara) lands for the establishment of an insurance population and captive breading program. To date 16 warru have been released into the pintji (fence), a 97ha predator free enclosure and are monitored closely by a team of Anangu rangers utilising kulini (radio tracking), and tjina ngurini (footprint tracking) to ensure they are surviving free of predation pressures. Indicators show that the individuals released into the pintji are quickly developing into a self sustaining population, with third generation of offspring being recorded in May 2012. Following on from their hardening off period, 2013 will see the first reintroduction attempts of pintji warru into the local wild populations, boosting genetic diversity, and increasing longer term viability of the smaller populations. Initial reintroductions will be conducted under robust monitoring and continued feral carnivore suppression activities with the largest immediate threat being predation by feral cats (*Felis catus*) and foxes (*Vulpes vulpes*).

Results/conclusions: Recent trapping surveys of the APY warru population have also shown positive indicators for the recovery of the species. 95-100% of females across populations surveyed were carrying pouch young whilst the western population near Kalka community had a four fold increase in trap rate producing a 100% increase in Kalka population estimates. Future challenges are being presented for the recovery of warru from the catastrophic invasion of buffle grass (*Cenchrus ciliaris*) on the APY lands altering fire regimes and vegetation structure, whilst recent tectonic activity has produced significant rockslides at Alalka's warru population, of which their impact has not yet been assessed.

Biography not available at time of printing.

Interactions in monsoon vine thickets: people, plants, fauna, fire and restoration in the Dampier Peninsula, Western Australia

Louise Beames[1], Judy Fisher[2], Nyul Nyul Rangers[3], Chris Sampi[4], Malcolm Lindsay[5]
[1]West Kimberley Nature Project Environs Kimberley, [2]Fisher Research Pty Ltd, [3]Nyul Nyul Rangers, [4]Bardi Jawi Rangers, [5]Environs Kimberley

Bardi Jawi and Nyul Nyul Indigenous Rangers have worked with Environs Kimberley and partners to understand interactions within monsoon vine thickets (MVTs) of the Dampier Peninsula, a unique, culturally significant and vulnerable TEC. This rainforest-allied ecosystem occurs in patches, within and behind the swales of coastal dunes. MVTs contain valuable bush-tucker, medicines, important water places and cultural sites. They provide habitat and refugia for birds, bats and other animals, which move between patches, maintaining their connection. Known threats include fire, weeds, clearing, tourism and recreation.

With the DEC, we utilised remote sensing to map the fire history of all 79 MVTs between 1990 and 2010. Our findings revealed significant annual fire damage and losses in MVT canopy cover.

We identified two health indicators, vegetation structure and ant communities, and developed, trialled and implemented protocols measuring across three habitat types: the middle (M), edge (E) and outside (O) the MVT vegetation. We found significant interactions between litter depth, litter volume, canopy cover, fire count and vegetation trend with separations in ant fauna and vegetation structure between habitats.

These new understandings of the impacts and interrelationships between fire and MVTs, invasive plants and ants have enabled us to identify the most vulnerable patches on Bardi Jawi and Nyul Nyul country, overlay cultural and conservation priorities and adapt fire and weed management. The collaboration between Indigenous rangers with strong Traditional local knowledge and practical skills, ecologists and partners has enabled the development of sound, culturally-informed science that is quickly useful for management.

Biography not available at time of printing.

Concurrent session 7C
Ecological genetics

Genetic rescue of the mountain pygmy possum, *Burramys parvus*, through wild translocation

Tom Kelly[1], Josh Griffiths[1], Andrew Weeks[1], Dean Heinze[2], Ian Mansergh[3]
[1]cesar, [2]Consultant, [3]Department of Sustainability and Environment

Background/question/methods: The mountain pygmy-possum, *Burramys parvus*, is an endangered marsupial restricted to three geographically separated alpine and sub-alpine regions of south-eastern Australia. The Mt Buller (southern region) population has undergone a 10 fold reduction in numbers since 1996, with only 30 adult individuals known to exist in 2010. The drop in numbers has been paralleled by a drastic decline in genetic diversity and there is evidence that inbreeding depression exists for a number of traits. We undertook a wild translocation of adult male *B. parvus* from Mt Higginbotham (central region) to Mt Buller with the aim of increasing genetic diversity in the Mt Buller population.

Results/conclusions: An initial pilot translocation of 6 males in October 2010 resulted in two known hybrid progeny trapped in 2011, proving hybridisation was feasible in the wild. To achieve translocation aims of ~20% central genes in the Mt Buller population, we undertook another wild translocation of 6 Mt Higginbotham males to Mt Buller in spring 2011. All translocated males survived for at least 26 days post translocation. Trapping undertaken in early 2012 resulted in the capture of 9 hybrids from 18 juvenile *B. parvus*. Four Mt Higginbotham males were found to have sired young. The estimated rate of gene flow into the juvenile population is ~25% for the 2012 cohort, a substantial increase over the previous translocation (~6%) and in accordance with previously identified targets. Genetic diversity estimates for the Mt Buller population have significantly increased for the first time in over 15 years.

Tom Kelly has been involved in the study of small mammals in the alpine environment over the past four years. Recently working with key alpine researchers in undertaking the genetic rescue of the Mt Buller mountain pygmy-possum population.

Who's for dinner? Determining bat dietary preferences utilising high-throughput sequencing genetic analyses

Joanna Burgar[1], James Haile[1], Jayne Houston[1], Daithi Murray[1], Michael Craig[1,3], Vicki Stokes[2], Michael Bunce[1]
[1]Murdoch University, [2]Alcoa of Australia, [3]University of Western Australia

Background/question/methods: Diet studies are crucial in understanding species ecology; however, they are often limited in that very few provide detailed accounts of prey species consumed, particularly for bats. Traditionally, bat dietary studies relied upon morphological identification of prey remains in stomach contents, faeces or from remains discarded under feeding sites. Analysis of faecal matter is preferred as this non-invasive method explicitly captures the proportions of protein ingested from different types of prey. Recent advances in molecular technology, such as high-throughput sequencing (HTS), enable detailed prey identification from faecal samples to genus and species. Within the context of south-western Australia's biodiversity hotspot, we were the first Australian study to utilise HTS, comparing dietary preferences of eight species of bat, including two endemic species.

Results/conclusions: Unsurprisingly, preliminary analyses show that Lepidoptera are an important dietary component, with faecal samples from all species containing Lepidoptera. Diptera was the second most prolific prey overall, although not found as prey for all bat species. Diptera has rarely been mentioned as a dietary component for these bat species, likely as soft-bodied Diptera are not detected when morphologically teasing apart faeces. HTS provides an unprecedented level of detail into the study of bat dietary preferences and dramatically adds to our current knowledge of bat ecology. In addition, it provides an opportunity to comprehensively sample invertebrates inhabiting this biodiversity hotspot.

Joanna Burgar completed her BSc at the University of Victoria, Canada, and her MSc at Oxford University, UK, focusing on conservation biology and resource management. Currently at Murdoch University, she is presenting research from her PhD: dietary preferences of bats in restored jarrah forest.

The genetics of flammability in the eucalypt landscape

Julianne O'Reilly-Wapstra[1], Zach Holmes[1], Brad Potts[1]
[1]School of Plant Science, University of Tasmania

Background/question/methods: Fire is a part of the Australian landscape and eucalypts have a great propensity to promote fire. If fire promoting traits are to directly or indirectly evolve, there needs to be genetic variation in the expression of these traits within species. However, to our knowledge, no studies have addressed intraspecific genetic variation in flammability traits in eucalypts. Here, we use a common environment field trial to examine genetic variability in leaf flammability traits between different genetically distinct populations across the geographic range of *Eucalyptus globulus*.

Results/conclusions: Results show clear genetic-based variation in ignitibility of leaves, sustainability of the flame and rate of leaf area consumed. In addition, three leaf traits related to flammability; oil yield, leaf size and leaf moisture content. Population variation in foliar flammability appear to follow an adaptive environmental gradient from the drought prone north-east Tasmania to the less drought prone regions in the south. Fire appears easier to propagate but burns at a lower intensity in the north-east than the southern localities which are harder to ignite but burn at a higher intensity. This study places flammability in an evolutionary context, whereby, there is significant genetic variation in fire promoting traits within a eucalypt species for selection to directly or indirectly influence.

Julianne O'Reilly-Wapstra is a research fellow and lecturer in the School of Plant Science at UTAS in Hobart.

Tropical oaks have larger genome sizes than do their temperate relatives within and among genera

Sichong Chen[1,2], Charles H Cannon[2]
[1]Evolution and Ecology Research Centre, School of BEES, UNSW, [2]Xishuangbanna Tropical Botanical Garden, Chinese Academy of Sciences, China

Background/question/methods: Several studies have suggested that genome sizes differ between tropical and temperate plants, but without conclusive sampling or phylogenetic tests. In this study, genome size variation was examined within the Fagaceae, a family composed entirely of trees having major diversifications in both tropical and temperate regions. The study aimed to reveal the scale of variation and to test whether this variation correlated more closely with biogeographic distribution or with phylogenetic history. Nuclear DNA contents from 78 species from six genera of Fagaceae were compiled, including new measurements of 171 individuals from 47 Asian species. The samples covered all major diversifications in the family, with known phylogenetic context.

Results/conclusions: Although polyploidisation was not apparent, considerable genome size variation (>40%) was observed within the Fagaceae, ranging from 1.82 pg/2C in *Quercus rex* to 2.61 pg/2C in *Lithocarpus calolepis*. Tropical groups possessed significantly larger genome sizes than temperate groups, independent of phylogeny. This pattern was observed also within the genus *Quercus*, as the tropical species of subgenus *Cyclobalanopsis* possessed larger genome sizes than the temperate species in subgenus *Quercus*. Although the direction of variation cannot be determined, this study provides the first rigorous analysis of genome size evolution in a widely distributed woody plant family. Tropical species of Fagaceae have larger genome sizes than temperate species, regardless of phylogenetic relationship, within and among genera. These basic observations will assist in on-going whole genome sequencing efforts, and direct further research into diversification in these two biomes.

Sichong Chen is a PhD candidate in the Big Ecology Lab, University of New South Wales, under the supervision of Dr Angela Moles.

Species and sex specific mobility manifest in a range of landscape genetic responses in a suite of declining woodland birds

Nevil Amos[1], Alexandra Pavlova[1], Katharine Harrisson[1], Jim Thomson[1], Jim Radford[2], Ralph Mac Nally[1], Paul Sunnucks[1]
[1]Australian Centre for Biodiversity, School of Biological Sciences, Monash University, [2]School of Life and Environmental Sciences, Deakin University

Background/question/methods: There is evidence of continued decline in many of the woodland dependant birds of south-eastern Australia. This decline has been related to a disproportionate decline of many species with the level of landscape tree cover. We predicted the landscape genetic responses for each of ten species of resident woodland dependant passerines to structural connectivity of tree cover in the fragmented box-ironbark woodlands on central Victoria. These responses were then examined using microsatellite markers and circuitscape isolation-by-resistance models.

Results/conclusions: We found species-specific and sex-specific responses to the level of structural connectivity that could be partially explained by relative mobility. As predicted, the most sedentary species exhibited the strongest landscape genetic signals; however there was also some indication of connectivity effects in more mobile species. Finer-scale examination of the patterns showed differences between the east and west of the study area that could be related to differences in configuration and tree cover between east and west.

Nevil Amos is a 4th Year PhD student at Monash, working on landscape connectivity and site condition effects on declining woodland birds.

PopGenReport: simplifying population genetics analyses in R

Aaron Adamack[1], Bernd Gruber[1]
[1]Institute for Applied Ecology, University of Canberra

Background/question/methods: Microsatellites are an important tool for answering ecological questions about population structure and gene flow across landscapes. Analysis of microsatellite data is complicated by an alphabet soup of specialised analytical programs, each (often) having its own requirements for how input data should be organised and a distinct set of operating instructions. There has been a slow shift towards using R to analyse microsatellite data, but many researchers are intimidated by the steep learning curve of R and thus continue to use older, less flexible programs. Additionally, while many popular programs have been shifted to R, the problem of unique input data organisation requirements persists.

Results/conclusions: To simplify the basic analysis of microsatellite data, we have developed a new R package 'PopGenReport', which simplifies population genetics analyses. The package accepts input data in a number of formats and uses a single command line to carry out multiple analyses on a data set. Analyses include: number of alleles per locus and population, observed and expected heterozygosity, F_{st}: pairwise and by locus, Jost's D, HWE by location and locus, and isolation by distance. Most analyses are automatically repeated for subgroups such as sex, age-class or other user-defined groupings. Output is provided in an easy to read PDF file while the R code that was executed for the analysis is exported for further analysis if desired. Package development is ongoing and contributions from others are strongly welcomed. Ultimately we aim to provide a common and tested framework for population genetic analysis.

Aaron Adamack is currently working on using spatial genetics to study the spread of invasive species. Previously he worked on investigating the effects of anthropogenic stressors (e.g. eutrophication, freshwater diversions, and introduction of invasive species) on aquatic ecosystems and populations.

Concurrent session 7D
Herbivory

How do multiple enemies interact to reduce host-plant performance?

Andrea Stephens[1,2]
[1]Department of Zoology, University of British Columbia, Canada, [2]Department of Biological Sciences, Macquarie University

Background/question/methods: Although plants are attacked by a variety of insects and pathogens that reduce their performance, there is relatively little understanding of how multiple enemies interact. Weed biological control programs invariably introduce multiple exotic natural enemies under the assumption that multiple natural enemies will reduce plant performance synergistically or, at least, independently. Despite many examples of both synergistic and antagonistic interactions between natural enemies on plants, surprisingly no attempt has been made to correlate the non-independent effects of natural enemy diversity with traits of either the natural enemies or the host plant.

We used meta-analysis to better understand the overall effect multiple enemies have on their host plant, and to determine if traits of enemies or plants could predict when non-independent effects occur. Our review involved 68 studies, which provided 75 unique enemy-enemy-plant species combinations.

Results/conclusions: We found that, on average, interactions between natural enemies have independent effects on their host-plant. We were able to identify situations that correlated with antagonistic interactions such as species that attack the same plant part simultaneously or attack reproductive plant parts.

Interactions between the weed biological control agents may influence plant performance thus overall control. Understanding of what types of agent combinations interact to either increase or decrease plant performance will improve the selection of effective agents, thus biological control success.

Andrea Stephens is an ecologist interested in interactions between insects and their host-plants. In particular she is interested in factors which explain variation in the impact of damage—why are some insects more damaging and why are some plants more heavily attacked.

Out on a limb: are eucalypt-feeding insects at greater risk of predation on young foliage?

Petah Low[1], Clare McArthur[1], Dieter Hochuli[1]
[1]School of Biological Sciences, The University of Sydney

Background/question/methods: Herbivorous insects often exhibit a preference for young foliage relative to mature foliage. Although feeding on young foliage often enhances performance, it may also increase predation risk for herbivores by influencing the probability of detection by natural enemies. For example, young foliage tends to grow at the ends of branches where herbivores are likely to be more apparent to visual predators. Additionally, young foliage often contains greater concentrations of volatiles which, when released in response to herbivore feeding, could act as host/prey location cues. We test the hypothesis that herbivores on young eucalypt foliage are at greater risk of predation than those on mature foliage by assessing predation rates on plasticine model caterpillars associated with either young or mature eucalypt foliage. We also explore visual and chemical factors predicted to contribute to a difference in predation risk.

Results/conclusions: Overall, 13% of model caterpillars were attacked by a range of predators in multiple trials. Invertebrates were the major predators, as detected and quantified by impressions left in the models. Motion sensing cameras set on high sensitivity, associated with a subset of model caterpillars, were unsuccessful at recording predation events. Foliage age, volatiles, distance from branch end, canopy openness and height from ground variously affected attack rates. We propose that predator foraging strategy, interacting with these variables, influences the trade-off herbivores face between maximising performance and minimising predation risk when selecting leaves on which to feed.

Petah Low is a PhD candidate at the University of Sydney, studying the interactions between insect herbivores, host plants and natural enemies.

Effects of plantation management on eucalypt understory ecology

Adam Frew[1], Markus Riegler[1], Uffe Nielsen[1,2], Scott Johnson[1]
[1]Hawkesbury Institute for the Environment, [2]School of Science and Health, University of Western Sydney

Background/question/methods: Eucalypt plantations account for 90% of the 100 million ha of woodland in Australia and are of considerable commercial importance globally. In addition to plantation trees, forest management practices may also influence understory ecology through changes in host plant chemistry and changes in the community dynamics of plants and invertebrates. Little is known about how management practices shape understory ecology however. In a large-scale field experiment, involving 2560 *E. saligna* trees, we investigated the individual and combined effects of irrigation and fertilisation on the understory environment. We focused on the impact of management practices on the grasses, soil, root-feeding insects and associated natural enemies (entomopathogenic nematodes).

Results/conclusions: We found that insect populations were dominated by scarab beetles, particularly *Sericesthis nigrolineata*, Christmas beetles (*Anoplognathus porosus*) and the Argentine scarab (*Cyclocephala signaticollis*). Irrigation and fertilisation increased understory grass coverage and altered composition, with fertilisation promoting growth of *Microlaena stipoides* and improving grass nutritional quality generally. There was a trend for higher insect larval abundance in fertilised plots, which could be related to better nutritional quality of the grasses and greater occurrence of the nutritionally superior *M. stipoides*. Contrary to expectation, irrigation did not affect larval abundance. However, irrigation increased the incidence and abundance of entomopathgenic nematodes in the soil. We suggest that potential benefits of irrigation to insects could have been masked by the high incidence of entomopathgenic nematodes. We conclude that eucalypt plantation management also affects understory ecology, altering host plant quality and community composition together with the soil invertebrate communities.

Adam Frew is a PhD student at the Hawkesbury Institute for the Environment, based at UWS, investigating the biology of root-feeding scarabs in eucalypt and grass ecosystems. He was the recipient of the 2012 FG Swain award for his PhD research.

Effects of grazing on plant biodiversity and reproductive phenology in arid cracking-clay ecosystems

Helen Waudby[1], Sophie Petit[1]
[1]School of Natural and Built Environments, University of South Australia

Background/question/methods: Australian rangelands constitute approximately 70% of the continent; these mainly native pastures support a substantial livestock-grazing industry. Australian rangelands have experienced a limited evolutionary history of grazing by large herbivores; native plant species may respond negatively to the extensive grazing systems that dominate contemporary rangelands. Australia has a greater area and diversity of vertosols (cracking-clay soils) than any other country. In South Australia, these soils occupy approximately 44,400 km^2; in the Stony Plains bioregion, cracking-clay soils are often considered highly productive sites for stock grazing. Landsberg et al (2003) noted that despite the considerable research on interactions between grazing and economically-valuable plants, less-common species (constituting the majority of diversity in rangeland areas) have received comparatively little attention. We examined plant biodiversity and reproductive phenology at six paired, grazed and less-grazed sites from September 2009 to May 2011, on a cattle station in arid South Australia.

Results/conclusions: Of 92 identified species, 16 were classed as restricted, being found at one site only, while 19 species were detected at each of the sites. Nineteen species were detected at less-grazed sites only and 12 at grazed sites only. Total rainfall, recorded at two weather stations, ranged from 359.4–375.2 mm. Above-average rainfall was experienced for much of the study. The responses of plant species assemblages to grazing, relative to above-average rainfall, will be discussed.

Helen Waudby is completing a PhD in Environmental Science through the University of South Australia. Her research examines the biodiversity of small vertebrates, invertebrates, and plants of cracking-clay soils, and the effects of cattle grazing on these ecosystems.

Environment, herbivory and the evolution of foliar chemistry in the red ironbarks (*Eucalyptus* series Siderophloia)

Ben Moore[1], Jane DeGabriel[2], Ian Wallis[3], Michelle Waycott[4,5], William Foley[3]
[1]University of Western Sydney, [2]Office of Environment and Heritage, NSW, [3]Australian National University, [4]University of Adelaide, [5]State Herbarium of South Australia

Background/question/methods: Leaf chemistry, including nutrient content and anti-herbivore defences, should reflect plants' evolutionary histories as well as balance the competing demands of defence against herbivores, growth and tolerance of environmental extremes. We measured a range of physical and chemical characteristics of leaves from 21 eucalypt taxa from the series Siderophloia (the red ironbarks), including nitrogen (N), concentrations of potent antifeedant secondary metabolites called formylated phloroglucinol compounds (FPCs), tannin activity, leaf size, thickness and specific leaf area. We also measured accumulated herbivory on these plants. Foliage was collected from 50 sites across Queensland, incorporating a range of soils, climates, altitudes and latitudes.

Results/conclusions: In line with the range of morphological variation and environmental tolerances observed in this group, we found variation in all traits measured. FPCs showed considerable quantitative variation across environments as well as qualitative differences between species. Foliar N was influenced by climate, soils, leaf morphology and latitude; tannin activity varied with foliar N and leaf thickness; FPCs varied with elevation and covaried with foliar N and tannin activity. We will ask whether the evidence supports tradeoffs between different types of defence and whether consistent defence syndromes can be characterised. We will discuss the relationship between foliar chemistry and herbivory by insects and vertebrates, and demonstrate progress towards the analysis of these results in the context of a new molecular phylogeny for this group.

Ben Moore studies all sorts of trophic interactions, but especially between plants and herbivores and how these are shaped by plant nutrition and defence in heterogeneous landscapes. He has studied and worked as an ecologist in Melbourne, Canberra, Townsville and Scotland before arriving in Sydney this year.

A world on a plate: heterogeneity in brushtail possum nutrition

Karolina Petrovic[1], David Watson[1], Ian Lunt[1]
[1]Charles Sturt University

Background/question/methods: Environmental heterogeneity has been broadly discussed in nutritional ecology to explain adaptive responses of generalist herbivores to the distribution, abundance and nutritional quality of forage. However, these studies have rarely considered that generalist herbivores exhibit a level of resource selectivity at different scales of environmental heterogeneity. In this paper, resource selectivity of the common brushtail possum (*Trichosurus vulpecula*) was examined in the context of forage availability. Resource selection was measured at a broad landscape scale, and within defined home-range boundaries, using spotlighting, radio-tracking and faecal content analysis. Small-scale chemical heterogeneity was studied within individual native tree species, and co-occurring parasitic mistletoes, using a novel analytical method for estimating nutritional value of forage for herbivores.

Results/conclusions: Possums exhibited resource selectivity at multiple scales of environmental heterogeneity ranging across habitats, tree species, and individual trees, to discrete patches of mistletoes within tree canopies. The most dominant species in the habitat—narrow-leaved peppermint *Eucalyptus radiata*—was consumed less than expected, while silver wattle *Acacia dealbata* was eaten disproportionally more than its availability in the habitat. Possums also selected drooping mistletoe (*Amyema pendula*) over its tree hosts, and another parasitic species, cherry ballart (*Exocarpos cupressiformis*). Despite inter- and intra-specific differences among trees and parasitic plants in the amounts of nitrogen, tannins, and fibre available to herbivores, possums showed no clear patterns for all measured attributes. In summary, the heterogeneity of tree assemblages, and availability of parasitic plants, appear to be more important for generalist herbivores than the chemical variability among plant species and individuals.

Karolina Petrovic is a general biologist with a long-lasting interest in tritrophic interactions among tree hosts, parasitic plants and herbivores. She has experience of multidisciplinary research from Europe and Australia. Currently, she investigates the nutritional ecology and impacts of common brushtail possums on native flora of Australia and New Zealand.

Concurrent session 7E
Population and metapopulation dynamics

Conserving koalas in the 21st century: synthesising the dynamics of Australia's koala populations

Clive McAlpine[1], Working Group Participants
[1]School of Geography, Planning and Environmental Management, The University of Queensland

Background/question/methods: The recent Senate Inquiry into the status, health and sustainability of Australia's koala population identified the lack of a comprehensive and integrated understanding of koala population dynamics across the broad geographic range of this species as a key shortcoming to the management and conservation of koalas at a national scale. An ACEAS working group was formed to address this problem. The working group conducted two workshops with the aim of integrating available data and expert opinion on koala population numbers and their trends, synthesised by the biogeographic regions where koalas occur. The first workshop (held in February 2012) identified areas where koala populations are in decline, where they are stable, and where populations are natural or introduced. The second workshop (held in June) was to build on this work by estimating koala population sizes and estimates of changes in population sizes in the 38 bioregions where koalas occur.

Results/conclusions: The evidence assembled confirms the koala populations of Queensland have declined by over one third in the last 18 years, namely in three generations of the koala. In New South Wales, the scenario was similar, but more striking in that some populations have been traced to extinction on coastal New South Wales. In contrast to Queensland, the New South Wales koala population was generally regarded as being much smaller, by an order of magnitude, and its widespread decline was roughly in line with the decline in Queensland. In contrast, the introduced populations of Victoria and South Australia are mostly stable, increasing, or subject to managed declines.

Dr Clive McAlpine is an ARC Future Fellow with the School of Geography, Planning and Environmental Management, The University of Queensland. He has published 100 refereed papers and book chapters on biodiversity conservation in fragmented landscapes, landscape change studies, and climate change impacts.

Translocation removes island dwarfism in the golden bandicoot (*Isoodon auratus*)

Judy Dunlop[1], Keith Morris[2], Andrew Thompson[1]
[1]Murdoch University, [2]Department of Environment and Conservation, Western Australia

Background/question/methods: Two translocated populations of golden bandicoots (*Isoodon auratus*) were monitored following relocation from one island to another and to mainland Australia. We compared skeletal and mass measurements of the new populations to long-term monitoring data from the source populations.

Results/conclusions: Bandicoots born at translocation sites were approximately 130% of the size of founder island population within 18 months of establishment. Translocated males increased in condition and females had a greater reproductive output at both new sites. The time of effectiveness took place in a single generation of at both mainland and island translocation sites, suggesting that the response is not one of evolution by natural selection. We conclude that 'island dwarfism' is driven by ecological processes of resource limitation in *I. auratus*.

Judy Dunlop completed her undergraduate degree and honours in Zoology at UWA. This allowed her to work on a variety of very interesting projects for the Department of Environment and Conservation for 7 years and is now in the last year of a PhD.

Is immigration limited by habitat abundance or supply of dispersers? Patch-scale habitat use is important

William Bovill[1], Barbara Downes[1], Jill Lancaster[1]
[1]The University of Melbourne

Background/question/methods: The number of dispersers successfully establishing at localities (immigration) has implications for the size and spatial distribution of populations. Immigration is mediated by the relative abundance of: (1) dispersers arriving at a location (supply); and (2) suitable habitat at that location. If supply exceeds habitat carrying capacity, immigration is 'habitat-determined', but if habitat exceeds supply, immigration is 'supply-determined'. Habitat abundance varies widely between sites (e.g. stream reaches), and species that are gregarious should require less habitat than species that are not gregarious. Hydrobiosid caddisflies use emergent rocks in streams to oviposit, and the number of egg masses is a measure of immigration. Egg masses of *Apsilochorema sp.* are over-dispersed, whereas *Ulmerochorema sp.* egg masses are spatially clumped. We hypothesised that *Apsilochorema* sp. are limited more frequently by habitat than *Ulmerochorema sp.*, and surveyed oviposition by both species on emergent stream rocks at 17 sites, across a gradient of emergent rock (habitat) density.

Results/conclusions: *Apsilochorema sp.* oviposition was habitat-determined at all rock densities, meaning that the initial population distribution of the aquatic larval phase was strongly related to the distribution of oviposition habitat. *Ulmerochorema sp.* oviposition was supply-determined at high rock densities, suggesting that the distribution of eggs and neonate larvae may be determined by the numbers of gravid females at these sites. *Ulmerochorema sp.* oviposition exceeded *Apsilochorema sp.* oviposition by an order of magnitude at most sites. Egg hatching rates are high, so post-immigration density-dependence may have greater influence on benthic populations of *Ulmerochorema sp.* larvae than on *Apsilochorema sp.* larvae.

William (Wim) Bovill is a PhD student at The University of Melbourne, in the Department of Resource Management and Geography. His thesis examines the supply-side ecology of stream insects (caddisflies), linking stream-scale distribution of eggs and neonates with implications for population dynamics.

Dynamics and spatial ecology of the desert rodent *Pseudomys australis*: importance of refuges for persistence

Chris Pavey[1]
[1]CSIRO Ecosystem Sciences

Background/question/methods: Most desert rodents have irruptive population dynamics which are structured by pulses in primary productivity triggered by rare and episodic rainfall. Rodents often disappear during drought; however, this is not considered to represent regional extinction because recolonisation occurs after subsequent rainfall. It is widely assumed that arid rodents occupy drought refuges; although the locations of very few of these are known. Here I investigate the occurrence and population dynamics of the plains mouse, *Pseudomys australis*, during the bust phase of the population cycle. I sought to locate drought refuges and to investigate aspects of the demography of refuge populations.

Results/conclusions: *Pseudomys australis* contracts to discrete areas of the landscape during drought which occupy a small proportion (~17%) of the range during population peaks. Refuges are the main locations occupied for the majority of any given time period; the 138 month study duration included a minimum of 108 months (78%) in the bust phase. Refuge populations are in good condition (as assessed by body mass), occur at high density and reproduce during dry conditions. There was no difference in capture rate between bust refuge populations and boom populations at outbreak sites. Refuge populations of *P. australis* represent a significant concentration of biomass to predators in a resource-poor environment and, therefore, are at risk from predation by the feral house cat and red fox during the bust phase.

Chris Pavey is an Ecologist at CSIRO in Alice Springs. His current research focuses on arid systems particularly the response of mammals and birds to resource pulses and the impact of threatening processes on declining mammal populations.

Diet changes in American mink population in Iceland

Rannveig Magnusdottir[1,2,3], Menja von Schmalensee[1,2], Robert A Stefansson[1,2], David Macdonald[3], Pall Hersteinsson[1]
[1]Faculty of Life and Environmental Sciences, University of Iceland, [2]West-Iceland Centre of Natural History, Iceland, [3]Wildlife Conservation Research Unit, Zoology Department, University of Oxford

Background/question/methods: The alien invasive American mink *Neovison vison* is fully established in the low biodiversity environment of Iceland. The mink population peaked in 2003, followed by a continuous decline. The Icelandic marine environment has experienced various changes during these years, including rising sea temperature and sand-eel collapse followed by seabird recruitment failure and population declines. Furthermore the arctic fox population has increased six-fold in the last three decades. In an effort to reveal the causes of the population decline we analysed the stomach contents of 662 mink obtained from hunters in 2001-2009 in the Snæfellsnes Peninsula, West Iceland. Three, nonexclusive, explanations for mink population decrease were considered; decrease in prey availability, less access to prey and reduced capability of mink to hunt.

Results/conclusions: The diet of mink in Iceland consists mostly of fish and birds and the most marked shift in composition was a decrease in consumption of birds. Our findings indicate that climate change events on top of terrestrial diet constraints, caused by increasing numbers of arctic foxes, contributed to the sharp reduction in the mink population from 2004 and onwards. Despite their generalist behaviour, mink have apparently failed to adapt fully to these environmental changes, and this susceptibility may benefit attempt to control their numbers. Furthermore, these results may prove to be valuable in the context of climate change and various invasive carnivores elsewhere.

Rannveig Magnusdottir received a MSc degree in 2005 from the University of Iceland in collaboration with Deakin University, Australia. Her project was on the swamp antechinus (Antechinus minimus). Her PhD project, in collaboration between the University of Iceland and University of Oxford, is on the American mink (Neovison vison) in Iceland. This work is in the loving memory of Professor Pall Hersteinsson, who sadly died in October 2011.

Bayesian hierarchical modelling of population growth rates

John Baumgartner[1], Tracey Regan[1], Michael McCarthy[1], Dean Heinze[2]
[1]ARC CEED, The University of Melbourne, [2]Research Centre for Applied Alpine Ecology, La Trobe University

Background/question/methods: A central aim of population ecology is to predict the probability that a species will persist. This requires an understanding of how population growth rates respond to dynamic environmental conditions. However, the identification of factors influencing growth rates is challenging, particularly because we often lack relevant data on processes that truly affect population growth. For species with multiple populations, growth rates may vary through time independently or synchronously, depending on the scale at which influential processes operate. Hierarchical models provide a means to identify the extent of temporal variation in growth rates of multiple populations, at various spatial scales. This reveals the relative importance of environmental processes that operate at each scale, thereby facilitating collection of data that may improve model performance. We fitted Bayesian hierarchical models to time series data on abundance of the mountain pygmy-possum, *Burramys parvus*, to estimate the strength of processes governing population growth rates, and the dominant spatial scale at which density-independent fluctuation in growth rates occurred.

Results/conclusions: While density dependence explained considerable variation in growth rates, environmental influences generally failed to improve model fit substantially. However, models revealed that density-independent variation was greatest at the site scale, highlighting the importance of site-specific processes in driving fluctuations. It is likely that proximal factors affecting growth relate to food availability (e.g. abundance of the Bogong moth, vegetation condition, etc.) for which available data is limited, and possibly local landscape attributes. Data pertaining to these and other site-scale variables may improve the predictive capacity of our models, and consequently, our predictions of the possums' fate.

John Baumgartner is a PhD candidate in the Centre of Excellence for Environmental Decisions at The University of Melbourne. His research aims to estimate climate change-related extinction risks through integration of correlative and mechanistic models of habitat change, and population dynamics.

Concurrent session 7F
Ecological expertise and decisions for management

How good are experts anyway? Validating a state-and-transition process model for adaptive management

Libby Rumpff[1], Peter Vesk[1], David Duncan[2], Damian Michael[3], Chris Jones[1], Brendan Wintle[1]
[1]ARC Centre of Excellence for Environmental Decisions, University of Melbourne, [2]Arthur Rylah Institute, Department of Sustainability and Environment, [3]Fenner School of Environment and Society, ANU

Background/question/methods: Adaptive management (AM) provides a framework for decision making in the face of uncertainty. Quantitative process models are a crucial element of AM, as they represent current knowledge about system dynamics, and are used to predict the response of the system to management intervention. Given high uncertainty and a general lack of data, we often rely on experts to construct and parameterise process models, with the knowledge that these models will be updated as new data accumulates with monitoring. However, our rate of learning is dependent on the level of confidence we place on the initial model. This rate of learning is important as subsequent decision making relies on these judgments. In this study we validate an existing expert elicited state-and-transition process model with field data collected from the Goulburn Broken catchment in Victoria. In 2010-2011, 109 sites on private and public land in varying vegetation condition were surveyed. We specifically test two components of the model, hypotheses about the condition of woodlands in the landscape, and the vegetation attributes that define different states of condition.

Results/conclusions: Results indicate that 5 of the 7 woodland states identified by the experts were overlapping in vegetation condition when defined by the vegetation attributes used in the model, and 2 were quite distinct. However, though there was broad overlap, all states could be differentiated by a smaller set of vegetation attributes. The attributes initially used to define the states were often supported by the data, though some states were differentiated by attributes not predicted by the experts. The findings of this study will be used to define a set of attributes that can be used to differentiate transitions between states to guide a targeted monitoring strategy.

Libby Rumpff finished her PhD in 2009 and is currently a postdoctoral research fellow at the University of Melbourne. Her work focuses on structured environmental decision making for natural resource management.

Giving ecology a place in resolving 'wicked problems'

Judy Lambert[1]
[1]Community Solutions

Background/question/methods: Problems such as competition for available water, and sustainable use of land are 'wicked problems'. They have multiple, inter-related causes the 'realities' of which are seen differently by different interests. 'Wicked problems' lack a simple cause and effect relationship or a simple solution. They require collective wisdom and behavioural changes that are both personal and social in nature. Each 'wicked problem' is a unique product of the time, place and people involved. As the title of this conference suggests, ecology is the science that provides reality to the future of the biosphere. However, ecology is but one of many 'realities' perceived by different sectors influencing decision making. No matter how good the science, the ecological perspective is often overridden by economic, political or other 'realities'. The focus question for much of our work must surely be 'How can ecology gain a more influential place in addressing the complex problems that our systems currently face?'.

Results/conclusions: Based on more than a decade of work with Professor Valerie Brown, using her action learning theories of collective learning in achieving transformational change, this paper will explore collective how learning involving an agreed set of different ways of knowing, can help give ecology a more powerful voice in managing our landscapes and our planet. Collective learning, as applied in other areas of change to a more sustainable future, could do much to enhance the voice of ecology in sustaining our biosphere. However, the changes needed are many and varied, ranging from the individual to the systemic, from the science to the policy and practice.

Judy Lambert has worked at the interface between science, policy and on-ground practice for more than 20 years, seeking to improve ecological outcomes by improving shared understanding. Her primary focus is in rural production landscapes.

Trading off accuracy and effort in eliciting expert assessments of extinction risk for threatened species

Marissa McBride[1], Mark Burgman[1]
[1]University of Melbourne

Background/question/methods: Threatened species assessments frequently rely on expert opinion to inform decisions about the status and management of at-risk species. Expert knowledge is perceived to be of value as an alternative, cost-effective source of information for decision making in the absence of empirical data. However, the procedures available to minimise the error and biases in elicited knowledge are still costly in terms of the investments of time and effort they require. Practitioners are usually limited in the resources they can devote to elicitation, but the information to guide their decision making about how investment in different possible elicitation procedures leads to improvements in response accuracy is mostly lacking.

In this study we explored the utility of a cost-benefit approach for improving the efficiency with which managers deploy funds for elicitation. We collected information about the costs and benefits associated with different elicitation techniques at a threatened species assessment workshop conducted for two Victorian frog species.

Results/conclusions: We found that targeting investment into different elicitation procedures provides differential returns in accuracy, and importantly, that the overlay of costs is necessary for the identification of the most cost-efficient approaches. Techniques such as face-to-face discussion and using large groups of experts, for example, improve accuracy but represent comparatively poor investments where experts are not located locally. These findings illustrate the power of a cost-benefit approach for identifying the best elicitation techniques to invest in, within the constraints of a given elicitation context.

Marissa McBride is a doctoral student in the School of Botany at the University of Melbourne. Her dissertation research focuses on methods for evaluating and improving the use of expert knowledge in ecology.

How good are our decision models? An experimental test of optimal surveillance

Joslin Moore[1], Wan-Jou Lin[2], Georgia Garrard[2], Michael McCarthy[2]
[1]Australian Research Centre for Urban Ecology, [2]School of Botany, University of Melbourne

Background/question/methods: We rely increasingly on decision models to allocate resources for conservation and management. Our analyses assume that the model captures the critical features of the system and that we can effectively estimate key parameters. But are our models good enough? Do these analyses confer the benefits they predict when applied in a real system? We tested a model of optimal surveillance that allocates search time between sites of varying abundance to maximise the total number of individuals detected assuming that the rate of detection is constant through time. We used estimates for the detection rate (a key parameter) from an experiment the previous year to predict the benefit (additional number of plants detected) of the optimal surveillance allocation compared to other reasonable strategies. We then undertook an experiment with observers searching sites of known abundance to measure the realised benefit in the field.

Results/conclusions: While detection rates were different between years and the rate of detection varied with time in some cases, the realised benefit of the optimal allocation was close to that predicted. Our results suggest that this simple decision model is good enough to improve the allocation of survey effort in the field.

Joslin Moore is senior ecologist at the Australia Research Centre for Urban Ecology, Royal Botanic Gardens, Melbourne. The aim of her research is to use ecological theory as a tool to solve and inform applied ecological problems that will aid in the conservation and management of natural resources.

Attitudes to interdisciplinary collaboration in the Ecological Society of Australia: do members differ from non-members?

Alison Specht[1], Lucy Keniger[2]
[1]Australian Centre for Ecological Analysis and Synthesis, [2]School of Biological Sciences, University of Queensland

Background/question/methods: Improving interdisciplinary collaboration within the ecosystem science and management community is critically important for understanding and addressing the complex environmental problems facing us in Australia today. Professional societies can play an important role in facilitating and enabling collaboration.

The Ecological Society of Australia (ESA) has over 1500 members and fosters both disciplinary and interdisciplinary collaboration. In an exploratory study we aimed: (i) to identify the demography of the ecosystem science and management community, and the subset of the ESA within it, and (ii) to determine whether there are significant differences in attitudes towards interdisciplinary collaboration between members and non-members. A total of 751 randomly selected, nationally distributed individuals from a diverse range of institutions participated in the survey.

Results/conclusions: The results highlight the importance of the ESA in the community (48% of participants were ESA members) and key differences between ESA members and the rest of the ecosystem science and management community. There was a greater representation of major universities within the ESA group and a higher proportion of recent-graduates. Attitudes towards interdisciplinary collaboration were positive throughout, however scores of recent collaborative behavior indicated a preference for collaborating with people from one's own discipline and with those with whom one has previously worked. The results suggest that the ESA is underrepresented in regional centres and in smaller universities. Recommendations are made for actions to promote and facilitate interdisciplinary research collaboration within the ecosystem science and management community.

Associate Professor Alison Specht is Program Manager for the Australian Centre for Ecological Analysis and Synthesis, a facility of the Terrestrial Ecosystem Research Network. Her major interest is in ecosystem dynamics.

Concurrent session 8A
SYMPOSIUM: Australian phenology

Gigapixel resolution time-lapse imaging for phenological monitoring of every plant in a landscape

Timothy Brown[1], Justin Borevitz[1]
[1]Research School of Biology, Division of Plant Sciences, Australian National University

Background/question/methods: It has traditionally been challenging to record plant phenology data in field settings over long time periods at high spatial and temporal resolution. National monitoring networks such as TERN have a pressing need for new tools to enhance landscape monitoring over long time periods at high resolutions.

We developed a solar powered billion-pixel resolution timelapse camera system ('Gigavision') that enables daily phenological observations for nearly every plant in a 10-hectare area. The camera was installed at Indiana Dunes State Park, Indiana, USA. For this project we were interested in testing hardware reliability and quantifying total species and numbers of plants and time-resolution of phenological stages that could be monitored with the Gigavision system. Results were compared with those from traditional monitoring approaches such as ground observations, 'plantcams' and remote sensing. We recorded onset and duration of phenological stages in all visible plants in the study area (stage duration, time of 50% conversion to stage). 'Pheno-stages' recorded were: leaf -budburst, -emergence, -fullsized, -turning, -dropped; Flower -budburst, -open, -dropped.

Results/conclusions: The Gigavision camera recorded 1.3 gigapixel resolution images daily over 7-hectares for two growing seasons (April 2010 – October 2011). We had 70% camera up-time (with maintenance every 4-6 weeks). Phenological stages were recorded for 350 individuals in 12 species of plants in the field site. Gigapixel time-lapse imaging presents significant technical hurdles but the resulting data is orders of magnitude greater than other standard available techniques (e.g. on site surveys, traditional cameras, remote sensing).

Tim Brown is a post-doctoral fellow in the Borevitz Lab at ANU building data analysis and image processing pipelines for enabling high-throughput phenomics. Prior to that he spent 6 years designing advanced landscape monitoring and data visualisation systems.

Soil warming reduces seedling emergence in a Mediterranean-climate ecosystem

Anne Cochrane[1,2], Gemma Hoyle[1], Colin Yates[2], Jeff Wood[3], Adrienne Nicotra[1]
[1]School of Biology Australian National University, [2]Department of Environment and Conservation, [3]Statistical Consulting Uni ANU

Background/question/methods: Plants are heavily reliant on favourable environmental conditions for successful seed germination and seedling establishment. However, within a species, requirements for this phase of the life cycle can vary both spatially (i.e. along its geographical distribution) and temporally (e.g. under a changing climate). This variation in regeneration requirements can affect community composition and influence population persistence. We used a field-based climate manipulation to investigate seedling emergence patterns under altered climate conditions (water reduction and addition, and temperature increase). We sowed seeds from six populations of four Western Australian *Banksia* (Proteaceae) species collected from across a natural east-west climate gradient in the South West Australian Floristic Region. We hypothesised that tolerance to warmer, drier conditions would be retained (niche conservatism) across populations along the climatic gradient but that species' responses would differ.

Results/conclusions: Soil warming slowed germination across all species and reduced total seedling emergence in 3 out of 4 species, although seed response to watering treatments was inconclusive. Within species, populations differed significantly in response to the warming treatments, but contrary to expectations, these differences were not correlated with latitude, longitude or climate at the seed collection sites. The implications of these results will be discussed in the light of a warming, drying climate as predicted for the region, including addressing strategies for conservation and restoration of long-lived woody species in this and other Mediterranean-climate ecosystems.

Anne Cochrane is a full-time external PhD candidate at ANU investigating the impact of altered climate conditions on seed and seedling ecology. She also manages the WA Department of Environment and Conservation's seed conservation facility located in Perth.

Predicting the onset of breeding and moulting in little penguins from ocean temperatures

Peter Dann[1], Lynda Chambers[2]
[1]Phillip Island Nature Parks, [2]Centre for Australian Weather and Climate Research, Bureau of Meteorology

Background/question/methods: Ocean temperature has been shown to be related to various demographic parameters in a number of seabird species including the timing and success of breeding. However, the influence of sea temperatures on the timing of moult of seabirds is rarely considered and yet it is a critical stage in the annual cycle of some seabirds, particularly penguins. Here we consider the influence of ocean temperatures on the timing of both breeding and moult and the interactions between them.

Using a 40-year life-history dataset of little penguins in south-eastern Australia, we examined the timing of breeding (mean laying date) and the timing of moult (mean moulting date) with seasonal sea-surface temperatures (SSTs) in north-central Bass Strait.

Results/conclusions: Egg-laying date was correlated with SST in the first three months of the year prior to breeding. SST explained 53% of the variance in mean laying date. This model predicted an early egg-laying date, higher average chick mass at fledging and a higher number of chicks produced per breeding pair when autumn SSTs in Bass Strait are warmer.

Preliminary analyses indicated that ocean temperatures did not appear to be a driver of timing of moult in little penguins. However the timing of moult was associated with breeding success which was, in turn, driven by ocean temperatures.

In future, egg-laying would be expected to be earlier as Bass Strait warms and it appears likely that the timing of moulting will follow a similar pattern tempered by post-breeding food availability.

Peter Dann has worked on the ecology of shorebirds and seabirds for over 30 year in Australia, New Zealand and the United Kingdom. He is currently editor of Marine Ornithology and a research associate at Melbourne University and University of New South Wales.

Fruit hotspots: using models of spatio-temporal resource availability to map seasonal fauna habitat

Brian Hawkins[1], Ralph Mac Nally[1], Jim Thomson[1]
[1]Australian Centre for Biodiversity, School of Biological Sciences, Monash University

Background/question/methods: Knowledge of spatio-temporal patterns of resource availability is fundamental to understanding the seasonal distributions of fauna that track resources such as food. However, there have been few attempts to map such patterns across large areas. We measured monthly fruit availability over 24 months at 81 sites in a 300 000 ha study area in subtropical eastern Australia. We used the data to model fruit availability and produce maps of seasonal frugivore habitat.

Results/conclusions: Fruit availability showed a consistent annual cycle, with a peak between February and April and a lean season from July to November. Spatial patterning of fruiting was governed by factors such as vegetation type, distance to the nearest watercourse and gross primary productivity (derived from satellite telemetry). In each month of the study there were 'fruit hotspots', or areas of high fruit availability likely to be important to frugivores. The locations of these hotspots shifted seasonally. From November to June, hotspots were in extensive areas of subtropical rainforest in conservation reserves, but for much of the lean season, the only hotspots were in small patches of weedy regrowth. Weedy regrowth, a novel ecosystem dominated by exotic plant species, had more fruit than any other vegetation type and is likely a key habitat for native frugivores. Dynamic resource availability models have broad applicability in mapping seasonal fauna habitat, particularly where multiple species depend on a single resource.

Brian Hawkins is completing a PhD on the landscape ecology of forest birds on the NSW mid-north coast (supervisors: Ralph Mac Nally, Hugh Ford and Simon Ferrier).

Flowering phenology of *Microlaena stipoides* in north-east Victoria

Meredith Mitchell[1], Jim Virgona[2], Joe Jacobs[1], David Kemp[2]
[1]Department of Primary Industries, [2]School of Agricultural and Wine Sciences, Charles Sturt University

Background/question/methods: *Microlaena stipoides* var. *stipoides* (Labill.) R.Br. (Microlaena) is a tufted C3 perennial grass that has a wide geographic distribution throughout the high rainfall zone (>550mm AAR) of south-eastern Australia and is widely recognised as being an important species in extensive grazing systems. Reproductive development is important for plant growth, competition, persistence and the timing of grazing strategies.

The experiment was conducted at Chiltern (S36°12', E146°35') in north-east Victoria, on an existing native grass pasture, with the main component being Microlaena (19% basal cover). The phenological stage of Microlaena was recorded approximately fortnightly over an eighteen month period (December 2009 to July 2011). When 50% or more of the population was in a phenological category, it was recorded. The stages noted were vegetative, stem elongation, ear emergence, seed maturity, seed falling and seed fallen.

Results/conclusions: Ear emergence commenced in early November, flowering intermittently for 113 days with seed maturity and seed fall occurring in late summer and autumn. Chasmogamous (open) flowering was recorded several times during the period of the experiment. The precocious flowering of Microlaena demonstrated during summer would appear to indicate that Microlaena could produce inflorescences quickly in response to environmental triggers, especially moisture.

Used in conjunction with other monitoring methods, these results offer a valuable insight about the dynamics of an individual species, and can contribute to the development of appropriate management strategies to maintain populations of Microlaena within grazed pastures.

Meredith Mitchell is currently undertaking a PhD on the ecology of *Microlaena stipoides* in grazing systems. *M. stipoides* is a native perennial grass that is widespread in the temperate high rainfall zone (>550mm AAR) of south-eastern Australia.

Concurrent session 8B
Biogeochemistry and nutrient cycling

Effects of native and exotic millipedes (diplopoda) on decomposition, nutrient release and plant growth

Anne Tomlinson[1], David Wardle[2], Jacqueline Beggs[1]
[1]School of Biological Sciences, University of Auckland, New Zealand, [2]Department of Forest Ecology and Management, Faculty of Forestry, Swedish University of Agriculture

Background/question/methods: Invasive detritivores may influence ecosystem processes by altering the rate and timing of litter decomposition and nutrient cycling, thereby affecting the availability of soil nutrients for plant growth. Exotic, naturalised litter invertebrates are widespread throughout New Zealand and may co-exist with native litter fauna. A microcosm experiment was established using native (*Spirobolellus antipodarus*) and exotic (*Oxidus gracilis*) millipedes, both found in native broadleaf forest. The aim was to compare individual and combined species effects on: (1) rates of litter decomposition and litter nitrogen (N) and phosphorus (P) release; (2) soil N and P levels; and (3) seedling growth and foliar N and P levels of the native species *Vitex lucens*. There were six treatments, two controls without millipedes, two single species treatments, and two combined species treatments.

Results/conclusions: There were significant positive correlations between millipede biomass and decay rates of high nutrient litters and N and P mobilisation. Soil nitrate (NO_3) and phosphorus (Olsen P) declined from initial levels, but ammonium (NH_4) levels increased substantially in the exotic millipede treatments. Seedling growth rates and leaf production were not significantly higher in the millipede treatments. Foliar N and P levels declined across all treatments with low N:P ratios indicative of N limitation, a surprising result given the elevated NH_4 levels in the exotic millipede treatments. *V. lucens* seedlings may preferentially uptake N in the form of NO_3 rather than NH_4 which would explain the lack of a significant effect of millipede biomass on seedling growth rates.

Anne Tomlinson is a PhD student at the University of Auckland studying interactions between co-existing native and exotic millipede species across an urbanisation gradient in Auckland City. The subject of the presentation at ESA is a microcosm study on the ecosystem effects of exotic and native millipedes on decomposition and nutrient cycling.

Can a little vegetation go a long way? Effect of vegetation replanting on whole-stream metabolism

Darren Giling[1], Michael Grace[2], Ross Thompson[1], Ralph Mac Nally[1]
[1]Australian Centre for Biodiversity, Monash University, [2]Water Studies Centre, School of Chemistry, Monash University

Background/question/methods: It is becoming increasingly common to seek to restore ecosystem functions in degraded ecosystems. Relatively few studies have assessed the effect of riparian replanting on functional aspects of stream health, such as stream metabolism, which incorporates gross primary production (GPP) and ecosystem respiration (ER). Stream metabolism is expected to respond to replanting as it is driven partly by availability of light and organic matter. We measured whole-stream metabolism at paired untreated/replanted reaches on two streams (replanted 17 and 20 years ago), and paired untreated/untreated reaches on a 'control' stream in an agricultural catchment of central Victoria, Australia. We assessed the effect on steam function (metabolism) of replanting vegetation at the relatively small scales (i.e. 100s of m) most typical of stream restoration activities.

Results/conclusions: The range in GPP (0.39 to 2.14 $gO_2\ m^{-2}\ day^{-1}$) and ER (1.93 to 17.96 $gO_2\ m^{-2}\ day^{-1}$) was similar to past estimates in agricultural streams. All reaches were heterotrophic (i.e. GPP:ER < 1), meaning most energy was derived from terrestrial inputs rather than in-stream production. Replanted reaches were more heterotrophic than untreated reaches (mean GPP:ER 0.11 and 0.31 respectively), whilst differences were not observed between reaches on the control stream. The results indicate isolated replanting affects stream ecosystem function, even when the spatial scale of restoration is relatively small in a whole-of-catchment context. This contrasts with recent meta-analyses suggesting local vegetation is of marginal value to some indicators of aquatic ecosystem health. A range of indicators must be monitored to assess the effectiveness of restoration activities.

Darren Giling is a graduate student at Monash University, Victoria, Australia, studying freshwater ecology under supervisors Dr Ross Thompson and Prof Ralph Mac Nally. His thesis is titled 'The effect of riparian vegetation on aquatic organic carbon dynamics and biodiversity in an agricultural landscape'.

The colour of mud: blue carbon storage in Darwin Harbour mangrove communities

Le Bai[1], Lindsay Hutley[1], Keith McGuinness[1], Stephen Livesley[2]
[1]Research Institute for the Environment and Livelihoods, Charles Darwin University, [2]Department of Resource Management and Geography, The University of Melbourne

Background/question/methods: Blue carbon is the carbon captured and sequestered in coastal and marine environments. Whilst comprising only 0.05% of the biomass of terrestrial plants, marine ecosystems can store and sequester carbon at much greater rates per unit area and per unit time. This study focused on carbon stored in the near-pristine mangrove communities of Darwin Harbour, in particular, soil organic carbon (SOC) associated with dominant mangrove communities. These data were combined with existing vegetation structural data and allometric relationships to estimate the total carbon storage across the harbour. Fifteen sites were sampled that were representative of the four most dominant mangrove floristic assemblages or communities. At each site, five cores were sampled at four depths to 1m where possible. A piston sampler was used for bulk density and samples were analysed for carbon and nitrogen concentration.

Results/conclusions: Bulk density ranged from 0.2 to 1.6 g cm^{-3}, with a mean of 0.61 g cm^{-3} with differences between depths and communities evident (p=0.001). SOC ranged from 2 to 8% and differed similarly to bulk density across depths and community type. Scaling mean SOC for each community based on area provided a storage estimates estimate for the entire 19,040 ha mangrove estate of 4.34 Tg. This is ~4 times the SOC stored in savanna ecosystems that fringe the mangroves. Based on previous studies, carbon storage in these mangrove forests, both above- and below-ground, was estimated as ~1.14 Tg C. The total harbour carbon storage (soil plus vegetation) is therefore 5.48 Tg with 80% of this carbon is stored in the soil. These data provide a baseline on Darwin Harbour which is an extremely valuable reference site for comparative analysis, especially given the rapid industrialisation and proximity to urbanisation.

Le Bai is an Honours student currently enrolled in Charles Darwin University, with a passion for coastal and marine ecology that started from 2009 when Le was doing voluntary work in Arnhem Land. Le has a strong interest in biogeochemical cycles of vegetated coastal ecosystems and in particular mechanisms that control C sequestration in these ecosystems.

Hydrological variation and dissolved organic matter in streams of the Pilbara, WA

Andre Siebers[1], Neil Pettit[2], Greg Skrzypek[1], Jason Fellman[1], Shawan Dogramaci[3], Pauline Grierson[1]
[1]Ecosystems Research Group, School of Plant Biology, UWA, [2]Centre of Excellence in Natural Resource Management, UWA, [3]Rio Tinto Iron Ore

Background/question/methods: Dissolved organic matter (DOM) is a complex mixture of organic compounds that plays a fundamental role in aquatic ecosystems, including the biogeochemical cycling of carbon and nutrients and the maintenance of foodwebs. However, the composition of DOM and the factors that influence it remain poorly described, particularly in arid regions. Here, we present DOM data from several intermittent streams in the semi-arid Pilbara, Western Australia, where water chemistry is strongly influenced by extreme cycles of flooding and evaporative contraction. Using fluorescence excitation-emission spectroscopy and parallel factor analysis (PARAFAC), we decomposed DOM fluorescence matrices into different, independent fluorescence components. In addition, the hydrological regimes of stream pools were characterised using the stable isotope ratios of water (δ^2H and $\delta^{18}O$) as an indicator of surface water origin (rainfall vs groundwater) and evaporative pressure.

Results/conclusions: Across the entire set of Pilbara streams, $\delta^{18}O$ was strongly correlated with the DOM components representative of humic and fulvic acids, but not protein-like components. However, individual catchments displayed very different trends between hydrology and different DOM components. In particular, protein-like fluorescence correlated strongly with $\delta^{18}O$ in some rainwater-replenished pools, or with the development of littoral vegetation over time in others. These results suggest that evaporative contraction in Pilbara streams affects the concentration of terrestrially derived DOM components (humic/fulvic acids) directly, but that autochthonous DOM is subject to a more complex suite of hydrological pressures.

Andre Siebers is currently working on a PhD in freshwater ecology and biogeochemistry at the University of Western Australia, focusing on links between terrestrial and freshwater systems in the semi-arid Pilbara, north-west WA.

Phytotoxicity of *Phragmites australis* through residue decomposition

Md Nazim Uddin[1], Domenic Caridi[2], Randall W Robinson[1]
[1]Ecology and Sustainability, Victoria University, [2]Chemistry, Victoria University

Background/question/methods: *Phragmites australis* is the most widespread and invasive plant on the earth. Allelopathy has been considered as a major driver for its invasion into natural ecosystems. Allelochemicals may release several ways and residue decomposition is the most important of them. Generally we overlook it but the constant accumulation may produce adverse impact on plant growth as well as plant community. We evaluate the allelochemicals phytotoxicity of *Phragmites australis* through residue decomposition. In the first experiment, three treatment series (litter alone, soil alone and litter with soil) and two types of decomposition (aerobic and anaerobic) were maintained for 5 weeks in laboratory with each week sampling. We measured the changes of physio-chemical characteristics and phytotoxic effects of aqueous extracts on root elongation of model plant. In the second experiment, long term decomposed residues were used to test phytotoxic effects on germination and growth of associated plant.

Results/conclusions: The results indicate that concentration of water soluble phenolics and dissolved organic carbon (DOC) were reduced sharply in first two weeks and remained constant during the study period in aerobic condition, but higher concentrations were observed in anaerobic condition with fluctuations. Other parameters varied significantly with time and conditions. Aqueous extracts exhibited strong inhibitory effects on root elongation of *Lactuca sativa* at the beginning of decomposition with decreased effects at the end phases. The germination and growth effects by decomposed residues on *Melaleuca ericifolia* were also more prominent. This study may prove useful in understanding the potential impacts of allelochemicals by residue decomposition on recruitment of plants in wetlands that contain *Phragmites australis*.

Md Nazim Uddin is a PhD student in ecology and sustainability group of Victoria University, Melbourne, Australia. He has degrees from Khulna University, Bangladesh University of Engineering and Technology and Saitama University. Mr Uddin is doing his research on allelopathy regarding Phragmites australis in wetland ecosystems.

Concurrent session 8C
SYMPOSIUM: Bridging the temporal divide

Fires in the fens: fire history and management of the patterned fens of south-east Queensland

Patrick Moss[1], Felicity Shapland[1], John Tibby[2], Cameron Barr[2], Lynda Petherick[3]
[1]Geography, Planning and Environmental Management, The University of Queensland, [2]Geography, Population and Environment, The University of Adelaide, [3]Earth, Environmental and Biological Sciences, Queensland University of Technology

Background/question/methods: The patterned fens of the Great Sandy Region, south-east Queensland are unique wetlands that form an elaborate network of pools ('flarks') surrounded by vegetated peat ridges. In general, the patterned fens are bordered by coastal communities (in the case of Fraser Island) or a river channel (in the case of the Cooloola region) and there is some uncertainty about their formation and antiquity. There is some concern about how the patterned fens may respond to future environmental change and in particular the impacts that alterations in fire regimes and sea-level rise may have on their future survival. This project has investigated two patterned fen sites on Fraser Island, Wathumba and Moon Point, to examine how these communities have responded to past fire regimes of the Holocene period.

Results/conclusions: Data derived from pollen and charcoal analysis of sediment cores collected from each of the sites suggests that patterned fens can be burnt with little impact on their survival. Furthermore, the Moon Point site suggests that patterned fens have not been impacted by the sea-level rise (ca +1m) that characterises the mid-Holocene period. These results have significant implications for the management of the patterned fens, particularly that a unique fire management plan is not required for the survival of this community into the future and that they may be able to survive sea-level changes up to at least one metre. Although additional research is required to understand their antiquity and formation processes.

Patrick Moss is a Senior Lecturer in Physical Geography at the School of Geography, Planning and Environmental Science at The University of Queensland. His research interests are in reconstructing past environments in eastern Australia for the late Quaternary period (last 100,000+ years).

Paleoenvironmental reconstruction over the late Quaternary period for patterned fens at Moon Point, Fraser Island

Felicity Shapland[1], Patrick Moss[1], Lynda Petherick[2], John Tibby[3], Cameron Barr[3]
[1]Geography, Planning and Environmental Management, The University of Queensland, [2]Earth, Environmental and Biological Sciences, Queensland University of Technology, [3]Geography, Population and Environment, The University of Adelaide

Background/question/methods: The patterned fens found throughout Fraser Island and the Great Sandy Region are a unique wetland system which forms a series of connected pools bordered by peat ridges. Their existence in this subtropical zone is unique; this feature is usually found only in Northern Hemisphere boreal environments. Little is understood about the formation of the fens and the environmental conditions which preceded them. This lack of knowledge has an impact for the future management strategies of the fens, and so is the basis for undertaking this research investigation. A palaeoenvironmental record has been constructed to provide detail about the environmental changes occurring during the late Quaternary period. Results from a macrocharcoal and pollen analysis have been used to determine the fire and floristic history of the site. These results have been aligned with six radiocarbon dates taken throughout the core. In addition, loss on ignition and particle size analysis have been undertaken to determine the changes occurring in the sediment over this period.

Results/conclusions: The results from these investigations have produced findings which support the idea that the fens formed during the Holocene period (over the last 10,000 years), possibly during the late Deglacial as a response to rising sea levels. Results also suggest that the fens are fairly resilient to changes in fire regimes and sea level, continuing to survive despite increases in burning and a rise in sea level during the mid-Holocene. These findings are useful in determining appropriate management strategies for this World Heritage listed area.

Felicity Shapland is an Honours student at the School of Geography, Planning and Environmental Science at The University of Queensland. Her research is focused on examining the past environment of Fraser Island, specifically the formation of the patterned fens, for the late Quaternary period.

Palaeontology and species-area relations applied to conservation of terrestrial mammals around Shark Bay, WA

Alexander Baynes[1]
[1]Western Australian Museum

Background/question/methods: Shark Bay was formed by postglacial sea-level rise flooding shallow basins between two tectonically-uplifted ridges. It marks the northern extremity of south-western faunas and floras, and has been of interest to scientists for >200 years, though only 6 terrestrial mammal species were recorded during the 19th century, before local extinctions occurred. Cats introduced to Dirk Hartog and Faure Islands by pastoralists exterminated all but the smallest native mammals. In 1957 Bernier and Dorre Islands were declared fauna reserves, thereby conserving the last populations of at least 3 mammal species. Long term local focus by conservation agencies created a need for information on original (pre-European) mammal faunas. Some 76 sites containing terrestrial mammal remains were discovered throughout Shark Bay between 1970 and 2006, mainly along the coasts.

Results/conclusions: Data from the fossil sites and biological surveys indicate the following numbers of non-volant native mammal species: Bernier originally 7 (6 extant); Dorre 6 (6); Dirk Hartog 13 (3); Edel Land 20 +(6); Peron Peninsula 21 (7); Faure 3 (0). Species-area relations show typical values for mammals on islands except Faure, which is slightly larger than Bernier or Dorre, but had half as many species. Cats were eradicated from Faure and 2 mammals re-introduced; 3 other highly endangered species were also chosen to be introduced. One of the second group failed to establish, the other 4 are thriving. Attempts to translocate mammals to Peron Peninsula have been less successful, with only 2 of 6 surviving, probably because attempts to eradicate cats, though vigorous, have failed.

Alex Baynes conducts research on fossil mammals from cave deposits from the western two-thirds of Australia. This research has practical application in determining pre-European faunas of potential reserves and sanctuaries, for use in choosing mammal species to be re-introduced.

The thylacine myth: stable isotopes and skull biomechanics reveal their actual diet and extinction risk

Marie Attard[1], Stephen Wroe[1], Tracey Rogers[1]
[1]School of Biological, Earth and Environmental Sciences, University of NSW

Background/question/methods: With rapidly increasing rates of contemporary extinctions, predicting extinction vulnerability has become a key challenge in ecology. Previous efforts to understand why Australia's iconic thylacine (*Thylacinus cynocephalus*), or Tasmanian tiger went extinct have been confounded by limited knowledge about their diet and trophic interactions. We used two novel techniques commonly used in paleoecology and ecological studies to (i) determine whether diet specialisation and competition influenced their extinction, and (ii) track long-term ecological shifts within Tasmania's marsupial carnivore guild. Three-dimensional computer simulations of the thylacine skull were used to assess their biomechanical limitations and maximum prey size. In addition, stable isotope ratios of carbon ($\delta^{13}C$) and nitrogen ($\delta^{14}N$) in marsupial carnivore tissues were used to investigate intra- and inter-individual diet variation, and explore long-term shifts in diet and habitat use since the 1830s.

Results/conclusions: Both approaches suggest that the thylacine competed for food resources with the two largest remaining marsupial carnivores, the Tasmanian devil (*Sarcophilus harrisii*) and spotted-tailed quoll (*Dasyurus maculatus*). Our biomechanics findings reveal a limitation in the size of prey hunted by thylacines. With this inherent vulnerability, thylacines may have been less well adapted to cope with environmental disturbances such as intensive hunting and habitat degradation. We also found a dramatic change in marsupial carnivore $\delta^{13}C$ values over the past 180 years, suggesting a shift in habitat use from grasslands to woodlands. Investigation of past and present feeding behaviour has provided a framework to identify species resilience to environmental change, and may help improve conservation strategies.

Marie Attard's PhD assesses the diet and habitat use of marsupial carnivores, including the extinct thylacine, and their ecological response to environmental change. Marie uses stable isotopes and biomechanics to provide a window back in time to assess the role of these top predators in past and present ecosystems.

A fire-driven catastrophic regime shift between forest and moorland in temperate Tasmania

Michael-Shawn Fletcher[1,3], Samuel Wood[2], Simon Haberle[1]
[1]The Australian National University, [2]The University of Tasmania, [3]University of Chile

Background/question/methods: Questions over the origin and maintenance of the forest/non-forest mosaic that prevails across the landscape of cool temperate Tasmania, in which pyrophobic rainforest frequently abuts pyrophytic moorland, have received considerable attention. Recent palaeoecology and landscape ecology-based studies reveal a remarkable degree of stability between these paradoxically juxtaposed vegetation types at millennial and decadal times-scales, respectively, and this system is now being viewed through the lens of the alternative stable states paradigm. While there is consensus over the mechanisms of self-maintenance in these vegetation systems, there is an absence of empirical evidence that documents the establishment of both vegetation type in place of the other and the factors leading to the establishment of these apparently alternative stable states remain untested. To address this, we conducted a fine-scale palaeoecological analysis of wetland sediments located within a small patch of moorland that is surrounded by forest in temperate Tasmania. We specifically asked: (1) When did the moorland vegetation become established? (2) What was the principal factor leading to moorland establishment? (3) Is there any evidence for transitions between forest and moorland?

Results/conclusions: Our results reveal a unidirectional shift from forest to moorland in response to a catastrophic fire at the site. The persistence of moorland at the site despite long fire-free intervals implies that the factors resulting in the establishment of this vegetation type at the site differ from those responsible for self-maintenance. We discuss the relevance of these results to the continuing discussion over the mechanisms responsible for forest/non-forest mosaics.

Michael-Shawn Fletcher is interested in the long-term interactions between humans, climate, disturbance and vegetation at local, regional and global scales.

Concurrent session 8D
Competition and life history traits of plants

Growth trajectories: a new way of understanding the influence of traits on plant growth

Daniel Falster[1]
[1]Macquarie University

Background/question/methods: Plant species differ in many structural and allocation traits (SATs), each with its own distinct influence on plant function. Here, I show how these SATs combine with size and light environment to determine growth and survival throughout a plant's life. I present a new theoretical framework, based on carbon fluxes and allocation, which extends earlier models designed to understand differences in the relative growth rate of seedlings. In both old and new models, growth rate is decomposed into several components, each influenced by traits. Unlike models that focus exclusively on seedlings, the new framework explains how the influence of traits is moderated by plant size. This leads to specific hypotheses about the effect of some well-known SATs, including leaf mass per area, wood density, leaf nitrogen content and seed size, on plant growth.

Results/conclusions: The new model suggests four fundamental predictions about growth. First, growth rates show a hump-shaped relationship with plant size. Second, the expected correlation between growth rate and individual SATs varies with size, with some relationships increasing in strength, others decreasing, and some reversing direction as size increases. Third, SATs moderate how growth rate responds to resource levels. Fourth, shade tolerance decreases with size and select SATs. Combined, these results suggest that individual SATs do not necessarily imply fast or slow growth, but rather define a trajectory of growth with size and light level that determines a species' growth strategy.

Daniel Falster is an ARC post-doctoral fellow at Macquarie University. In a biodiverse and data-rich world, Daniel searches for the general principles structuring the life history and evolution of plants and animals. He is currently working on theory that explains what plants grow where and why.

A comparison of recruitment success of introduced and native species under natural conditions

Habacuc Flores Moreno[1], Angela Moles[1]
[1]EERC/BEES/UNSW

Background/question/methods: It is widely accepted that introduced species have higher germination and seedling survival than native species. However, this idea has not been widely tested, and those studies that have compared survival for introduced and native species have produced mixed results. We compiled data on survival through germination (seed to seedling survival), early seedling survival (one week survival from seedling emergence) and survival to adulthood (seedling emergence to reproductive maturity) under natural conditions for 285 native and 63 introduced species.

Results/conclusions: Contrary to expectations, we found that introduced and native species do not significantly differ in survival to germination, early seedling survival or survival to adulthood. These comparisons remained non-significant after accounting for longevity, phylogenetic relatedness, and seed mass. Thus, our data do not support the idea that introduced species have higher recruitment success than do native species. Perhaps any advantages of introduced species (such as enemy release) are counterbalanced by the fact that native species have had longer to adapt to their environment.

Habacuc Flores Moreno is presently conducting his PhD studies with Dr Angela Moles at the EERC at UNSW. Currently his research focus on the ecological mechanisms and evolutionary patterns of introduced species. His main interests are the study of general rules and patterns in ecology and evolution.

How does your garden grow? Disentangling the competing influences of traits, biomass allocation and plant size on field growth rates

Ian Wright[1], Caroline Lehmann[1], Julia Cooke[1], Daniel Falster[1]
[1]Department of Biological Sciences, Macquarie University

Background/question/methods: Growth rates (GR) are pivotal in plant ecology, as key determinants of competition, stand productivity, and species' ecological 'strategies'. Across species, variation in several functional traits is thought to underpin GR differences. This relationship is well documented for seedlings grown under favourable conditions where variation in specific leaf area (SLA) typically dominates effects of other traits and of differences in biomass allocation to leaves, stems and roots. By contrast, trait-GR relationships for field-grown plants are poorly understood, with studies on larger plants often yielding results contrary to those of seedling studies. One possible reason for this discrepancy is that the relative influences on GR of tissue traits, and biomass allocation to different tissue types, change systematically with plant size. The nature of these interactions have been formalised in a new theoretical framework. Here we provide the first test of this framework by quantifying trait-biomass-GR relationships for individuals of a range of ages/sizes for 17 species from a Northern Territory savanna.

Results/conclusions: Photosynthetic rate was a strong driver of interspecific variation in growth rates, both among saplings and adults. Sapwood tissue density was poorly related to GR—in contrast to previous findings. As predicted by the new growth model, the influence of SLA decreased with increasing plant size/age, and biomass allocation to leaf rather than stem was a key predictor of adult but not of sapling GR. These results conflicts with the common wisdom that knowledge from seedling studies can simply be applied to adult plants. While whole-plant growth can be understood as a balance between photosynthetic gains, and respiratory and tissue turnover losses, our results suggest the tantalising possibility that whole-plant growth rates can be predicted from relatively simple measurements made on terminal branches and tissues, in accord with new growth theory.

Ian Wright is an ARC Future Fellow (2011-15) and thereafter a tenured regular academic at Macquarie University. His group investigates the functional ecology and ecological strategies of plants—the 'how and why' of differences among species in their structural, chemical and physiological traits—and the implications of this variation for larger scale processes.

The relevance of life-history traits to the persistence of a rare herb (*Trioncinia retroflexa*) in semi-natural Queensland grasslands

Alex Haller[1], Margaret Mayfield[1], Rod Fensham[1]
[1]University of Queensland; School of Biological Sciences

Background/question/methods: Habitat loss is a major driver of biodiversity loss and the extirpation of remnant populations. While the general implications of habitat loss and population isolation are understood, how these effects fluctuate among species with different life-history traits is less well-known. Quantifying a species' life history traits and understanding these long-term plant-environment relationships are vital when considering remnant population persistence within semi-natural landscapes. Here, I report on the importance of life history traits to the persistence of *Trioncinia retroflexa*, an endangered endemic to Queensland's heavily modified bluegrass grasslands. The objectives of this study are to: define the life history traits of *T. retroflexa* across all remnant populations and assess trait importance to the species' persistence historically and within modern heavily-modified remnant habitat. The traits I focus on are: seed viability and germination, seed bank viability, seedling establishment and associated community diversity.

Results/conclusions: Seed germination varied significantly regardless of germination conditions. Germination rates were well below seed viability for the species, suggesting that *T.retroflexa* has a highly specific set of environmental germination cues. Tests of seed viability in the soil revealed that seed banks have a two season turn over, with seed viability dropping dramatically after 18 months in the soil. Seedling survival was low across a range of bluegrass community types, including those dominated by native vs exotic grassland species. Low germination rates and seedling survival across a range of grassland environments suggest that *T. retroflexa*'s germination and early growth strategies are poorly adapted to modern conditions in Queensland's bluegrass grasslands.

Alex Haller received his BS at Oregon State University (USA) and his Master of Environmental Management at the University of Queensland. His current PhD research revolves around the integration of population genetic, conservation biology and restoration ecology principles in order to preserve plant species in the semi-arid regions of Queensland.

Biotic interactions among annual plant species in a novel ecosystem

Claire Wainwright[1], John Dwyer[1], Richard Hobbs[2], Margaret Mayfield[1], Yvonne Buckley[1]
[1]The University of Queensland, [2]The University of Western Australia

Background/question/methods: Novel species interactions are becoming increasingly common in ecosystems experiencing rapid environmental change, such as the forb-rich York gum woodlands of south-west Western Australia. While these novel interactions are expected to alter overall ecological community structure, experimental evaluations of their fundamental properties and contingencies are lacking. In particular, density-dependency may influence the outcomes of competitive interactions, key to novel community formation. Experimental studies can help us determine if community-level density mediates both the intensity and type of interactions that occur as these communities form.

To assess the influence of density on outcomes of competitive interactions, we grew common annual herbaceous species from York gum woodlands in monocultures, two-species, and three-species combinations at varying total planting densities. By comparing the performance of plants competing with conspecifics or heterospecifics at varying densities, we assessed the relative impacts of inter and intraspecific competition on species' performance across all life history stages.

Results/conclusions: Survival and the magnitude of competitive suppression varied dramatically, such that species were differentially sensitive to interactions between density and competitor identity. In addition, the relative impacts of interspecific vs intraspecific competition on survival shifted with density for some species, but not others. These results highlight the complexity of novel species interactions due to their sensitivity to fundamental community characteristics. These results may also make experimental competitive outcomes more generalisable, while also providing insight into novel community assembly in natural systems.

Claire Wainwright recently completed her M Sci at the University of California, San Diego and is now embarking on a PhD at the University of Queensland. Her PhD research investigates impacts of synergistic environmental change on novel community assembly in annual wildflower assemblages in south-west Western Australia.

Competition within dense stands of *Eucalyptus regnans* saplings leads to facilitation

Mark Hovenden[1]
[1]School of Plant Science, University of Tasmania

Background/question/methods: Facilitation is generally viewed as the poor cousin of competition and is largely ignored apart from in environments somebody has decided are extreme in some way, or when the plants involved have particular traits. When facilitation is considered, it is mostly interspecific in nature where the presence of species A increases the growth or fitness of species B. However, facilitation can and does occur alongside competition and operates within and among species as these interactions are strictly between individual plants regardless of their species. I used an individual-based model to consider the impact on plant populations of facilitation and competition occurring simultaneously. I also used data from an experiment in regenerating *Eucalyptus regnans* forest to test whether the two processes can be detected in the wild. A clearfelled *E. regnans* forest in the Styx Valley in southern Tasmania was burnt and sown with 1, 2, 4 and 8× the local prescribed sowing density in a randomised block design with plots 20x20m, sapling density estimated and saplings harvested from $1m^2$ sub-plots at 1 year of age.

Results/conclusions: Both the individual-based model and the field experiment not only demonstrated that facilitation can occur simultaneously within competing stands, but that competition and competitive suppression of some saplings in dense stands actually leads to facilitation. Thus, the largest plants growing in dense stands were larger than plants growing in sparse stands, despite substantial competition from many conspecific neighbours. Hence, facilitation should be more widely considered as a basic plant-plant interaction in non-extreme environments.

Mark Hovenden, originally from Sydney, is Tasmanian but has worked from tropical forests to the Antarctic. He is most interested in processes that shape vegetation and how the operation of fundamental processes are influenced by environmental drivers. He enjoys watching the Tour de France and dreaming.

Concurrent session 8E
Population and metapopulation dynamics

Population dynamics of aquatic insects: interactive effects of adult behaviour and density-dependent larval mortality

Jill Lancaster[1], Barbara Downes[1]
[1]Department of Resource Management and Geography, University of Melbourne

Background/question/methods: For species with complex life cycles, determining at which life stages various factors set population size is challenging. The traditional view for aquatic insects is that mortality during the long-lived larval stage drives populations. We explored an alternative hypothesis that egg-laying behaviours of the short-lived adults could have lasting effects on populations. The oviposition behaviours of some aquatic insects are specialised, such that eggs are laid in particular locations. We tested whether oviposition behaviours influenced larval densities at the scale of whole riffles ranging in area from 80 to 460 m2. We examined two species, a mayfly and a caddisfly, with larvae that are riffle specialists and adults that oviposit on emergent rocks in riffles. For comparison, we also examined blackflies with larvae that are also riffle specialists, but adults that oviposit on trailing vegetation, not necessarily associated with riffles.

Results/conclusions: For neonate mayflies and caddisflies, larval abundances were positively associated with the number of potential oviposition sites, but not with riffle area. In contrast, the abundance of neonate blackflies was not associated with either predictor variable. This suggests a strong influence of adult behaviour on early instar densities. For later instars, riffle area was a good predictor of larval abundance, suggesting an adjustment of densities during larval life. Previous work indicates that larval movement is trivial and thus density-dependent mortality may be much stronger in neonates than older instars. These results challenge traditional views about aquatic insect populations, which may have more complex and interesting dynamics than considered previously.

Biography not available at the time of printing.

Modelling effects on populations with temperature-dependent sex determination

Maria Boyle[1], Lisa Schwanz[2], Jim Hone[1], Arthur Georges[1]
[1]Institute for Applied Ecology, University of Canberra, [2]Research School of Biology, The Australian National University

Background/question/methods: Models of climate change have predicted major consequences (local extinctions) for populations with temperature-dependent sex determination (TSD) arising from biased primary sex ratios. Climate warming is already impacting on both primary sex ratios and juvenile survival. In many TSD turtles, females are produced at warmer temperatures and increasingly feminised populations are occurring. Juvenile survival may also be affected by temperature, because eggs successfully incubate only at certain temperatures. In this study, the population dynamics of hypothetical female biased TSD populations were compared with populations with genotypic sex determination (GSD). The effects of climate (ambient air temperature) on juvenile survival, primary sex ratio and male limitation on population dynamics were evaluated. A population growth equation was used to estimate the population sizes of females in ecological equilibrium along a gradient of environmental temperatures. Included in the equation were cohort-sex ratio response curves (CSRs) (to model skews in the sex ratio) and curves to model temperature-dependent juvenile survival (TS curves).

Results/conclusions: Warmer climates producing female-biased sex ratios in TSD populations resulted in larger effective population sizes of females in the short-term. Female biased populations may potentiate short-term growth, but a continued reduction in male density reduced population sizes via male limitation. For TSD (and GSD) populations, the shape of the TS curve influenced the number of surviving populations. For TSD populations, despite short-term increases in population sizes in female biased populations the decrease in males and reduction in juvenile survival as a result of climate warming are likely to offset any short-term gains.

Maria Boyle is a PhD student at the Institute for Applied Ecology, University of Canberra. Her interests are ecological modelling of population dynamics of species and the implications for endangered reptilian species in a changing climate.

Causes of decline in the forty-spotted pardalote, an endangered habitat specialist

Amanda Edworthy[1], Rob Heinsohn[1], Naomi Langmore[1]
[1]Australian National University

Background/question/methods: Habitat specialists are over-represented among endangered species globally. Forty-spotted pardalotes, specialist Tasmanian songbirds, have declined by as much as 60% in the past twenty years. Their early range contraction was likely driven by clearing of dry eucalypt woodlands, which they rely on for food and nest hollows, but causes of recent decline are uncertain. Here we discuss factors affecting population viability of habitat specialists as groundwork for a study of causes of decline in forty-spotted pardalotes.

Results/conclusions: Ecological theory predicts that habitat specialists will face the greatest risk of extinction from habitat loss and degradation. However, the individual ecological characteristics of a species can provide grounds for many alternative hypotheses. For example, hollow-nesting birds are thought to invest heavily in individual breeding attempts because hollows are safe, but rare, nest sites. Thus, an introduced nest predator capable of accessing these nests might have a devastating effect on forty-spotted pardalote populations. It is often important to discern among multiple hypotheses to identify factors that limit population growth in endangered species. Forty-spotted pardalotes present the opportunity to learn about the mechanisms of population regulation for habitat specialists and hollow nesters in changing environments.

Amanda Edworthy is a PhD student at the Australian National University. She has studied land snails and tree cavities in British Columbia ('Beautiful British Columbia' as their license plates say), but forty-spotted pardalotes are currently closest to her heart.

Populations are important for improving species distribution models

Nathan Emery[1,2], Glenda Wardle[1], Murray Henwood[1], Catherine Offord[2]
[1]The University of Sydney, [2]The Australian Botanic Garden

Background/question/methods: We test an important assumption inherent in most species distribution models, namely that, populations are equivalent in their response to current or future environments. For most models, suitable environmental conditions that govern distributional limits are estimated by correlating species presence records, with a suite of environmental variables. Distributional shifts are then modelled based on the expected changes in the environmental variables. However, differences in traits among populations can influence the response to future environments. For example, traits such as abundance vary among populations and will influence persistence but these differences are not captured at the species level. Therefore, we hypothesise that predictive distribution models will be more informative if population traits linked to environmental processes are included. To determine how populations differ in key attributes we collected plant phenotypic and life-history traits, including reproduction, germination and performance from 26 *Actinotus helianthi* populations throughout its distribution along the east coast of Australia.

Results/conclusions: Population abundance ranged from 50 to 10,000 plants. We found no correlation between abundance and germination. Local habitat, plant size, floral display size, reproduction, and performance all varied among populations and showed no obvious environmental pattern. We compared our population data with a Maxent prediction, which indicated a shift to more southern latitudes, and explore the limitations of each approach. Our results illustrate the need to incorporate traits that limit abundance at the population level to improve our predictions of how shifts in populations that contract, expand or colonise new habitats, ultimately shape species distributions.

Nathan Emery is currently a PhD candidate at the University of Sydney in cooperation with the Australian Botanic Garden, Mount Annan. His work primarily focuses on plant population ecology.

Inferring large-scale trajectories of change in fauna using remote sensing of forest-stand condition

Hania Lada[1], James R Thomson[1], Shaun C Cunningham[1], Erica Fleishman[2], Ralph Mac Nally[1]
[1]Australian Centre for Biodiversity, School of Biological Sciences, Monash University, [2]John Muir Institute of the Environment, University of California

Background/question/methods: Many ecological systems around the world are changing rapidly in response to direct human actions and climate change. We need tools to assess dynamically, and over appropriate scales, the condition of ecosystems and their responses to the mitigation of stressors if these occur. We determined whether stand condition of floodplain forest is related to the densities of a small mammal (a carnivorous marsupial, *Antechinus flavipes*) and to breeding and assemblages of birds in 60,000 ha of the extant river red gum (*Eucalyptus camaldulensis*) forests of south-eastern Australia. Stand condition was assessed remotely using models built from robust indicators of stand condition. Trapping of the mammal was conducted at 272 plots (0.25 ha) in seven river red gum forests. Bird surveys occurred on 45 sites (2 ha) in two forests.

Results/conclusions: Densities of second-year antechinus females (i.e. females that survived to a second breeding year) and breeding success (based on number of suckled teats) were higher in stands of better condition. Measures of records of all birds, species richness, total breeding activity and breeding species were related positively to stand condition. We used these functional relationships with hindcast estimates of proportions of the floodplain forests in different stand conditions to infer changes in avifauna and the abundance of antechinus since 1990 and before European settlement (1750). We have established the first chain from remote sensing of ecosystem condition (stand condition) to biodiversity responses (antechinus and avian measures). These links provide potential tools for broad-scale planning and biodiversity management of arboreal landscapes.

Hania Lada is a member of the Australian Centre for Biodiversity at Monash University. She is interested in landscape and conservation ecology at regional and global scales, including molecular ecology of terrestrial and aquatic organisms in massively altered landscapes in south-eastern Australia.

Concurrent session 8F
Management practices and experiences

Lessons learnt: theory versus practice of vegetation condition monitoring by natural resource management bodies

Alison Skinner[1], Helen Waudby[1], Emmo Willinck[1]
[1]Murray Catchment Management Authority

Background/question/methods: Murray Catchment Management Authority (CMA) invests in a range of NRM projects in NSW for public benefit, including projects to maintain and/or improve biodiversity through provision of financial incentives intended to influence landholders' practices. In 2008, Murray CMA established a vegetation condition monitoring program to assess the effectiveness of its management interventions on public and private land, including a project focusing on high conservation value travelling stock reserves.

Results/conclusions: Four years into the program, trends in vegetation condition at intervention sites have been positive, but implementation of long-term monitoring programs continues to present numerous challenges for public NRM bodies. These challenges include: an emphasis on 'output' reporting (i.e. number of hectares actively managed), staff capacity, changing investor preferences, quality of datasets and the changes (improvements) in intervention measures. Here, we reflect on the disparities between long-term monitoring program ideals and the realities of practice, and how Murray CMA is addressing these challenges. Lessons from this program are applicable to resource condition monitoring being undertaken by other NRM bodies.

Alison Skinner completed her PhD studies on the effects of the grassy understorey on eucalypt regeneration in agricultural landscapes at Charles Sturt University. She has worked at Murray CMA in the biodiversity team since 2010.

Using thresholds to guide natural resource management: toward resilience or business-as-usual rebranded?

Alexander Gold[1]
[1]Institute of Environmental Studies UNSW

Background/question/methods: Resilience theory posits that social-ecological systems may contain thresholds that act as tipping points between desirable and undesirable system states. The NSW Natural Resources Commission (NRC) has urged Catchment Management Authorities (CMAs) to apply resilience theory by identifying thresholds in their catchments and investing to remain within thresholds or to transform to a more desirable state.

With representatives from a CMA and other land management agencies, I convened workshops to build conceptual models and try to identify thresholds governing resilience of endangered upland swamps in the Blue Mountains of NSW. I also analysed NRC and CMA planning instruments and conducted key informant interviews to assess how CMAs are beginning to apply resilience concepts generally.

Results/conclusions: Instead of providing unambiguous targets for management, the workshops supported a less-cited yet crucial tenet of resilience theory: that the existence and value of thresholds are likely to change over space and time. Because of this uncertainty and the ensuing risk of management tracking an obsolete threshold, resilience theory suggests that thresholds serve as indicators for monitoring and evaluation that supports learning about system change. Documents and interviews, however, suggest that thresholds are being promoted primarily as management targets rather than indicators for monitoring and evaluation. Moreover, government requirements severely limit the funding for CMA monitoring and evaluation. Rather than representing a paradigmatic shift toward building landscape resilience, therefore, the use of thresholds by CMAs risks following a conventional, target-based approach to natural resource management that fails to learn about system function and change.

Alexander Gold is a PhD Candidate at UNSW with experience in ecology and ecological modelling who is now investigating the use of science in decision making. Topics include the use of climate models to guide adaptation investment and the uptake of resilience concepts by land managers.

When to stop new management actions

Chooi Fei Ng[1,3,4], Michael A McCarthy[2], Tara G Martin[3], Hugh P Possingham[1,4]
[1]School of Biological Science, University of Queensland, [2]School of Botany, University of Melbourne, [3]CSIRO Ecosystem Sciences, Ecosciences Precinct, [4]School of Mathematics and Physics, University of Queensland

Background/question/methods: Time is of critical importance when dealing with a species that is declining. Failing to act soon enough may result in its extinction. This requires understanding the tradeoffs between time spent among different management actions. Even though several studies have attempted to tackle this problem, the majority of them have been action or situation specific. A new framework is needed to assimilate these studies to provide general solution for a wide variety of conservation actions. We devised a basic theoretical framework for when to stop a new management action before reverting to an old management action with the aim of providing a simple solution to a very complex problem. We applied this solution for the Christmas Island pipistrelle bat where there is a common belief that we can avoid its extinction if we started a new captive breeding program earlier. Our model demonstrates when to stop captive breeding program and revert to managing the species in the wild, given that the management goal is to maximise the chance of reaching a target population size. Using this case study, we examined the effect of several parameters on the optimal time to change actions from new to old.

Results/conclusions: The optimal switching time was driven mainly by the target population size, management timeframe and the growth rates of the population while conducting new or old management actions. Knowing when to change management actions will encourage conservation managers to act in a timely manner to avoid the extinction of a species.

Chooi Fei Ng is currently a PhD student in University of Queensland supervised by Professor Hugh Possingham, Michael A McCarthy, Tara Martin and Jonathan Rhodes. Chooi's research interest deals with how to allocate resources optimally among management actions in conservation. This may include optimal monitoring, deciding when to change from monitoring to another management action, or to allocate resources among actions to mitigate multiple threats.

Making robust policy decisions using global biodiversity indicators

Emily Nicholson[1], Ben Collen[2], Alberto Barausse[3], Brendan Costelloe[4], Kathryn Sullivan[4], EJ Milner-Gulland[4]
[1]School of Botany, The University of Melbourne, [2]The Institute of Zoology, Zoological Society of London, UK, [3]University of Padua, Italy, [4]Silwood Park, Imperial College London

Background/question/methods: To influence global policy effectively, conservation scientists need to be able to provide robust predictions of the impact of alternative policies on biodiversity and measure progress towards goals using reliable indicators. We present a framework for using biodiversity indicators predictively to inform policy choices at a global level. The approach is illustrated with two case studies in which we project forwards the impacts of feasible policies on trends in biodiversity and in relevant indicators. The policies are based on targets agreed at the Convention on Biological Diversity meeting in Nagoya in 2010. The first case study compares protected area policies for African mammals, assessed using the Red List Index; the second example uses the Living Planet Index to assess the impact of a complete halt, versus a reduction, in bottom trawling.

Results/conclusions: In the protected areas example, we find that the indicator can aid in decision making because it is able to differentiate between the impacts of the different policies. In the bottom-trawling example, the indicator exhibits some counter-intuitive behaviour, due to over-representation of some taxonomic and functional groups in the indicator, and contrasting impacts of the policies on different groups caused by trophic interactions. Our results support the need for further research on how to use predictive models and indicators to credibly track trends and inform policy. To be useful and relevant, scientists must make testable predictions about the impact of global policy on biodiversity to ensure that targets such as those set at Nagoya catalyse effective and measurable change.

Dr Emily Nicholson is a Centenary Fellow at the University of Melbourne. She recently returned to Australia from postdocs at Imperial College London and Princeton University. Her research focuses on decision making for conservation and natural resource management. www.emilynicholson.wordpress.com

Bundles and tradeoffs of ecosystem services in the urban core

Cynnamon Dobbs[1], Dave Kendal[1], Mark McDonnell[1]
[1]ARCUE w/o School of Botany, University of Melbourne

Background/question/methods: Ecosystem services are an increasingly used concept for linking ecosystem structure and function to the wellbeing of urban inhabitants. The urban forest plays a crucial role in the delivery of ecosystem services. When analysing multiple ecosystem services synergies and tradeoffs can be expected, e.g. as tree cover increases the space for recreation decreases. By understanding the bundles and tradeoffs existing in the highly populated urban core the benefits for society can be maximised, enhancing net human well being.

Ten ecosystem services and 2 disservices relating to regulation, provision, supporting and cultural functions were quantified across the urban core of Melbourne. Tree data together with urban forest functional models, and spatial and thermal imagery was used to quantify services, and the relationships existing among services and between services were explored by sociodemographics data and land ownership.

Results/conclusions: Trade-offs exist for cultural services, while synergies exist for regulating, support and provision services. An inverse relation between the cultural and production services was found, given that a reduction in biomass increases the value for recreation and aesthetics.

Spatial analysis showed that in an inner city area public land contributes greatly to the provision of ecosystem services. Ecosystem services are maximised in areas of high income and education. Findings of this research can contribute to direct management and policy making towards the maximisation of ecosystem services delivered by the urban forest.

Cynnamon Dobbs is a forest engineer with a Master of Science in Forest Resources and Conservation doing a PhD in University of Melbourne. Cynnamon's area of research is urban forestry in relation to how the spatial distribution of its structure has consequences on urban ecosystem services at multiple scales.

Concurrent session 9A
Environmental stressors: the urbanisation syndrome

Urbanisation, plant traits and the composition of urban floras

Nicholas Williams[1,2], Amy Hahs[2,3], Peter Vesk[3]
[1]Department of Resource Management and Geography, University of Melbourne, [2]Australian Research Centre for Urban Ecology, Royal Botanic Gardens Melbourne, [3]School of Botany, University of Melbourne

Background/question/methods: Plant functional traits can facilitate generalised and mechanistic understanding of plant responses to urbanisation, yet the consistency of trait responses is unclear. We developed three hypotheses to explain variable responses drawing on the consistency and strength of urban stressors acting on those traits, and the importance of local factors. To explore these hypotheses, we synthesised the results of 29 studies that specifically examined plant traits or niche indicators (e.g. Ellenberg numbers) of urban floras.

Results/conclusions: Niche indicators for nutrients, temperature and alkalinity consistently increased across many studies. Some plant traits (e.g. woodiness, seed mass and height) tended to increase in response to urbanisation, while other traits have mixed responses and many are understudied. Our synthesis highlights the complexity of urban plant-environment interactions with many traits influenced by multiple abiotic, biotic and disturbance effects. Multiple stressors make it difficult to detect trends in urban plant trait signatures unless one urban stressor drives a particularly strong response or multiple stressors act in the same direction. While our review has developed a better understanding of how urbanisation may assemble urban floras, further advances can be gained through studies that focus on specific urbanisation processes, measurable morphological traits and analyses that facilitate meta-analysis.

Nick Williams's research interests include urban plant ecology, plant traits, weed ecology, the ecosystem services provided by urban green space and the development and evaluation of vegetated roofs and walls for Australian conditions.

The influence of different urban green spaces on wild bee abundance and diversity

Caragh G Threlfall[1], Luis Mata[2], Amy K Hahs[3], Nicholas SG Williams[1], Ken Walker[4], Stephen Livesley[1]
[1]Department of Resource Management and Geography, The University of Melbourne, [2]Department of Animal Biology, University of Barcelona, [3]Australian Research Centre for Urban Ecology, Royal Botanic Gardens Melbourne, [4]Science Department, Museum Victoria

Background/question/methods: In urban landscapes, native bees are under pressure from the impacts of habitat loss and fragmentation, and the simplification of vegetation structure within urban green spaces. To understand how urban bee diversity changes with green space management, we collected bees from 130 plots within 39 urban green space sites in south-east Melbourne using coloured pan traps and sweep nets. The selected sites represented three different types of urban green spaces (golf courses, urban parks and residential gardens), with variable management intensities. The sites were stratified by management approach, plant structural complexity and time since establishment.

Results/conclusions: A total of 13 species of native bees were recorded. The abundance and diversity of native bees was similar across the three green space types. Preliminary analyses suggest that bee diversity was not strongly influenced by plant species richness, the number of plant species in flower, or the distance of the green space to remnant vegetation. Urban parks contributed more unique native bee species overall, probably because two parks contained three unique species. Interestingly these two parks are not managed primarily for biodiversity conservation, but rather contain recreational facilities. A positive trend of higher species richness with increasing site age was apparent, but the result was not statistically significant. This research suggests that management approaches complimentary to both amenity use and biodiversity conservation are possible and that new green spaces in developing suburbs can be designed to offer native bee habitat without a long temporal delay.

Caragh Threlfall is as a postdoctoral research fellow who recently completed her PhD in urban ecology, at the University of New South Wales. Her research interests include urban ecology, urban planning and landscape design, and the maintenance of ecosystem services and biodiversity in urban areas.

The effect of urbanisation on the size and condition of golden orb-weaving spiders

Lizzy Lowe[1], Dieter Hochuli[1], Shawn Wilder[1]
[1]School of Biological Sciences, The University of Sydney

Background/question/methods: Urbanisation can drastically alter ecological processes on multiple landscape scales by modifying abiotic conditions, altering vegetation structure, and increasing habitat heterogeneity. Urban areas around the world continue to expand, therefore it is important to understand how intraspecific variation may reflect the capacity of species to inhabit novel urban ecosystems. We examined the effect of urbanisation at a local and landscape scale on the body size and condition of *Nephila plumipes*, a common urban coloniser in the Sydney region. Landscape variables from each study site (classified as park, remnant bush land or continuous bush land) were used to create an urbanisation index. Immediate habitat characteristics and web traits were measured for each spider as well as the webs proximity to important landscape features. Body condition was quantified using a lipid analysis and the residuals from a regression of body mass on tibia length.

Results/conclusions: In urban parks, the habitat immediately surrounding spider webs was more open with reduced leaf litter and canopy cover compared to the bushland sites which had higher habitat complexity. Condition tended to be higher in urban parks than urban bush land and was affected by larger scale landscape features more than fine scale habitat variation. Sites with a high urban index also contained larger spiders, indicating urban spiders had increased foraging success during development. The changes in spider size and condition along the urbanisation gradient are consistent with the hypothesis that *N. plumipes* benefits from the habitat changes associated with urbanisation.

Lizzy Lowe is a PhD candidate at The University of Sydney studying the effect of urbanisation on spider assemblages

Leaf litter removal in urban green spaces: contrasting responses of ants and detritivores

Briony Norton[1,2], Linda Thomson[3], Nicholas Williams[1,4], Mark McDonnell[1,2]
[1]Australian Research Centre for Urban Ecology, Royal Botanic Gardens, [2]School of Botany, University of Melbourne, [3]Bio21, Zoology Department, University of Melbourne, [4]Melbourne School of Land and Environment, University of Melbourne

Background/question/methods: Green spaces in urban environments can provide valuable habitat for maintaining local and regional biodiversity. Many urban green spaces are, however, managed for human recreation, where vegetation structure is modified and critical resources such as leaf litter and woody debris are removed. We quantified the difference in available resources between ten public parks and 11 sites where vegetation is managed to reflect a pre-European state, all with remnant *Eucalyptus camaldulensis* (river red gum) overstoreys. The effects of changed resource availability were examined for ants (Hymenoptera: Formicidae) and two macrodetritivores; millipedes (Diplopoda) and slaters (Isopoda: Oniscidea). Arthropods were sampled using pitfall traps in two years (October 2008 and 2009) and from leaf litter extractions using Tullgren funnels in November 2009.

Results/conclusions: Site assessments confirmed litter layers were almost three time shallower in parks compared to remnants, and also showed that parks had less vegetation in the mid- and over-storeys, and fewer dead wood resources. Ninety-four species of ants were detected across all sites, all but two of which were native. The diversity of ants did not differ between park and remnant sites, but the composition of the community did. The millipede and slater communities, in contrast, were made up almost exclusively of a small number of introduced species (98.5% and 99.5% of the communities respectively), and their distribution was patchy, and associated with leaf litter and shrub cover. The contrasting responses of the studied taxa will be discussed, and suggest that a one-size-fits-all approach to conservation of urban arthropods is not appropriate.

Briony Norton completed a PhD at the University of Melbourne on the effects of removing leaf litter on urban arthropod communities. She currently works on a project developing a decision tool for land managers to effectively implement green infrastructure to mitigate the urban heat island effect.

The influence of urbanisation on wetland invertebrate biodiversity

Teresa Mackintosh[1], Ross Thompson[1], Jenny Davis[1]
[1]School of Biological Sciences, Monash University

Background/question/methods: The construction of wetlands in the urban environment is primarily carried out to assist in the removal of contaminants from wastewaters, however they have the added benefit of providing habitat for wildlife. Relatively few studies have quantified the biodiversity of these urban wetlands, and how this interacts with other values such as contaminant removal. This study aims to establish whether the degree of urbanisation and its associated change in stormwater runoff effects invertebrate species richness and abundance within constructed wetlands. Urban wetlands in Melbourne's west and south-east were sampled along a gradient of heavy metal contamination. Benthic macroinvertebrates were sampled using a stovepipe sampler.

Results/conclusions: The number of taxa and species abundance was generally higher in sites where metal concentrations were lower. Chironomidae was the most abundant family at the majority of sites. Chironomids are able to endure a wide array of environmental water quality gradients. As such, they are often the dominant taxa in urban wetland systems due to their tolerance to degraded environmental conditions. It is important to understand the impact of contaminants such as heavy metals on aquatic biota to ensure urban wetlands continue to provide important habitat for wildlife.

Teresa Mackintosh was born in the UK and is an international PhD student in the School of Biological Sciences at Monash University. Her research interests lie in understanding the processes occurring in urban aquatic systems, and making sure these habitats continue to provide important refuges for native wildlife.

Is translocation an effective conservation tool for striped legless lizards?

Megan O'Shea[1], Vivienne Turner[1], David Bryant[1]
[1]Department of Sustainability and Environment

The striped legless lizard *Delma impar* is a threatened species found in a threatened grassland community on the outskirts of Melbourne. Recent expansion of the Melbourne Urban Growth Boundary will see almost 7,000ha of habitat cleared for development over the next ten years, resulting in the potential displacement of many *D. impar*.

Background/question/methods: Translocation has been proposed as a mitigation measure for human-wildlife conflicts. For reptiles, the success of translocation has been estimated to be as low as 33%. However many translocations lack statistically robust scientific designs that include post-release monitoring or clear criteria for measuring success. This innovative project proposes a replicated study for assessing whether *D. impar* can be translocated to form self-sustaining, viable populations. A challenge is the absence of information relating to the number or timing of available animals for translocation.

Results/conclusions: The project establishes a set of criteria for selecting potential recipient sites and draws on population viability analyses to inform the minimum number of animals required. It takes into account the demographic and genetic make-up of founder populations. A soft-release approach is proposed, with a six year program of post-release monitoring. Clearly defined measures of success will be evaluated annually.

Although ambitious, this project demonstrates the extensive approach required to quantitatively assess the value of translocation for a threatened species. If translocation is determined to be successful and feasible, the outcomes of this study will be used to inform protocols for the future translocation of *D. impar* populations.

Megan O'Shea is interested in the conservation of the grasslands of the Victorian Volcanic Plain. She is an ecologist who has developed methods to study the cryptic Delma impar and understand their habitat requirements. She currently works on a project to evaluate the success of translocating Delma impar

Novel urban ecosystems and ecosystem services

Michael Perring[1], Pete Manning[2], Richard Hobbs[1], Ariel Lugo[3], Cristina Ramalho[1], Rachel Standish[1]
[1]The University of Western Australia, [2]Newcastle University, UK, [3]International Institute of Tropical Forestry, Puerto Rico

Background/question/methods: Urban landscapes are becoming more common and their ecological footprint arguably leads to the formation of novel ecosystems across the globe. However, until recently, urban areas have been overlooked in the novel ecosystems framework, which has traditionally focused on the crossing of thresholds in either 'pristine' areas that have become degraded through invasion of non-native species and/or overwhelming abiotic changes, or intensively cropped or grazed landscapes that have become abandoned. In this talk, we discuss why such novel ecosystems are also found in the urban landscape. We suggest a framework, based on a gradient of ecological novelty and a detailed literature review, to understand urban systems in terms of their capacity to provide ecosystem services.

Results/conclusions: We show that the gradient of novel ecological spaces provides ecosystem services including carbon sequestration, maintenance of biodiversity, cultural services and regulation of water supply. Contributions from novel components (such as non-native species or man-made substrates) are also demonstrated. Managers may further boost ecosystem service provision by traditional and novel approaches (e.g. planting non-native species to fulfil functional goals). There is also the potential to manage novel ecosystems for the provision of multiple ecosystem services yet more research is needed to elucidate the synergies and trade-offs among services in urban landscapes. We call for collaboration among ecologists, urban planners and social scientists to understand how to optimise the delivery of ecosystem services in urban landscapes.

Michael Perring is an ecosystem ecologist interested in the fundamental relationships among biodiversity, abiotic conditions and the provision of ecosystem services. He is a post-doctoral researcher in Richard Hobbs' Ecosystem Restoration and Intervention Ecology Research Group.

Concurrent session 9C
Sampling, monitoring and experimental design

Observing the observer: experiments that estimate weed detectability

Cindy Hauser[1], Joslin Moore[1,2], Katherine Giljohann[1], Georgia Garrard[1], Dave Kendal[1,2], Michael McCarthy[1]
[1]School of Botany, University of Melbourne, [2]Australian Research Centre for Urban Ecology, Royal Botanic Gardens Melbourne

Background/question/methods: Weed eradication requires successful detection before control can take place. Surveys are imperfect and there is a risk that individual weeds remain undetected. Yet imperfect detection rates are rarely incorporated formally into eradication plans. Evidence-based estimates of weed detectability are even rarer. We set up detection experiments to estimate the time required to detect invasive hawkweed species in the Australian alps under a range of conditions. Glasshouse-grown hawkweeds and hand-crafted flower mimics were planted in marked plots on the Bogong High Plains of Victoria, Australia. Government employees, private contractors and volunteers who participate in hawkweed surveys searched these plots, and their successful detections and search times were recorded.

Results/conclusions: We present models estimating the time required to find hawkweeds, exploring the influence of hawkweed characteristics, background vegetation, and observer attributes. We also discuss how these models can be used to design effective weed surveys which acknowledge the variation and imperfections that are unavoidable.

Cindy Hauser graduated with a PhD from the University of Queensland in 2006 and took up a researcher position at the University of Melbourne. There she develops survey and monitoring designs that combat imperfect detection.

Monitoring cryptic species via quantified sound analysis

Kathryn Lambert[1], Paul McDonald[1]
[1]Centre for Behavioural and Physiological Ecology, Zoology, School of Environmental and Rural Science, University of New England

Background/question/methods: All ecological censoring and conservation management rely on the accurate monitoring of population dynamics. However, many species are visually obscure or difficult to survey accurately, due to a cryptic nature or specific habitat characteristics. Under these conditions, population size estimations can fluctuate markedly and are largely reliant upon the level of observer expertise. Consequently, survey comparisons are difficult. We used bell miners *Manorina melanophrys*, a species notoriously challenging to census visually, as a model to assess the ability of acoustic-based sampling to provide a more accurate measure of abundance. Whilst our techniques have relevance to any vociferous animal population that is difficult to census, the population dynamics of bell miners is significant beyond a model system, given their association with parasitic psyllids and declining vegetation health. Thus, we compared the accuracy of visually counting bell miners with a largely automated acoustic assessment method. Model effectiveness was tested over a three-year period, and throughout most of this species geographical range. Sound was recorded using cheap, easily accessible hardware, with results analysed using free software to encourage subsequent adoption by managers. Traditional point count data and the new survey methods were compared.

Results/conclusions: Recording analyses revealed that bell miner density, taking one-minute averages over ten minutes, was more accurate than visual counts that suffered from the cryptic nature of the species. Monitoring the population dynamics of this species at a landscape level is now feasible as the accuracy and transferability between observers enables greater scope for data collection at far less expense. Our techniques could easily be adapted to other species that are difficult to monitor by conventional means.

Kathryn Lambert, PhD Candidate, has completed an honours degree gaining experience observing and measuring groups of grey-crowned babblers, *Pomatostomus temporalis*. She is an experienced environmental consultant that has worked in association with the North Parkes Mines.

Vegetation condition in riparian areas: towards refinement of assessment and management

Christopher Jones[1], Peter Vesk[1], David Duncan[2]
[1]School of Botany, The University of Melbourne, [2]Arthur Rylah Institute for Environmental Research, DSE Victoria

Background/question/methods: Managing native vegetation for environmental and production outcomes requires an understanding of the system's responses to environmental and production pressures. This information can be obtained through vegetation assessments across space and time, however this is often difficult and costly. Riparian vegetation presents additional complexities due to the presence and movement of water. We studied riparian vegetation on crown land grazed by livestock in north-central Victoria to investigate the vegetation attributes of sites with varied management. We examined spatial distribution of vegetation and the apparent effects of management tools both within and between sites. We contrasted findings using single time-step (snapshot) surveys with estimates of change over time from multiple survey periods.

Results/conclusions: In our riparian system, understorey vegetation changed systematically away from the water's edge and along the watercourse. The pattern of change varied between life forms. Understorey cover varied under alternate management scenarios and these responses were also influenced by the spatial gradients. Management covariates were generally poor predictors of understorey vegetation, tree cover, tree density and log density using snapshot data.

Estimates of vegetation change over time aided our interpretations of vegetation response to management, although the estimates were uncertain.

Optimal management of riparian vegetation should account for systematic spatial changes and the potential for spatial variations in response to management. Determining the effect of management from snapshot surveys is common but may result in inaccurate assumptions of the magnitude, rate and direction of vegetation change, and therefore inappropriate management.

Chris Jones is a PhD candidate within the Centre of Excellence for Environmental Decisions at The University of Melbourne. His current work is examining monitoring and evaluation of vegetation condition. For more information visit: www.csjonesresearch.wordpress.com

A new method for surveying terrestrial reptiles

Dustin Welbourne[1]
[1]University of New South Wales Canberra

Background/question/methods: The cryptic nature of reptiles mean that multiple detection techniques such as active searches, pit-fall trapping, and funnel trapping are required to adequately sample the reptiles of a region. These techniques often require numerous experienced herpetologists to spend days in the field collecting data, consequently leading to increased research costs and standardisation problems. While similar problems exist with terrestrial mammals, the past 20 years have seen camera traps become a mainstay for the mammal ecologist. In fact, camera traps have been shown to be more effective than comparable survey methods such as hair tunnels or physical trapping animals. Yet, due to limitations in camera technology, cameras have not yet been applied to surveying reptiles in any significant manner.

Results/conclusions: Many modern camera systems use passive infrared (PIR) sensors that require a difference in heat to pass across a detection zone to trigger the camera. Given that reptiles are ectothermic, PIR sensors are considerably ineffective at detecting their presence, subsequently resulting in fail-to-trigger events. However, by augmenting the detection zone of remote cameras, cameras using PIR triggers can be used to survey diurnal terrestrial reptiles while simultaneously surveying mammals. This technique increases research standardisation and when combined with other reptile research methods, can result in improved efficacy, ultimately resulting in lower research expenditure.

Dustin Welbourne is undertaking a PhD with the UNSW Canberra. His research, DAMASCAS (Defence Automated Monitoring And Survey using Cameras And Sound), is assessing non-invasive survey methodologies as a means for the Australian Defence Force to monitor defence estates.

The effect of patch characteristics and trap configuration on trapping success

Bronwyn Hradsky[1]
[1]University of Melbourne

Background/question/methods: Researchers often use indices of trapping success as a response variable when investigating the distribution and abundance of fauna. This approach assumes that changes in the value of the index represent true changes in population density. However, factors that may affect trapping success despite a stable underlying population density are rarely considered. Here, I use simulation modelling to explore the effects of patch characteristics and trap configuration on trapping success. A small-mammal trapping scenario is used to parameterise the model.

Results/conclusions: Based on nominal parameters of five animals per hectare and 500m daily movement distance, a linear transect of 25 traps in a large 'forest' patch will capture more animals than an identical transect in a narrow 'roadside' strip nearly 80% of the time. On average, 9.5 animals will be trapped on the forest transect but only 7 animals on the roadside, despite the true density of animals remaining constant. Using the same input parameters but arranging the forest traps in a grid instead of a linear transect reduces forest trapping success by 36%. Differences in trapping success between patch shapes and trap configurations are most extreme at low densities and converge as traps become saturated at higher densities. For a given density of animals, trapping success is most similar when animals move small distances but diverges as movement increases. Simulation modelling provides a powerful tool for exploring the effects of study design on trapping success. Implications for other wildlife survey techniques such as camera surveys and spotlighting are also discussed.

Bronwyn Hradsky is a PhD candidate with the Forest and Fire Ecology research group at the University of Melbourne. Her project investigates the role of predation in mammal responses to fire. This modelling experiment was inspired by her Honours project on fragmentation, and she worked at the zoo in between.

Monitoring rare mycophagous mammals: detecting the presence of potoroos via foraging dig surveys

Robert Reed[1], Kath Handasyde[1]
[1]The University of Melbourne

Background/question/methods: Methods used to detect and monitor rare and endangered wildlife populations occurring at low densities are crucial for conservation management, however monitoring such species directly is usually problematic, and requires substantial time and funding. Therefore, developments of other census methods, such as detection of secondary signs, are extremely important. The potoroids, a group of small mycophagous macropodids, have experienced dramatic population declines since European settlement. Our aim was to evaluate the efficiency of foraging dig surveys as a rapid and inexpensive technique to detect long-nosed potoroos (*Potorous tridactylus*). Seven sites were surveyed quarterly for foraging digs in the French Island National Park, Victoria, between October 2007 and October 2009. Trapping and hair-tubing for potoroos were also conducted.

Results/conclusions: While all three techniques were successful at detecting potoroos, this varied between sites. Live trapping was only successful at four of seven sites, while foraging dig surveys recorded animals at 100% of these. Hair-tubing was successful at two of three sites. Substantially higher mean dig densities (355 ± 48 digs ha^{-1}) occurred at successful trapping sites compared to unsuccessful trapping sites (79 ± 21 digs ha^{-1}), indicating foraging dig surveys are better at detecting potoroos at lower population densities. Dig densities were significantly higher in winter compared to summer and varied across different habitat types, being higher in wetter vegetation communities. Foraging dig surveys provide a relatively inexpensive detection technique and should be considered for initial surveys for presence, and also for monitoring changes in distribution and abundance of potoroids and similar species.

Robert Reed is a PhD student currently writing up his thesis investigating the effects of habitat disturbance on the distribution and habitat use of potoroos.

Temporal variation in microbat calls and implications for monitoring programs

Elizabeth Williams[1]
[1]The University of Queensland

Background/question/methods: Microbat populations are commonly monitored by employing ultrasonic detectors to record echolocation calls. Such devices were used at an active underground coal mine in the Blue Mountains, NSW, and was aimed at discerning the impact of mining on threatened or potentially sensitive species. Species call rates captured by ultrasonic detectors were analysed spatially and temporally to determine appropriate monitoring locations and deployment length, particularly for targeted species.

Results/conclusions: Nightly peak call times for individual microbat species varied with the location of the ultrasonic detectors, which in turn differed between seasons. This may be due to variations in microclimate, localised food distribution, distance to roost sites or possible competition or interaction with other species. Furthermore, peak call times for several species were more than four hours after sunset, with at least one species often recorded only in the early hours of the morning.

These results contradict previous minimalist monitoring proposals or guidelines advocating that ultrasonic detectors be deployed for the 3-4 hours after sunset. In particular, more accurate data may be obtained by recording microbat calls over the entire night. To ensure efficiency in post-collection data analysis of these longer recordings, auto-recognition software may be suitable for targeted species.

Elizabeth Williams has a broad range of interests in ecology, wildlife conservation, and habitat management and restoration. Specifically, her research to date has focused on the use of fauna as bioindicators to assess ecosystem management and health.

On the accuracy of Bayesian models with informative priors: a comprehensive analysis using a large rainforest dataset

William Morris[1], Peter Vesk[1], Michael McCarthy[1], Patrick Baker[1]
[1]The University of Melbourne

Background/question/methods: Bayesian modelling techniques are becoming commonplace for ecological analyses, yet many researchers are reluctant to perform analyses using informative priors. Using informative, rather than uninformative or vague priors will typically increase the precision of parameter estimates. Despite this obvious benefit, when fitting Bayesian models, ecologists use vague priors. The reluctance to fully utilise this powerful feature of Bayesian methods may be due, in part, to a fear that informative priors may degrade model accuracy. While there are a few ecological studies demonstrating the benefits of using Bayesian methods for ecological analyses and some that emphasise the use of informative priors, none test the effect on both model precision and accuracy of using informative priors. We tested the effect of using prior information on tree mortality models with a large-scale long-term dataset from a tropical South-east Asian forest. To assess the effect on model precision and accuracy we fit 180 single species mortality models to data from 45 species. Half the models had vague, uninformative priors and the other half included an informative prior for the base mortality rate derived from a multi-species model relating growth rate to mortality.

Results/conclusions: Precision was always greater when using an informative prior, with the improvement varying from a small to a six-fold increase. Model accuracy with respect to the validation data for the single-species model was different to the effect on precision. Sometimes prior information improved accuracy and sometimes it decreased it. We demonstrated that when priors are specified appropriately they can lead to better, more precise models without a having a detrimental effect on model accuracy.

William Morris is a member of the Quantitative and Applied Ecology Group in the School of Botany, University of Melbourne. In 2012 he completed a Masters of Philosophy on 'Bayesian models of tree mortality'. He is now undertaking a PhD on 'Decision making for vegetation management'.

Concurrent session 9C
Landscape disturbances and consequences

Can revegetation projects rescue rainforest bird communities?

Carla Catterall[1], Amanda Freeman[1,2], Kylie Freebody[1,3], John Kanowski[1,4]
[1]School of Environment, Griffith University, [2]School for Field Studies, [3]Tablelands Community Revegetation Unit, [4]Australian Wildlife Conservancy

Background/questions/methods: Habitat restoration is often advocated to mitigate species' declines resulting from past or future deforestation and interacting effects with climate change. However there is debate about whether restored vegetation following agricultural land use could soon enough provide habitat of sufficient quality. We assessed the capacity of replanted rainforest to recover 'natural' bird assemblages, in Australia's region of highest bird diversity and endemism, the Wet Tropics uplands. We measured bird assemblages and sites' environmental contexts in 25 'best-practice' replanted sites aged 1-24 years across 800 km^2, together with 8 reference sites in intact rainforest and 5 in pasture, to consider the following questions: 1. How does bird species composition change over time? 2. Do bird assemblages become similar to those of reference rainforest, and at what speed? 3. Does landscape context influence the rate of recovery?

Results/conclusions: Open-country bird species declined with increasing site age, while rainforest-dependent species increased. After 10 years, restored sites averaged about half the number of rainforest-dependent bird species typical of rainforest. Mean values at around 20 years overlapped with the ''poorest'' rainforest reference sites, but high variability among sites inndicates that some were not on track towards ever achieving a rainforest-like bird community. Rainforest-dependent species, and especially those that are regionally-endemic or sedentary interior-dwellers, were slowest to colonise revegetated sites. The best predictor of recovery of the 'rainforest' bird assemblage at a site was the amount of nearby rainforest (e.g., cover within a 200m radius). Implications?—restoration strategies need to consider context and set realistic goals.

Carla Catterall, with co-authors on this paper and other colleagues have worked together on several projects investigating the processes and diverse consequences of rainforest restoration; we all wear multiple other hats as well.

Restoration of trophic structure along a revegetation chronosequence

Heloise Gibb[1], Saul Cunningham[2]
[1]Department of Zoology, La Trobe University, [2]CSIRO Ecosystem Science

Background/question/methods: Habitat loss is considered the single greatest driver of species extinctions and amelioration of this threat through habitat restoration is increasingly important in maintaining biodiversity and ecosystem functions. Success of restoration depends largely on the ability of species of a diversity of functional types to recolonise a restored site. We used a restoration chronosequence to investigate the success of revegetation efforts (direct-seeding and tubestock methods) in returning species and trophic functions of ant assemblages to land formerly used for livestock grazing in south-eastern Australia. We examined assemblages in terms of: 1) species composition; 2) trophic position and diversity, measured using stable isotopes of nitrogen; and 3) species richness of trophic groups.

Results/conclusions: Species composition followed a trajectory suggestive of partial recovery, with revegetated sites supporting assemblages that were intermediate to pastures and remnants, but distinct from both. Pasture assemblages had the highest trophic position (mean species δ^{15}N enrichment) and lowest trophic diversity (variance among species in δ^{15}N enrichment). Tropic position decreased and trophic diversity increased along the chronosequence to remnants. These patterns were explained by an increase in the richness of species with low δ^{15}N enrichment, which was also reflected in increases in the species richness of sugar feeders. Low δ^{15}N species did not drive patterns of turnover in species assemblages. Trophic analyses suggested that recovery of direct-seeded sites lagged behind tube stock sites of the same age, indicating that habitat features were more important than time in determining colonisation. These patterns suggest significant convergence in composition and function with succession.

Dr Heloise Gibb is a community ecologist, specialising on arthropods. She uses large-scale manipulative and mensurative experiments to address basic and applied questions in ecology. She examines drivers of assemblage structure and function, such as competition.

Using restoration records to assess resilience of jarrah forest to climate change

Rachel Standish[1], Matthew Daws[2], Raphael Didham[4,5], Colin Yates[3], Andrew Grigg[2], Richard Hobbs[1]
[1]School of Plant Biology, The University of Western Australia, [2]Alcoa of Australia, [3]Department of Environment and Conservation, [4]School of Animal Biology, The University of Western Australia, [5]CSIRO Ecosystem Sciences

Background/question/methods: There is an urgent need to understand the potential effects of future climate change on biodiversity and what interventions might be necessary to mitigate species loss. The biodiversity hotspot of south-western Australia has already experienced significant climate change—a 14% reduction in mean annual rainfall over the period 1975 to 2004 compared with mean rainfall from the mid-1900s to 1974. Long-term records of jarrah-forest restoration following bauxite mining have been collected by staff at Alcoa of Australia for the last 20-years of the observed rainfall decline in south-western Australia. Records include annual data on seeding rates and seedling establishment for over 550 species. These records offer an unprecedented opportunity to test for climate-based 'assembly rules' for ecosystem restoration by relating historical rainfall amounts and timing to patterns of vegetation development.

Results/conclusions: Rainfall amounts undoubtedly help determine patterns of seedling establishment in Mediterranean-climate ecosystems such as the jarrah forest, yet there is uncertainty about the response of individual species to the incremental decline in rainfall (i.e., threshold effects) and how these might sum to affect the resilience of the jarrah forest to ongoing climate change. We built a structural equation model to discriminate the relative effects of climate, restoration protocol, plant traits and their interactive effects on the similarity of plant assemblages. Our model was informed by decades of research on the restoration of jarrah forest after bauxite mining. We describe the model and its implications for understanding current and predicting future impacts of climate change on forest ecosystems.

Rachel Standish is a Plant Ecologist at the University of Western Australia. She has recently joined the Environmental Decisions Group, and this research will be a contribution to this group's efforts to determine if resilience and related concepts can inform ecosystem management.

Are passively regenerating woodlands a valuable resource? A case study with reptiles

Melissa Bruton[1], Clive McAlpine[1], Martine Maron[1]
[1]The University of Queensland

Background/question/methods: Historical broadscale clearing in Australia has created significant areas of regrowth woody vegetation. In terms of biodiversity, these regrowth woodlands are generally considered inferior to remnant woodlands and are poorly protected. However regrowth woodlands often contain plentiful shelter resources through increases in structural heterogeneity. Shelter sites are a key resource for reptiles. Therefore we predicted that reptile diversity and abundance would be similar or possibly greater in regrowth woodlands with limited shelter site disturbance (such as fire) than in remnant woodlands. We also predicted that regrowth woodlands would provide complementary, rather than inferior reptile habitat in age mosaic landscapes.

We addressed these predictions using a space for time substitution model in a regenerating mosaic landscape in semi-arid western Queensland. We conducted pit and funnel trap surveys of reptile communities in 55 remnant, cleared, and regrowth sites in two structurally different woodland habitat types (*Acacia catenulata* and *Eucalyptus populnea*) during two consecutive summer seasons.

Results/conclusions: Reptile species diversity and abundance did not vary between regrowth and remnant woodland sites or between woodland types; however reptile diversity (but not abundance) was significantly lower in cleared sites. Reptile community dissimilarity analyses are ongoing and the results will be discussed in the context of habitat complementarity and habitat age nestedness.

Further analyses are being conducted to identify how key habitat variables influence reptile abundance and diversity. These analyses will allow a greater understanding of the structural drivers of variation in reptile communities in regenerating landscapes.

Melissa Bruton is in the 3rd year of her PhD, which focuses on the habitat use patterns of reptile communities in recovering landscapes. This follows her honours work on filesnake metabolism. She is intrigued by the ecological impacts of the ectothermic physiology of reptiles.

Improving performance of species distribution models for a disturbance-sensitive legless-lizard

David Wong[1], Bernd Gruber[1], Stephen Sarre[1], William Osborne[1]
[1]Institute for Applied Ecology, University of Canberra

Background/question/methods: A common application of species distribution models (SDMs) is to predict the likely occurrence of threatened species. These species often have specialised habitat requirements. Human induced disturbance to, or destruction of, key habitat resources is an important driver of decline for many of these species. However, disturbance is rarely incorporated into SDMs, which often rely on bioclimatic and topographically-based data layers.

We investigated the effect of incorporating agricultural modification data derived from remote sensing into a SDM framework by comparing MaxEnt models at two spatial scales within the Australian Capital Territory (ACT) in south-eastern Australia, with and without agricultural modification data incorporated. We used the pink-tailed worm lizard *Aprasia parapulchella* as the study species for this case study as it is known to have a number of specialist habitat requirements, including a particular preference for sites dominated by species of native grass known to decline with increased levels of grazing and pasture improvement.

Results/conclusions: Soils, geology, slope, temperature, rainfall and agricultural modification were found to be important predictors and the responses of these variables confirmed habitat associations identified in previous research. We found that inclusion of the agricultural modification data into the SDMs improved model performance at both spatial scales investigated. The main difference between the models compared was that models without agricultural modification data predicted more areas with exotic vegetation as being suitable, whilst models with the agricultural data included predicted additional native areas.

Our findings highlight the value of incorporating the contribution of one form of disturbance (agricultural modification) into a SDM framework.

David Wong is a PhD student with the Institute for Applied Ecology. His interests include, conservation biology, reptile ecology, GIS, disturbance and how ecology can reach a broader audience, particularly through photography.

Soil warming increases diversity but decreases germination from an alpine soil seed bank

Gemma Hoyle[1], Susanna Venn[2], Kathryn Steadman[3], Roger Good[4], Joe McAuliffe[4], Emlyn Williams[5], Adrienne Nicotra[1]
[1]Department of Evolution, Ecology and Genetics, Research School of Biology, The Australian National University, [2]Research Centre for Applied Alpine Ecology, Department of Botany, La Trobe University, [3]School of Pharmacy and Queensland Alliance for Agriculture and Food Innovation, The University of Queensland, [4]Australian National Botanic Gardens, [5]Statistical Consulting Unit, Australian National University

Background/question/methods: Sizable seed banks have been found to exist in alpine soils all over the world, including the Australian Alps. Global warming is occurring more rapidly above the treeline than at lower elevations, therefore plant regeneration from seed will be crucial to the persistence, migration and post-disturbance recruitment of alpine plants in future climates. We used the 'seedling emergence method' to assess the impact of soil warming, as predicted under climate change, on germination from a persistent alpine soil seed bank. We hypothesised that warming would enhance seedling emergence and the growth hormone gibberellic acid would bypass physiological dormancy where present.

Results/conclusions: Contrary to expectations, soil warming lead to reduced overall germination. However, the germination response to temperature was species specific and, in some cases, altered with time and was dependent upon soil disturbance. Seeds of a significant proportion of species in the soil possessed physiological dormancy and showed evidence of dormancy cycling in response to seasonal temperature shifts in a dark laboratory setting. We found no evidence of subalpine species and little evidence of exotic weed species in the soil, suggesting that the soil seed bank will not facilitate their invasion of the Australian Alps. In conclusion, changes in recruitment from the alpine soil seed bank can be expected in the future, as a result of altered dormancy alleviation and germination cues. However alpine soil seed banks, and the species diversity therein, have the potential to help maintain local species diversity, support species shift and moderate species dominance under climate change.

Gemma Hoyle is interested in seed and seedling ecology that supports the conservation, restoration and management of native plant communities both in situ and ex situ. She is currently investigating impacts of climate change on the reproductive ecology and demography of Australian alpine flora.

Germination in the world's tallest angiosperm (*Eucalyptus regnans*) and the impact of recurrent disturbances

Annabel Smith[1], Sam Banks[1], Phillip Barton[1], David Blair[1], Wade Blanchard[1], Don Driscoll[1], Lachlan McBurney[1], David Lindemayer[1]
[1]Fenner School of Environment and Society, The Australian National University

Background/question/methods: Fire has shaped the biota of many ecosystems globally, but modern land management practices have altered the effect of fire on ecological communities. Australia is home to the world's tallest angiosperm, *Eucalyptus regnans* (mountain ash) which, unlike the majority of eucalypt species (>90%), is killed by intense wildfire and regenerates only from seed. Understanding factors that influence germination after wildfire is therefore fundamental to characterising the life cycle of this species and guiding sustainable forest management. In February 2009 major wildfires swept through the Central Highlands in Victoria, burning 72 000 ha of *E. regnans* forest. Within two months of this fire we began the first large-scale, controlled study of post-fire germination in *E. regnans*. Our sites (N=122, 42% burnt), spanned a range of fire intensities and disturbance (logging/fire) histories. Based on descriptive studies of *E. regnans* from the 1970s, we predicted that the number of seedlings would be (i) greater at burnt than unburnt sites and greatest overall where fire severity was high, and (ii) lower at sites with a history of frequent disturbance.

Results/conclusions: Generalised linear modelling showed that burnt sites had significantly more seedlings than unburnt sites, but frequent disturbances decreased the germination response. Among burnt sites, the effect of fire severity was weaker than we predicted. Although *E. regnans* requires fire for regeneration, frequent disturbance can impede seedling germination. Extending rotation times of logging practices and protecting old forest through strategic fire management will help ensure the persistence of this species.

Annabel Smith is a postdoctoral researcher at ANU, associated with the Centre of Excellence for Environmental Decisions. She is broadly interested in understanding how fire affects plant and animal populations so that fire management can be conducted in a way that conserves biodiversity.

Concurrent session 9D
Community assembly and disturbance

Trait-mediated responses of alpine plants to experimentally altered snow cover

Susanna Venn[1], John Morgan[1], Annika Korsten[2], Alan Mark[2]
[1]La Trobe University, [2]Otago University

Background: In plant community assembly theory, environmental filters are the abiotic conditions and resources that exclude species with unviable physiological limitations (defined by their functional traits) from entering or persisting in a community. Measures of functional trait diversity can be used to determine community responses to current and altered environmental filters. The Old Man Range snowfence, erected in 1959 in alpine tundra, New Zealand, provides an excellent opportunity to test the effect of a changed environmental filter on species/trait (re)distribution. The fence has profoundly affected the local environment, creating a lee-side snowdrift and significantly reducing wind speeds. Species composition has changed significantly over time. Functional traits, such as leaf dry-matter content (LDMC), leaf nitrogen (LN) and specific leaf area (SLA) (proposed as indicators of plant responses to environmental filters) may be the key to understanding the mechanisms that have allowed certain plants to establish, increase, persist or decline at the snow fence site.

Question: How have plant functional traits mediated the composition of species in the snowfence area?

Methods: We randomly sampled vegetation from three snowmelt zones in the lee of the fence and related leaf traits (LDMC, LN, SLA) with species abundance. We then used an index of functional diversity to determine the influence of each trait on vegetation composition within each snowmelt zone.

Results/conclusions: We saw clear differences in species distribution in relation to the snowmelt zones, and demonstrate how plant functional traits can provide a mechanistic understanding of the ways plants responds to altered environmental filters.

Susanna Venn is interested in how physical aspects of the alpine environment influence plant community patterns, processes and community (re)assembly over various temporal and spatial scales. Research topics include treeline recruitment and dynamics, snowpatch community assembly, freezing resistance and how plant functional traits influence community composition now and into the future.

Traits of foundation species influence the enactment of a facilitation cascade in Australian mangroves

Melanie Bishop[1], Jill Fraser[1], Paul Gribben[2]
[1]Department of Biological Sciences, Macquarie University, [2]School of the Environment, University of Technology Sydney

Background/question/methods: Facilitation cascades maintain biodiversity in a variety of habitats. Yet we know little about their sensitivity to variation in the traits of the basal and intermediary foundation species that underpin them. We examined how the individual and population level traits of interacting foundation species influence the establishment and persistence of a facilitation cascade in temperate Australian mangrove forests. In this system, mangrove pneumatophores trap free living algae, *Hormosira banksii*, which in turn supports dense and diverse assemblages of invertebrates. We hypothesised that the establishment and persistence of this cascade would be sensitive to variation in the density and height of pneumatophores, and the frond length and vesicle size of the alga.

Results/conclusions: Manipulations of pneumatophore height and density revealed that these traits affected both the establishment and persistence of the cascade. High densities of tall pneumatophores initially inhibited establishment of the cascade by serving as a physical barrier to algal colonisation of pneumatophore plots. These traits were, however, positively correlated with persistence of the cascade over the longer term because they enhanced the retention of algae penetrating plots, and this in turn facilitated epifaunal colonisation. Retention of algae by pneumatophores was correlated with thallus length but not vesicle diameter, and this effect occurred independent of pneumatophore morphology. Our study has demonstrated that both individual and population level traits of basal and intermediary facilitators may influence both the establishment and persistence of facilitation cascades.

Dr Melanie Bishop researches the mechanisms by which urbanisation and climate change modify coastal biodiversity and its important socio-economic values. Her important research has been recognised with the 2010 NSW Scientist of the Year Award (Category Water, Environment and Climate Change) and a 2011 NSW Young Tall Poppy Award.

Traits of exotic and native plants help explain why flow regulation facilitates riparian invasion

Jane Catford[1,2,3], Will Morris[1], Barbara Downes[4]
[1]School of Botany, University of Melbourne, [2]Fenner School of Environment and Society, Australian National University, [3]Department of Ecology, Evolution and Behavior, University of Minnesota, USA, [4]Department of Resource Management and Geography, University of Melbourne

Background/question/methods: Various studies have found a link between environmental modification and exotic invasion in riparian ecosystems. However, areas most heavily impacted by environmental modification tend to be areas most proximal to human activities. As such, environmental modification is often confounded with human-mediated propagule pressure and disturbance. This makes it difficult to determine whether invasion is chiefly related to exotics' superior adaptation to altered environmental conditions and disturbance or whether the trend is a function of differences in propagule pressure.

Building on previous work in River Murray wetlands, we examine how proportional cover of exotic plants relates to flood disturbance, human-mediated dispersal, impacts of flow regulation and livestock grazing. We use hierarchical models to test whether the response of exotic and native species groups to these factors can be explained by their traits (life history, specific leaf area—SLA, height, seed mass).

Results/conclusions: Of the factors examined, impacts of river regulation explained most variation in exotic plant cover. Proximity to towns and presence of cattle pugs explained the least amount of variation. Overall, exotic species had higher and less variable SLA and seed mass than natives. Hierarchical occupancy models support the hypothesis that a positive association between exotic cover and flow regulation is related to the higher SLA and seed mass of exotic species. However, responses of individual native and exotic species to flow regulation varied, which highlights that generalisations do not always hold. This study illustrates how plant functional traits can be used to infer casual processes.

Jane Catford is a plant ecologist and an ARC Discovery Early Career Researcher. Will is a PhD candidate in forest ecologist and a bona fide stats whiz. Barb is a professor in freshwater ecology.

Using species trait means underestimates community functional responses to environmental change

John Dwyer[1], Richard Hobbs[2], Margie Mayfield[1]
[1]School of Biological Sciences, The University of Queensland, [2]School of Plant Biology, University of Western Australia

Background/question/methods: Functional trait analysis has become an important tool in community ecology. Most trait analyses use species mean values to represent functional differences among species, even though intraspecific variation can be large and individual plants, not species, interact with their environment. In this study, we focus on specific leaf area (SLA) responses of natural herbaceous communities to environmental gradients. We hypothesised that using species means would underestimate community responses, compared to an approach that incorporates intraspecific trait-environment relationships. Community surveys were conducted in 2010 and 2011 in the herbaceous communities of York Gum Woodlands of Western Australia. SLA was measured on many specimens from each species over the two survey years. Statistical models were fitted for each species to quantify relationships between ln(SLA) and important environmental variables. Community SLA responses calculated using species means were then compared to those derived from species-specific trait-environment models.

Results/conclusions: SLA values from the drier growing season (2010) were typically lower than those from the wetter season (2011), and most species exhibited considerable SLA variation within years. For many species ln(SLA) was significantly related to environmental variables including woody canopy cover, soil nutrients (P and N) and rainfall. Community responses to key environmental gradients were dramatically underestimated when species mean trait values were used, especially if only sun-exposed leaves were considered and/or when interannual SLA variation was ignored. When assessing functional responses we therefore recommend that traits be measured on multiple individuals per species, sampled across important environmental gradients, so that trait-environment relationships can be incorporated.

John Dwyer is a plant ecologist with research interests in restoration and community ecology. His current research explores the assembly of novel annual plant communities within the fragmented agricultural landscapes of the Western Australian wheatbelt.

Spatial and temporal diversity patterns of bird assemblages in fire-prone mallee communities of Kangaroo Island

David McKenna[1]
[1]Department of Environment, Water and Natural Resources South Australia

Background/question/methods: The impact of large scale fire on island bird community structure and diversity are not well known. In this study, bird community composition and abundance were surveyed at 25 mallee sites from three vegetation communities across western Kangaroo Island in the spring and autumn of 2002 and 2004. A large scale bushfire in Dec 2007 burnt 96% of the native vegetation in the area, providing an opportunity to measure the impact of a large scale fire on bird diversity. A further survey was therefore conducted in the spring 2011. The aim was to examine changes in bird diversity both spatially and temporally. Bird species abundance and composition were compared using PERMANOVA+. Beta diversity was examined using analysis of multivariate dispersions.

Results/conclusions: A total of 67 bird species was recorded across the 5 surveys, ranging from 38 species in autumn 2004 to 57 species in spring 2011. Bird communities were significantly different between vegetation types in all surveys and generally different between surveys. Post-fire Beta diversity was significantly less than in the 4 pre-fire surveys, with sites having a mean turnover of between 44 and 52% of species pre-fire and only 30% post-fire. Post-fire species richness and abundance were also significantly higher. These findings suggest that bird species can recover well within 4 years of a large scale fire. Further investigation of bird data, fire history and plant survey data will be conducted to examine diversity patterns and explanatory variables.

David McKenna is a fire ecologist working in the Fire Management Program of the SA Department of Environment, Water and Natural Resources. I oversee the adaptive management program associated with our prescribed burning as well as providing ecological input to the fire planning and monitoring processes.

The influence of fire history on fauna occupancy in East Gippsland, Victoria

Matthew Bruce[1], Paul Moloney[1], Richard Loyn[1]
[1]Arthur Rylah Institute, Department of Sustainability and Environment

Background/question/methods: Fire is an important ecological factor in south-eastern Australia, but little is known about how animals respond to fire history variables such as fire frequency and time since fire. To address this we used a space-for-time substitution approach by selecting sites representing several combinations of time since fire and fire frequency, as part of a broad retrospective study. We conducted fauna surveys using automated camera traps at 89 sites in East Gippsland, Victoria, in two different vegetation types: tall mixed forest and grassy/healthy dry forest.

Results/conclusions: Twenty-four mammal species were detected in the camera trap surveys along with twenty-six bird species and two species of reptile. We modelled the occupancy of nine mammal species, two bird species and one reptile relative to time since fire and fire frequency. Our initial analyses have revealed that in tall mixed forest the occupancy of superb lyrebirds (*Menura novaehollandiae*) decreased as the number of fires at a site increased.

Matt Bruce is a wildlife ecologist with research interests including fire ecology, the evolution of animal signals and social learning in animals and humans.

Impacts of agricultural intensification on biodiversity: a case study from Tasmania

Peter McQuillan[1], Kerry Bridle[2]
[1]School of Geography and Environmental Studies UTAS, [2]Tasmanian Institute of Agriculture UTAS

Background/question/methods: Agricultural intensification has been shown to lead to a decline in biodiversity at a landscape scale. At local (field) scales, different land use types support different suites of species. The Tasmanian Government has invested in irrigation development in the historically dryland grazing districts of the Midlands in order to 'drought-proof' Tasmania. Intensification from dryland (largely extensive) grazing to irrigated cropping and grazing, will impact on biodiversity values at a range of scales. This paper presents data on one component of natural systems, soil meso fauna, assessing differences in fauna assemblages between crops, sown perennial pastures, and native vegetation on 19 mixed farms.

Results/conclusions: Paddock surveys of crops, perennial pastures and native vegetation indicated that the richness and composition of soil meso fauna differed between the three land use types. Most disturbed soil types (crops) supported fewer taxa than pastures or native vegetation. Composition of functional groups also differed between land uses. Higher order taxa such as predatory species were more common in native vegetation (mites) and pastures (beetles) than in crops. These results are discussed in the context of potential biodiversity loss and changes in ecosystem service provision under agricultural intensification.

Dr Peter McQuillan is a senior lecturer in the School of Geography and Environmental Studies. His research interests include fauna and ecosystem conservation and management. Peter has supervised many post-graduate students studying the conservation and ecology of Tasmanian invertebrates.

Insect responses to climate change: what are we testing for?

Nigel Andrew[1], Sarah Hill[1], Matt Binns[1], MD Bahar[3], Emma Ridley[2], Myung-Pyo Jung[4], Chris Fyfe[1], Michelle Yates[1], Mohammad Khusro[1]
[1]Centre for Behavioural and Physiological Ecology, Zoology, University of New England, [2]Department of Biology, University of York, UK, [3]Saskatoon Research Centre, Agriculture and Agri-Food Canada, [4]Department of Agricultural Biology, National Academy of Agricultural Science

Background/question/methods: Understanding how researchers are tackling globally important issues, such as climate change, is crucial to identify whether current research is comprehensive enough to make substantive predictions about general responses to climate change. We assessed the type of studies being conducted by researchers to understand the impacts of climate change on insects, published.

Results/conclusions: Most published research is generated from Europe and North America and being dedicated to core data analysis, with reviews being highly produced. Temperature—only is the main climate change factor being analysed, with most researchers are assessing changes in abundance or distribution/range shifts. Of most concern is the number of studies which do not specifically identify a climate change factor (ie just arm wave), the lack of studies on Hemimetabolous insects and the need for more studies to assess specific mechanistic responses to climate change.

Nigel Andrew is Treasurer of ESA.

Concurrent session 9E
Environmental management and land use

Biodiversity impacts of agricultural land use

Saul Cunningham[1], Kristen Williams[1], Tom Harwood[1], Linda Broadhurst[2], Robert Godfree[2], Andrew Young[2]
[1]CSIRO Ecosystem Sciences, [2]CSIRO Plant Industry

Background/question/methods: We investigated biodiversity and land use change in a bioclimatically defined region of 71 million hectares that accounts for much of Australia's cropping and improved pastoral land (the high rainfall cropping zone: HRCZ), and where significant agricultural changes are expected. Our goal was to understand past and potential future impacts of land use on Australian biodiversity at large spatial scales. We examined the inherent biodiversity potential of this landscape using generalised dissimilarity modelling, and then compared these results with land use patterns between 1992 and 2005.

Results/conclusions: Historical clearing of woody vegetation in the HRCZ makes it one of the planet's most transformed biomes. The HRCZ coincides with many of those parts of Australia that have the highest numbers of listed endangered species and communities. Active clearing is now diminished, but agricultural intensification continues. The most common agricultural land use in the zone is grazed native vegetation, which has the potential to support significant native biodiversity. During the assessment period, however, ~5 million hectares of this land (11%) was converted to more intensive forms of agriculture that have low biodiversity value (fertilised pasture and annual crops). This pattern was widespread, with the same trend occurring in 85% of statistical local areas. A survey of landholders indicates an intention to continue these trends in coming years. To improve the trajectory of biodiversity while supporting agriculture one could focus intensification on fields that have already lost their native vegetation, and manage the rest in a mix of native grazing, with restoration activities centred on recoverable biodiversity assets.

Saul Cunningham works on biodiversity in mosaic landscapes of agriculture and native vegetation. He has a particular interest in ecosystem services in these landscapes (especially crop pollination) and on the potential for restoration ecology to improve outcomes.

Reclaiming the woodlands: modelling for improved biodiversity management

Hannah Pearson[1], Libby Rumpff[1], Brendan Wintle[1], Doug Robinson[2]
[1]CEED, NERP, [2]Trust for Nature, Birds Australia

Background/question/methods: Land in south-eastern Australia has been valued for its' ability to support agriculture since European settlement, leading to extensive clearing of native vegetation and a significant decline in biodiversity. Despite considerable investment of resources, this decline continues today. Typically, attempts to limit biodiversity loss focus on the preservation of specific threatened species, or on increasing the extent and condition of habitat. It is assumed that improving habitat will translate to increased faunal diversity but this is rarely tested. In this research, we aim to test this hypothesis by integrating habitat suitability models with a previously developed Bayesian state-and-transition model to predict the influence of restoration actions on woodland vegetation and associated avifauna. The effectiveness and costs of restoration actions for the different bird and vegetation outcomes were then compared, exploring the usefulness of management strategies when the focus is on effectiveness versus cost efficiency.

Results/conclusions: The model created in this research shows that the most effective and most cost efficient forms of restoration are not always the same. There was no management strategy that was both most cost efficient and most effective for all outcomes. This research aims to provide information to help managers make decisions about woodland restoration strategies, provided that they specify the relative importance of the different outcomes.

Hannah Pearson has just completed a Masters of Science (Botany) and is hoping to begin a PhD in the new year. She is particularly passionate about conducting research which helps to improve the efficiency of conserving or rehabilitating the environment. Her potential PhD project concerns the investigation and potentially the improvement of grassland offset policy.

Integrating ecosystem services into land use planning, Central Kalimantan, Indonesia

Elizabeth Law[1,2], Erik Meijaard[1,3], Matt Streubig[4], Brett Bryan[2], Thilak Mallawaarachchi[5], Paul Dargusch[6], Kerrie Wilson[1]
[1]Environmental Decisions Group, University of Queensland, [2]CSIRO Ecosystem Sciences, [3]People and Nature Consulting International, Indonesia, [4]University of Canterbury, UK, [5]Risk Analysis Group, Economics, University of Queensland, [6]Geography, Planning, and Environmental Management, University of Queensland

Background/question/methods: The challenges of landscape planning for multiple objectives are particularly pertinent in the context of 'reduced emissions from avoided deforestation and forest degradation' (REDD+). Demonstration sites will ideally show effective carbon mitigation, while being beneficial for (or at least not negatively impacting) social and economic development, and biodiversity conservation. This study aims to provide decision support tools for land use planning in our case study region: a high priority REDD+ demonstration area in Central Kalimantan, Indonesia. We map the value of ecosystem services (agriculture, forestry, carbon, NTFP) and biodiversity across the study region. We define how different land use options affect each ecosystem service, and then apply multi-objective optimisation to evaluate the appropriateness of stated planning targets, and the development strategies that may be applied to achieve them.

Results/conclusions:

- We show how different methods of carbon accounting have distinctly different implications for land use planning and potential carbon mitigation through market mechanisms, in particular how those based on above ground storage fail to account for stochastic flux processes.
- We demonstrate a method for incorporating value of farming mosaics and the contribution of these to livelihoods through subsistence and commodity trading.
- We demonstrate the importance of defining the benefits for multiple targets, for both biodiversity and ecosystem services, over multiple land uses.

This study provides a framework for analyses of appropriate targets in multi-criteria land use planning, and provides a more rigorous approach to identification of planning strategies when faced with competing and synergistic actions.

Elizabeth Law is a current PhD student in the Wilson Conservation Ecology Lab, part of the EDG at UQ. She is supported with an APA, a Centre of Excellence in Environmental Decisions postgraduate fellowship, and a UQ-CSIRO Integrative Natural Resource Management Scholarship.

Monitoring and management of bush camp grounds in a Victorian national park

Kelly Hunt de Bie[1], Peter Vesk[1]
[1]The University of Melbourne

Background/question/methods: Management of visitor and recreation impacts in protected areas requires targeted and systematic monitoring programs that are used to inform management decisions. This talk will summarise a Victorian attempt to develop a coordinated approach to visitor impact monitoring for campsites in the Grampians National Park. The Grampians is one of the most highly visited parks in the state and is particularly popular as a camping destination. Campgrounds in the Grampians vary from small, bush, non serviced camps through to large, organised camping areas and commercial camping operations. The large number of bush campsites in the park was identified as unsustainable and has resulted in issues such as track proliferation and vegetation loss and damage. Bush campsites have generally been developed by the user with minimal planning, strategies or environmental or cultural consideration involved in their placement, with sites mostly created prior to the creation of the national park in 1984. We used a structured decision making (SDM) approach to develop a monitoring program for bush camp sites and identify relevant management responses. SDM is becoming popular tool in natural resource decision making, but has not been well utilised for visitor management.

Results/conclusions: This approach was able to successfully identify suitable indicators for monitoring which were directly linked to conservation objectives and able to inform management decisions. We propose that SDM may be a useful tool for facilitating development of visitor management and monitoring. This bottom up approach has some advantages over traditional decision frameworks commonly used in visitor management, through the development of conceptual models of impacts and acknowledgement of the resources available for management. In places like Victoria where management approaches are often determined on a park by park basis, SDM may prove a valuable tool for visitor impact management.

Kelly Hunt de Bie's current research focuses on recreation ecology and management of visitor impacts in protected areas. She is currently working in collaboration with Parks Victoria to develop and implement monitoring of visitor impacts and potential adaptive management responses.

Will *Xanthorrhoea glauca* subs. *angustifolia* survive the presciptive fire regimes on Victorian public land?

Peter Curtis[1]
[1]La Trobe University

Background/questions/methods: *Xanthorrhoea glauca* subs. *angustfolia* has several evolved traits for fire survival: Contractile roots take the seedling underground to develop for 45-60 years, its initial aerial growth of 1.0cm/year provides moist leaf bases that protect the shoot apex, post-fire flowering, and the dead leaves' contractile fibres sheath the stem, its flowering without a fire cue enables seed germination under ground-cover protection, The 12 year study followed a 1991 prescribed burning (Site A) in the Victoria North East's Warby Range State Park. In four study sites, annual *Xanthorrhoea* mortality in size classes was compared with an unburnt site (Site B).

Results/conclusions: By 2001, *Xanthorrhoea* mortality in Site B was 0.75% annually and Site A was 42% overall, with 72% in the 0-0.5m class, which in early growth accumulates flammable debris and dead leaves around the stem which increases flammability and mortality. Recruitment depends on plant survival in this class, not seedling numbers. From 1890 rabbit plagues eliminated *Xanthorrhoea* seedlings which meant no plant recruitment. Seedling survival re-commenced after *Myxomatosis* introduction in 1952. With a proposed 15 year burning frequency, the study indicates that without protection of the 0-0.5m class, this species' survival on Victorian public land is doubtful.

Peter Curtis found that retirement became more interesting when a Xanthorrhoea ecological study commenced after a prescribed burning in 1991 and concluded with a PhD in 2003. A simultaneous interest in Urban Landcare and a project of floodplain bush regeneration led to writing 'Floodplain Woodland Plants of North East Victoria' in co-authorship with his wife.

Under the radar: offsetting cumulative, offsite, cryptic and secondary ecological impacts in intact landscapes

Keren Raiter[1,2], Richard Hobbs[1,2], Suzanne Prober[3], Hugh Possingham[2,4]
[1]School of Plant Biology, University of Western Australia, [2]ARC Centre of Excellence for Environmental Decisions, [3]CSIRO Ecosystem Sciences, [4]School of Biological Sciences, University of Queensland

Background/question/methods: Surging worldwide interest in offsets holds the promise of addressing ongoing biodiversity decline caused by development projects. Offsets consist of conservation actions designed to compensate for deleterious impacts. While offsets are widely criticised, they are also an increasingly utilised, and therefore important, part of environmental conservation in the face of ongoing biodiversity decline.

We pose the question: Can biodiversity offsets be used to allay the impacts of developments in relatively intact ecosystems? To answer this, we review the literature and present a framework for conceptualising impacts that generally pass under the radar of evaluations used to calculate environmental offsets, such as environmental impact assessments.

Results/conclusions: We present a set of case studies and examples that suggest that in order to achieve the purported goal of 'no net loss' in relatively intact systems, biodiversity offsets need to account for cumulative, offsite, cryptic, and secondary impacts to ecological values. Accounting for these impacts, however, is not straightforward: it may involve enhanced cumulative impact assessments that incorporate projected offsite, cryptic and secondary impacts; improved incorporation of precaution into decision-making processes; designating no-development zones; developing means for restricting human access to areas with development, environmental risk insurance, and strategically applying offsets to perform conservation actions that will most enhance the values of the region. Lastly, truly achieving positive environmental outcomes in relatively intact systems requires that offsets are used only within their rightful place in the 'mitigation hierarchy', with unacceptable impacts avoided, acceptable impacts minimised, and restoration planned, all before offsets are considered.

Keren Raiter is a conservation ecologist interested in integrating practical ecology with well-founded policy. Her PhD research focuses on strategic mitigating of cumulative mining and exploration impacts in Western Australia's Great Western Woodlands: the world's largest remaining temperate woodland. Keren has also worked on climate change, forest hydrology, and Phytophthora dieback.

Calibration of the Carbon Farming Initiative's reforestation modelling tool to improve estimates of carbon sequestration by environmental and mallee plantings

Keryn Paul[1], S Roxburgh[1], J Raison[1], J Larmour[1], J England[1], S Murphy[2], K Brooksbank[3], T Fairman[2], R Law[2], P Ritson[3], T Hobbs[4], C Neumann[4], L Kmoch[1], B Finn[1], K Ryan[4], J Norris[2], M Brammar[2], A Winter[3], B Yeo[3], A Peck[5], J Bartle[5], D Freudenberger[6], M Rooney[6], J Jonson[7], S Cunningham[8], N Preece[9], D Wildy[10], T Powe[11], T Lewis[12], M Tucker[4], J Carter[1], R Bennett[1], D Mendham[1], R Sudameyer[3], Z Read[12], G McAurthur[13], M Brekalo[14], R Giles[5], G Minchin[15], A Higgins[15], P van Oosterzeeand[9], D Clifford[1], A Drew[1], G McLachlan[1], C Baillie[1], P Warburton[1], S Swift[12], D Butler[16]
[1]CSIRO, [2]Victorian Department of Sustainability and Environment, [3]WA Department of Agriculture and Food, [4]SA Department of Environment and Natural Resources, [5]WA Department of Environment and Conservation, [6]Greening Australia, [7]Threshold Environmental, [8]Monash University, [9]Biocarbon Pty Ltd., [10]Elementree Pty Ltd, [11]Greenfleet Pty Ltd, [12]Queensland Department of Employment, Economic Development and Innovation, [12]Australian National Univeristy,[13]AusCarbon Pty Ltd, [14]Carbon Neutral Pty Ltd, [15]Lachlan Catchment Management Authority, [16]Queensland Department of Environment and Resource Management

Background/question/methods: Most new tree plantings established for carbon sequestration are either mixed-species environmental or mallee eucalypt plantings. However, the current uncalibrated yield curve in the FullCAM carbon accounting model which is applied in both the National Inventory System and the Carbon Farming Initiative's Reforestation Modelling Tool generally leads to underestimation of biomass. Therefore, CSIRO, together with a wide range of collaborators, conducted a national project commissioned by the Department of Climate Change and Energy Efficiency to calibrate FullCAM for these plantings. New biomass data were collected and existing field inventories and biomass estimates were collated and refined for mixed-species environmental and mallee eucalypt plantings, resulting in a large (1,293-observation) database on growth and biomass accumulation rates. Categories of plantings that had significantly different growth rates were defined, and provided the basis for calibration (estimation of appropriate modifiers) of the 'Tree Yield Formula' in FullCAM.

Results/conclusions: Overall model efficiency was 59%, and there was no apparent bias when the model was applied to the various categories of plantings. Species-specific yield curves were calibrated to provide unbiased estimates of temporal change in above-ground biomass for a wide range of planting situations. Results indicate that when compared to the uncalibrated yield curves, early growth is likely to be more rapid and total above-ground biomass may be higher for many plantings at maturity. We conclude that repeated temporal measurement of growth in contrasting types of plantings would be extremely valuable for model evaluation of both above- and below-ground biomass, and for further refinement of the calibrations.

Keryn Paul has been working measurement and modelling of forest growth and carbon sequestration over the last 12 years. Recently she has been leading a nationally collaborative project which has completed the collation of datasets for the analyses of differences in carbon sequestration by different types.

Concurrent session 10A
SYMPOSIUM: Urban ecology in Australia

Interactions between climate change, urbanisation, and the capacity of current protected areas to sustain biodiversity

Jenni Garden[1], Carla Catterall[1]
[1]Environmental Futures Centre, Griffith University

Background/question/methods: Species living within areas affected by both urbanisation and climate change face the combined and potentially synergistic impacts of these processes. Networks of protected areas in urbanising regions have been established to protect habitats within species' current areas of occupancy (AOO). However, these AOO are likely to change as climate change causes shifts in the distributions of species and their habitats. Such shifts could result in altered levels of species' protection as their distributions move into, or out of, static protected areas. Here we review current knowledge regarding interactions between climate change and urbanisation, and report on recent research into the present and future capacity of a current regional-scale protected areas network to conserve forest-dependent biodiversity.

Results/conclusions: Systematic searches of the scientific and social sciences literature up to and including 2011, using combined terms for biodiversity, urbanisation and climate change, revealed 245 references for urbanisation-only impacts, and 453 references for climate change-only impacts, on biodiversity; with recent peaks in publication rates in 2011 and 2010 of 45 and 94 references, respectively. A variety of specific impacts were identified as being increased by both processes, including habitat loss, increased temperatures, and altered rainfall patterns. However, only five references focused on combined interactions from both—a significant knowledge gap. Distributional analyses for forest-dependent species in the urbanising south-east Queensland region, and predictive modelling under present and future climate scenarios, indicated that although species' AOO tend to become more restricted to locations within currently-protected areas, overall AOO amounts decline substantially. Future conservation planning will need to consider these likely impacts.

Jenni Garden is an Australian ecologist currently working as a research fellow within Girffith University's Environmental Futures Centre. Her research is supported by the Griffith Climate Change Response Program and is focused on urban biodiversity adaptation to climate change.

Challenges of a long-term, large-scale manipulation experiment in an urban ecosystem

Samantha Imberger[1], Christopher Walsh[1], Tim Fletcher[1], Darren Bos[1]
[1]The University of Melbourne

Background/question/methods: Australia and the rest of the world is undergoing a rapid urban transition, where new settlements are forming and existing cities are expanding. These urban ecosystems are dynamic environments characterised by the interaction of biological, physical and importantly, social components. This dynamic and interactive nature generates many opportunities, but also challenges for long-term, large-scale manipulation experiments such as The Little Stringybark Creek (LSC) Project. This project used a long-term before-after-control-reference-impact design to investigate the effects of dispersed lot- and precinct-scale water sensitive urban design applied across a whole catchment on in-stream ecological integrity. We selected 7 streams located in eastern Melbourne; 3 reference sites with little or no stormwater impacts, 3 urban controls, and LSC; our impact stream where we sought to retrofit existing stormwater infrastructure. Stream hydrology, structure and function have been monitored across all sites since 2001 and LSC stormwater treatment works began in 2008.

Results/conclusions: By the end of 2012, runoff from ~20 ha of impervious surfaces will be retained via harvesting and infiltration systems ranging in size from ~100 m^2 roofs to ~1 ha precincts. However over the study duration, infill development added a further ~5 ha of impervious surfaces; which unexpectedly necessitated working with council to implement new catchment wide planning regulations to prevent further connection of impervious surfaces. Despite varying climatic conditions throughout the study, our experimental design will allow a robust assessment of changes in LSC resulting from our manipulations. This project demonstrates the numerous challenges facing large-scale manipulation projects in urban ecosystems.

Samantha Imberger is a post-doctoral research fellow working in the waterway ecosystems research group at the University of Melbourne. Samantha's research focuses on the impacts of urbanisation on the structure and function of aquatic ecosystems.

Conserving birds and their habitat in urban and future urban landscapes

Karen Ikin[1], David Lindenmayer[1], Adrian Manning[1]
[1]The Fenner School of Environment and Society, The Australian National University

Background/question/methods: A significant challenge for conservationists, urban policy makers, planners and developers is to predict and prepare for the effects of urbanisation on biodiversity. Previous studies have shown that urban areas vary in their capacity to support biodiversity, suggesting that the appropriate design of urban landscapes can lead to improved outcomes for conservation. However, to achieve this, sound whole-of-landscape scientific evidence on which to base planning, management and conservation priorities is needed. We took a landscape ecology approach to this challenge, and investigated patterns of landscape use by birds in urban and future urban areas in Canberra, Australia. We asked (1) What are the relationships between birds and their habitat? (2) How can we use this information to guide urban strategies to achieve positive conservation outcomes? We approached these questions from three perspectives representing the spectrum of urbanisation: a landscape targeted for future urbanisation, the urban fringe where suburbs and protected areas meet, and within the centres of established suburban areas.

Results/conclusions: In this synthesis, we draw out key themes regarding: the importance of trees in the urban landscape, the relationship between habitat structural complexity and bird diversity, the value of degraded land and the provision of novel resources and the importance of management in the matrix. Based on our findings, we recommend a series of evidence-based strategies for urban planning, policy and management which can improve the city's capacity to support and maintain a rich diversity of birds.

Karen Ikin is a post-doctoral fellow with the Fenner School of Environment and Society, ANU. Her research focuses on the conservation, planning and management of habitat for diverse wildlife communities in mixed-use landscapes.

Diverse social values drive heterogeneity in urban parks and gardens

Virginia Harris[1], Caragh Threlfall[1], Dave Kendal[2], Amy Hahs[2]
[1]School of Land and Environment, University of Melbourne, [2]Australian Research Centre for Urban Ecology, Royal Botanic Gardens Melbourne

Background/question/methods: Urban parks and gardens are significant contributors to urban ecosystems, containing most of the vegetation that occurs in cities. These green spaces are also important to people for a range of social and ecological reasons including recreation, social networking, and biodiversity. Greater understanding of these values will help us to understand the relationship between the social values that shape green spaces, and the ecological implications of them. This study explored the values assigned to parks and gardens by the urban public through a postal questionnaire of 750 residents of south-eastern Melbourne.

Results/conclusions: Distinct park value groups were identified for public use, nature-for-people, and intrinsic natural values. Distinct garden value groups were identified for social and for native plant and animal values. There was little correlation between park and garden values, suggesting that people value public and private green spaces differently. However there were correlations between value groups and people's landscape preferences (e.g. use values correlated with preference for English landscape style parks, while natural values correlated with preference for dense vegetation).

Different types of parks and gardens are required to meet the needs and expectations of the public. These values strongly reflect the existing network of heterogeneous green spaces in Melbourne. While previous research has shown how the pressure of social norms can led to homogeneity in urban green spaces, this research suggests that different people have very different values and attitudes, which helps to explain the very high levels of plant and wildlife diversity observed in urban systems around the world.

Dave Kendal is interested in social and ecological patterns related to urban vegetation, particularly cultivated vegetation in gardens, parks and streets at global and local scales. He is interested broadly in applying different social science theory to the study of urban ecosystems.

Delayed effects of fragmentation on remnant woodlands of a rapidly urbanising biodiversity hotspot

Cristina Estima Ramalho[1], Etienne Laliberté[1], Pieter Poot[1], Richard Hobbs[1]
[1]The University of Western Australia

Background/question/methods: Contemporary urbanisation is leading to the rapid and extensive fragmentation of natural vegetation into small and scattered urban remnants. Understanding what factors alter plant communities in these newly formed remnants requires the consideration of the complex effects of fragmentation and how these might be delayed in time. We investigated the effects of fragmentation on plant species richness and abundance in 30 remnant *Banksia* woodlands of the rapidly expanding city of Perth, located in the south-western Australian global biodiversity hotspot. We considered a comprehensive set of factors characterising landscape fragmentation dynamics (current and past remnant area, time since isolation, and trajectories of landscape change), disturbance regimes (fire frequency, grazing intensity, and human activities), and local environmental conditions (soil nutrient status and litter depth). We used structural equation modelling to disentangle the direct and indirect effects of landscape and local factors on plant species richness and abundance.

Results/conclusions: We found that remnant *Banksia* woodlands in Perth are in a slow trajectory of change and that plant community responses to urbanisation-induced fragmentation are time-lagged. Nevertheless, the smaller and older remnants already indicate several changes in the plant community, local environmental conditions and disturbance regimes due to fragmentation, providing clues for urban planning and management that could help diminishing the impacts of urbanisation in the south-west Australian biodiversity hotspot.

Cristina Estima Ramalho has submitted her PhD thesis and is in the process of obtaining her final diploma. Cristina's PhD research is at the intersection between plant, landscape and urban ecology, and conservation planning.

On the road to ruin: metapopulation collapse in an endangered frog exposed to urbanisation

Geoffrey Heard[1], Michael Scroggie[2], Andrew Hamer[3], Michael McCarthy[1], Kirsten Parris[1]
[1]School of Botany, University of Melbourne, [2]Arthur Rylah Institute for Environmental Research, DSE, [3]Australian Research Centre for Urban Ecology, Royal Botanic Gardens of Victoria

Background/question/methods: Metapopulations can undergo swift declines in urbanising landscapes, because urbanisation undermines the balance of population extinction and colonisation that characterises these systems. Urbanisation leads to the loss, degradation and fragmentation of habitat, and can increase both the rate and severity of environmental perturbations. Metapopulation dynamics may unravel under these conditions, due to simultaneous increases in the risk of population extinction and decreases in the likelihood of patch colonisation. In this study, we compiled occupancy data for the endangered growling grass frog (*Litoria raniformis*) from 200 sites across northern Melbourne monitored between 2002 and 2012. *Litoria raniformis* relies on a balance of population extinction and colonisation, but urban growth threatens this balance across northern Melbourne. We used a Bayesian approach to quantify changes in wetland occupancy by *L. raniformis* between 2002 and 2012, and to predict occupancy trajectories given further urban growth.

Results/conclusions: Wetland occupancy by *L. raniformis* declined by 25% across northern Melbourne between 2002 and 2012. This includes the complete loss of several metapopulations, and the near loss of others. Habitat loss, degradation or fragmentation can be directly linked to some population extinctions. In other cases, urbanisation appears to have exacerbated existing perturbations, such as flash flooding. Without significant investment in wetland enhancement and creation schemes, we predict that wetland occupancy by *L. raniformis* will fall precipitously with further urban growth. Our study highlights the non-linear effect of urbanisation on metapopulation viability, and demonstrates the value of long-term data for quantifying and predicting the response of metapopulations to urban expansion.

Drs Geoffrey Heard, Michael McCarthy and Kirsten Parris are part of the QAECO Group at the University of Melbourne. Collaborations with Drs Andrew Hamer (ARCUE) and Michael Scroggie (ARI) are supported by an ARC Linkage Project on frog metapopulation management.

Concurrent session 10B
Sampling, monitoring and experimental design

Hypotheses, the Reverend Bayes, models and prediction: is our data-analysis paradigm changing?

Gerry Quinn[1], Ralph Mac Nally[2]
[1]School of Life and Environmental Sciences, Deakin University, [2]Australian Centre for Biodiversity, Monash University

Background/question/methods: The increasing sophistication of scientific and management questions being addressed by ecologists, and the complex nature of the data collected in both sampling and experimental programs, mean that more complex statistical analyses are required for cogent interpretation and for meaningful decision making. Researchers face a bewildering array of statistical methods, with new suggestions for to analyses appearing regularly in the literature and in software, and with some philosophical debates between different schools of statistical thought remaining unresolved.

Results/conclusions: We discuss some statistical topics of relevance to ecologists, each in the context of the debate between frequentist methods and Bayesian approaches to data analysis and modeling. First, recent advances in fitting and evaluating models linking response to predictor variables have gone beyond standard regression and ANOVA and can provide ecologists with greater predictive power. Second, methods have been developed to overcome the constraints imposed by traditional statistical modeling that requires independence of residuals and that ignores valuable correlation structures in many ecological datasets. Third, how we should teach statistical skills to the next generation of ecologists, some of whom are arriving at university with weak backgrounds in mathematics? We conclude with some recommendations for statistical training of early career researchers in ecology.

Gerry Quinn is Chair in Marine Biology at Deakin University's Warrnambool Campus and Ralph Mac Nally is Director of the Australian Centre for Biodiversity at Monash University.

The optimal number of surveys when detectability varies

Michael McCarthy[1], Alana Moore[1], Joslin Moore[2], Kirsten Parris[1]
[1]School of Botany, The University of Melbourne, [2]Australian Research Centre for Urban Ecology, Royal Botanic Gardens Melbourne

Background/question/methods: Species might not be detected when present at a site, such that the absence of a species cannot be determined with certainty. Several methods have been developed to account for imperfect detectability when designing revisitation studies, environmental impact assessment, and models of species distributions. However, these designs do not account for variation in detectability, yet there can be substantial unexplained variation in detection rates between visits or observers. This variation might be important because unpredictable variation in detectability suggests a trade-off when designing surveys. The chance of encountering favourable survey conditions increases with the number of surveys, but the time that would be available for surveys would decline due to extra fixed costs (e.g., travel time). Similarly, variation in detection rates between observers suggests a trade-off between the number of observers sent to search a site and the time that each observer has available to search. We present a model with variable detectability that addresses these trade-offs between the number of surveys/observers and the length of each survey/search, and their costs.

Results/conclusions: We show how the optimal number of surveys depends primarily on the coefficient of variation of the detection rate, and the ratio of the total budget available for surveys to the fixed costs of initiating each survey. We apply the model to two case studies—identifying the optimal number of visits to a site for frog surveys and the optimal number of observers to allocate to a vegetation survey searching for a specific plant species.

Michael McCarthy develops, analyses and evaluates models to assist environmental management and to provide ecological insight. Information on his research group is available from http://qaeco.com.

Designing occupancy surveys and interpreting non-detection when observations are imperfect

Brendan Wintle[1], Terry Walshe[1], Kirsten Parris[1], Mick McCarthy[1]
[1]Quantitative and Applied Ecology, School of Botany, University of Melbourne

Background/question/methods: Widely used statistical methods estimate the probability that a species will be detected during a biological survey of an occupied site. However, estimates of detection probability are alone not sufficient to calculate the probability that a species is present given that it was not detected. We demonstrate methods for correctly calculating (1) the probability a species occupies a site given one or more non-detections, and (2) the number of sequential non-detections necessary to assert, with a pre-specified confidence, that a species is absent from a site. Occupancy data for a tree frog in eastern Australia serve to illustrate methods that may be applied anywhere species' occupancy data are used and detection probabilities are <1.

Results/conclusions: We show that the number of sequential non-detections necessary to assert that a species is absent increases nonlinearly with the prior probability of occupancy, the probability of detection if present, and the desired level of confidence about absence. If used more widely, Bayesian analytical approaches to interpreting occupancy data would improve study design and inference, and provide a coherent way to set minimum survey effort requirements for monitoring, impact assessment and distribution modelling.

Brendan Wintle is Associate Professor in Conservation Ecology and ARC Future Fellow in the School of Botany at the University of Melbourne, Deputy Director of the NERP Decisions Hub and theme leader in the ARC Centre of Excellence for Environmental Decisions. He likes possums.

Causal modelling with multivariate species data

Warren Paul[1], Marti Anderson[2]
[1]Department of Environmental Management and Ecology, La Trobe University, [2]New Zealand Institute for Advanced Study, Massey University, Auckland

Background/question/methods: Causal modelling facilitates the design and analysis of an observational study, and in certain circumstances it enables some causal inferences to be drawn from observational data. It requires careful logical thought regarding the data-generating process, which includes the mechanisms that might be driving observed ecological change, and it guides the search for covariates that may need to be measured in order to control potential confounding factors. We propose here a method for building and testing causal models that uses ordination axes arising from multivariate species data. This is demonstrated through the analysis of macrobenthic species abundance data observed at multiple times before and after the 1978 Amoco Cadiz oil spill (Dauvin 1982). The available data consist of 21 quarterly observations on 257 species during the period 1977-1982.

Results/conclusions: A causal model of the impact and subsequent recovery was built and tested using distance-based redundancy analysis (dbRDA). In addition, to predict the time required for recovery of the community, nonlinear models were fitted to the first two PCO axes. The fitted nonlinear models were used to generate predictions for 20 years beyond the last observation in the data set, and these predictions were found to compare favourably with the results from longer term studies carried out by Dauvin (1998). The approach described here lends itself to a general approach for causal modelling of multivariate species data as a whole community. We outline the steps of this proposed method and discuss some of the limitations and advantages of causal modeling in an ordination setting.

Warren Paul is a lecturer in statistics within the Department of Environmental Management and Ecology at La Trobe University. His research interests include causal modelling of ecological systems and multivariate methods for detecting and modelling the effects of environmental disturbances. He is an accredited statistician (SSAI) and an active consultant.

Using adaptive management principles to design an ecological thinning trial in river red gum forests

Emma Gorrod[1], David Keith[1], Paul Childs[1], Michael Pennay[2], Patrick Pigott[3]
[1]NSW Office of Environment and Heritage, [2]NSW Environment Protection Authority, [3]Parks Victoria

Background/question/methods: In newly gazetted river red gum (RRG, *Eucalyptus camaldulensis*) reserves in both NSW and Victoria, there is concern that widespread RRG forest stands exhibiting high stem density and canopy dieback may negatively affect the regional persistence of indigenous species through a paucity of critical habitat features. NSW Office of Environment and Heritage and Parks Victoria have collaborated to address these concerns using an adaptive management framework. Adaptive management emphasises the use of process models to identify causal processes and gaps in knowledge about the system, which in turn underpin an experimental design. A process model, an experimental design and a monitoring plan have been developed for an ecological thinning trial in Barmah (Vic) and Millewa (NSW) National Parks.

Results/conclusions: The central tenet of the process model for RRG forests is that competition for scarce water (and other) resources is the primary causal process contributing to high stem density and canopy dieback. It is postulated that ecological thinning will reduce competition amongst retained stems, facilitating development of hollow bearing trees, improve canopy health and increase understorey structural diversity. The experimental design for the trial consists of a randomised block design stratified by coarse indicators of competition: initial stem density and water availability. Sites are replicated in Barmah and Millewa, affecting a total of 396 ha. Pre-thinning monitoring is under way and thinning will commence with recession of current floodwaters. The approach adopted here may be a useful template for integrating ecological knowledge into assessment of alternative management options.

Dr Emma Gorrod manages the Adaptive Management Science Unit within NSW OEH. She has collaborated with NSW national park managers and Parks Victoria to implement adaptive management in river red gum forests.

Monitoring for outcomes in an Australian conservation incentive program: Environmental Stewardship Program

Geoffrey Kay[1], Jeff Wood[1], David Lindenmayer[1]
[1]Fenner School of Environment and Society, Australian National University

Background/question/methods: The importance of incorporating biodiversity conservation into sustainable agricultural production systems is globally recognised, and increasingly market-based incentive schemes are being developed towards this goal. A novel large-scale biodiversity incentive scheme—the Environmental Stewardship Program (ESP)—has been developed in Australia which contracts individual landowners for up to 15 years to protect and manage nationally endangered ecological communities. We report on the design and implementation of ecological monitoring for the ESP targeting the critically endangered box gum grassy woodland (BGGW) ecological community of south-east Australia which, reduced to <4% of their original extent, persist as small remnants of variable condition mostly on private farmland. A network of 'ESP incentive' and matched 'control' sites were established on 153 farms spanning 172,232 sq km (7 NRM regions) from southern New South Wales to southern Queensland. Terrestrial biodiversity (bird, reptile, amphibian and mammal) and ecosystem structure data were gathered at each site over a baseline period (2010-11) and repeated in 2012 (not presented here).

Results/conclusions: Survey results over the baseline period reveal no difference in faunal species richness between investment and control sites, nor across NRM regions. Vegetation exhibited more complex relationships between investment and control sites, as well as between NRM regions. Multiple detections of species of conservation concern highlight the importance of remnant BGGW on private land. Furthermore, increased overstorey sapling richness and abundance at incentive sites over time indicate targeted management of these private refuges could lead to broader ecological outcomes over longer timeframes.

Geoffrey Kay is a Project Manager in Prof David Lindenmayers research group. He manages a large long-term ecological monitoring project (called the Environmental Stewardship Project) which focuses on conserving on-farm biodiversity through provision of financial incentive scheme for landholders.

Concurrent session 10C
Landscape disturbances and consequences

Long-term monitoring for fire management: ten years on in the Australian Alps

Margaret Kitchin[1], Genevieve Wright[2], Geoff Robertson[2], Daniel Brown[3], Arn Tolsma[4], Steve Stern[5]
[1]Conservation Research, ACT Environment and Sustainable Development, [2]NSW Office of Environment and Heritage, [3]Parks Victoria, [4]Victorian Arthur Rylah Institute, [5]Australian National University

Background: The interaction between fire and Australia's alpine vegetation is complex and information about long-term impacts is scarce. In moving to address this, in 1996 the cooperative management program of the Australian Alps established forty long-term monitoring vegetation survey plots to better understand and manage the impacts of fire. Plots are located in the montane and sub-alpine forest and woodlands of the three Alpine National Parks of Kosciuszko (NSW), Alpine (Victoria) and Namadgi (ACT). Baseline surveys were undertaken in March and April of 1996 recording all vascular plant species, cover/abundance and structural elements. The sites were permanently marked with star pickets and photo-monitoring. The survey design was to wait until fire occurred in some of the plots and then start a 5-year monitoring sequence. Survey started after the widespread 2003 wildfires which burnt nearly all of the original plots.

Results/conclusions: Results show that species richness recovered quickly within 1-2 years after fire and there was little change in floristic composition. The wetter forests were slower to recover than drier peppermint communities. The vegetation structure was still recovering 5 years after the fire. Fire frequency and interval variables were not statistically significant. The surveys collected much data on post-fire regenerative mechanisms and recovery periods following high intensity wildfire. Results from these surveys have informed fire management planning in the Alps region and the paper will provide insights into the challenges of large-scale monitoring and the utility of these plots for long-term Alps fire monitoring.

Margaret Kitchin is the Forest Ecologist with ACT Conservation Research. She works on fire ecology and its application for management of ACT's natural areas.

Guidelines for ecological burning regimes in *Banksia* woodlands: challenges in a peri-urban system in Western Australia

Barbara Wilson[1], Leonie Valentine[1,2], Janine Kuehsa[1], Tracy Sonneman[1], Kristen M Wolfe[1]
[1]Department of Environment and Conservation, [2]School of Veterinary Biology and Biomedical Sciences, Murdoch University

Background/question/methods: In Mediterranean ecosystems a major challenge for land managers is the development of fire regimes that are optimal for biodiversity and reduce the occurrence of damaging wildfires. The aim of this study was to develop guidelines for ecological fire regimes in a peri-urban landscape dominated by remnant *Banksia* woodlands. Tolerable fire intervals of key fire flora and fauna response species were determined based on plant juvenile periods and fauna requirements, and fire history over four decades was analysed. Temporal and spatial distribution of post-fire ages at the landscape and local scales were assessed and ideal age class distributions estimated.

Results/conclusions: Based on tolerable fire intervals it was recommended that a minimum fire interval of 8-16 years be adopted for the woodland communities. The fuel age distribution at the landscape level and within major vegetation communities was highly skewed to 1-6 years post-fire age and areas of old fuel age (>21 years) were very low. The current fire regime has implications for key flora and fauna species, particularly those that require long-unburnt *Banksia* woodlands, such as the critically endangered Carnaby's black-cockatoo (*Calyptorhynchus latirostris*), honey possum (*Tarsipes rostratus*) and common dwarf skink (*Menetia greyii*). Planning to protect and increase areas of long-unburnt vegetation is recommended for these species. Susceptible biota associated with wetlands (southern brown bandicoot *Isoodon obesulus*, water rat *Hydromys chrysogaster*) also require protection from frequent fire. The guidelines provide a model for ecological burning regimes for optimal biodiversity outcomes in similar Mediterranean ecosystems.

Barbara Wilson is currently acting as manager of conservation in the Swan Region Perth. Her research interests include mammal ecology, fire ecology and the impacts of *Phythophthora cinnamomi* on flora and fauna.

Adding fuel to the fire: will revegetation of agricultural landscapes lead to bigger wildfires?

Luke Collins[1], Trent Penman[1], Ross Bradstock[1], Owen Price[1]
[1]Centre for Environmental Risk Management of Bushfires, University of Wollongong

Background/question/methods: There has been an increasing occurrence of revegetation across agricultural landscapes globally, largely because of the environmental benefits these plantings provide. However, the effect increased native vegetation cover will have on fire regimes within these landscapes is unknown. This project assesses how revegetation is likely to alter wildfire size and intensity across agricultural regions of the Hawkesbury-Nepean Catchment of south-eastern Australia. The Phoenix fire characterisation model was used to simulate fire behaviour under a range of revegetation scenarios (i.e. 5%, 10% and 30% increase and complete revegetation), pasture fuel biomass and fire weather conditions.

Results/conclusions: The effect of revegetation on fire size and intensity was dependent upon pasture fuel biomass, fire weather and current native vegetation extent. Under low pasture fuels (2 tha^{-1}), increasing native vegetation cover led to an increase in fire size. When pasture fuels were moderate (4.5 tha^{-1}) or high (7 tha^{-1}), fire size decreased with increasing native vegetation cover within landscapes that had been extensively cleared, but showed little change within landscapes that experienced low levels of clearing. Changes in fire size were relatively small under the 5% and 10% revegetation scenarios and all but the most extreme fire weather conditions. Fire intensity followed similar patterns to fire size. The results of our study suggest that revegetation of agricultural areas at levels that are likely to be achieved under current revegetation schemes (~5%), or could possibly occur under future carbon sequestration initiatives (~10%), are unlikely to lead to major changes in wildfire size or intensity.

Luke Collins is a postdoctoral researcher at the University of Wollongong. His research focuses on (i) how landscape change and fire management strategies alter fire risk, (ii) how climate, landscape and fuels interact to shape fire regimes and (iii) the effect fire regimes have on habitat and biodiversity.

Community safer places? Determinants of patches remaining unburnt in a major wildfire

Steve Leonard[1], Mike Clarke[1], Andrew Bennett[2]
[1]Department of Zoology, La Trobe University, [2]School of Life and Environmental Sciences, Deakin University

Background/question/methods: Periodic large wildfires contribute to landscape heterogeneity in many ecosystems globally. Vegetation patches that remain unburnt within large fire boundaries can act as refuges for plants and animals, allowing them to survive fire and persist in the post-fire landscape. Planned burning is often advocated as a means of promoting the occurrence of refuges. This study examined the factors influencing whether patches remained unburnt during the Black Saturday fires that occurred in Victoria, Australia in February 2009. We ascertained topographic, vegetation and fire history attributes of points within all unburnt patches greater than 1 ha within the fire boundary (100) and 419 burnt points. We then identified the variables that best discriminated burnt and unburnt points.

Results/conclusions: For the whole landscape, unburnt patches typically occurred in deep, rainforest or wet forest gullies. Generally, time since fire had only a minor influence. However, in dry forest, time since fire was much more important, with half of unburnt dry forest points having been burnt <6 years prior to 2009. Dry forest unburnt patches exhibited lower perimeter-area ratios than wet/rainforest patches and differed markedly in terms of vegetation structure and composition.

Differences in the mechanisms producing unburnt patches are reflected in their post-fire attributes, and hence their refuge value for any given species. Furthermore, the kind of planned burning that increases the likelihood that dry forest patches will remain unburnt during wildfire appears likely to increase the contrast between these patches and those of wetter forest types and reduce patch refuge value for fire-sensitive species.

Steve Leonard completed his PhD on the effects of herbivory on grassland flammability at the University of Tasmania in 2009. Since then he has pursued an interest in the interactions between fire, vegetation and fauna. He is currently working on fire ecology projects in forest and Mallee systems.

Facing facts about fire in the desert: are we managing for conservation?

Glenda Wardle[1], Aaron Greenville[1], Chris Dickman[1]
[1]Desert Ecology Research Group, The University of Sydney

Background/question/methods: Fires alter vegetation cover and the habitat resources available for wildlife. To control the spatial extent and connectedness of wildfire, fire management plans often recommend a combination of fire-breaks, prescribed burns and active fire suppression. However, evidence for the effectiveness, or failure, of these measures is limited. We used satellite imagery to map the fires, spectral indices to track vegetation recovery and field assessment to determine how graded lines, burnt breaks, vegetation type, clay pans, land tenure and previous fire history influenced the 2011/2012 fires in the Simpson Desert.

Results/conclusions: The strongest factor in shaping the spatial extent of the 2011/2012 fires was a decade-old wildfire scar. Graded breaks (3 blades wide), burnt breaks (~100m wide), and fire suppression activities during the fires did not substantially alter the area burnt. Cattle grazing also did not reduce the area burnt (cattle station 30.8%) compared to two conservation reserves (Ethabuka, 13.2% and Cravens Peak, 19.2%).

It is time to face facts. We have limited ability to change the outcomes of large fires in remote areas, vegetation recovery is rain-dependent, and the appropriate fire regimes are often unknown. Increased predation by feral animals has more impact on wildlife than fire per se. Therefore, much of the activity directed towards fire suppression in deserts may be futile. Instead, efforts to track fire weather and managing ferals may prove more useful. To improve the outcomes for the conservation of wildlife we must address these issues directly and 'call a spade a spade'.

Glenda Wardle is an Associate Professor in Ecology and co-leader of the Desert Ecology Research Group. Her long-term research in the Simpson Desert explores the dynamics of populations, species and ecological interactions in relation to ecological drivers such as unpredictable rainfall, changing climates, fire, and grazing.

Concurrent session 10D
Community assembly and resource dynamics

Species traits predict biodiversity dynamics at ephemeral resource patches created by carrion

Philip Barton[1], Saul Cunningham[2], Ben Macdonald[3], Sue McIntyre[2], David Lindenmayer[1], Adrian Manning[1]
[1]Fenner School of Environment and Society, Australian National University, [2]CSIRO Ecosystem Sciences, [3]CSIRO Land and Water

Background/question/methods: Carrion is an ephemeral and spatially patchy resource that supports a diverse subset of species linked to nutrient cycling and the decomposition process. A number of studies have separately documented changes in the diversity of plants, arthropods and vertebrates at individual carcasses, but surprisingly little is known about the traits that underpin these responses. We used a carcass addition experiment to assess how dynamic changes in species composition were related to species traits.

Results/conclusions: We found that changes in insect assemblage evenness and heterogeneity were determined by species' dispersal traits, and that plant assemblage responses to subsequent soil nitrogen changes was most apparent among graminoids and exotic species. In particular, large and manoeuvrable beetles and plants with high specific leaf area displayed strong responses to the carcass addition. These results provide an integrated example of how traits of different groups of organisms enable them to exploit patchy and dynamic resources, and establish a clearer mechanistic understanding of how carcasses can drive biodiversity dynamics. This raises important questions about the way animal remains are managed in natural ecosystems, such as leaving sufficient carcasses to decompose in situ to ensure spatial and temporal continuity in this resource.

Philip Barton is a community ecologist interested in the spatial and temperal drivers of biodiversity dynamics. He has a particular interest in beetles.

Convergence of multitrophic community structure across three continents

James Cook[1,2], Simon Segar[2]
[1]Hawkesbury Institute for the Environment, University of Western Sydney, [2]School of Biological Sciences, University of Reading, UK

Background/question/methods: Ecologists have long sought rules for community assembly, but with limited success. Recently, some studies have achieved deeper understanding of community assembly by also incorporating evolutionary (phylogenetic) history. However, this integrative approach has been largely limited to assemblages of species at one trophic level. We studied multi-trophic fig wasp communities to test if their guild structure has converged across three continents, or if evolutionary history constrains the similarity of communities using the same resources in different places. We conducted long-term quantitative field sampling of insects in Australia, Africa and America and also estimated the phylogenetic relationships of all insect species sampled.

Results/conclusions: No insect species and few genera or subfamilies were shared between continents and species diversity also varied considerably. Evolutionary history therefore plays a strong role in local community composition, but what are the consequences for community structure? To answer this question we defined five insect guilds—three of herbivores and two of parasitoids—that differ in their resource use. We found that community structure at the guild level was remarkably conserved across continents. Niches are generally conserved within wasp subfamilies, but different lineages have sometimes evolved to fill the same niche space in different continents. However, this alone is not sufficient to conserve community structure and we also identify cases where a single lineage has radiated locally to fill multiple niches. Overall, ecological community structure is remarkably conserved across continents, despite major differences in evolutionary history.

James Cook is an evolutionary ecologist with particular interests in symbiosis and reproductive behaviour. His current research focuses on insect/plant and insect/microbe interactions within their wider community context and how species interactions change along environmental gradients.

Competitive interactions between forest trees are driven by species' trait hierarchy, not phylogenetic or functional similarity: implications for forest community assembly

Georges Kunstler[1,2]
[1]Department of Biological Sciences Macquarie University, [2]Mountain Ecosystems Research Unit, France

The relative importance of competition vs. environmental filtering in the assembly of communities is commonly inferred from their functional and phylogenetic structure, on the grounds that similar species compete most strongly for resources and are therefore less likely to coexist locally. This approach ignores the possibility that competitive effects can be determined by relative positions of species on a hierarchy of competitive ability. Using growth data, we estimated 275 interaction coefficients between tree species in the French mountains. We show that interaction strengths are mainly driven by trait hierarchy and not by functional or phylogenetic similarity. On the basis of this result, we thus propose that functional and phylogenetic convergence in local tree community might be due to competition-sorting species with different competitive abilities and not only environmental filtering as commonly assumed. We then show a functional and phylogenetic convergence of forest structure with increasing plot age, which supports this view.

Georges Kunstler is a forest ecologist at Irstea (Grenoble France) working in Mark Westoby' group at Macquarie University for 2 years. He has several research areas, including the impacts of global change on forest dynamics, tree demography, competition/facilitation, and plant functional traits.

Vegetation patterns and processes inside and outside groves of *Casuarina pauper* in a chenopod shrubland

José M Facelli[1], Andrew Barritt[1]
[1]School of Earth and Environmental Sciences, The University of Adelaide

Background/question/methods: Recent research in arid lands has documented the functional importance of patches created by individual perennial plants. In chenopod shrublands, *Casuarina pauper* form groves of a few hundred square meters to a few square kilometres. Here investigated the differences in soil nutrient content, understorey vegetation and grazing by sheep and kangaroos between groves and open spaces in a landscape with negligible slope. We used surveys (soils, soil seed bank, vegetation, and animal activity) to compare groves with nearby open areas, and selected one grove to perform experimental tests. We transplanted blocks of soil between the two sites (to separate effects of soil and microclimate), and fenced plots (to determine effect of different grazing regimes).

Results/conclusions: We found higher content of N and organic C in soils inside the grove and lower light intensities, and minimum and higher maximum temperatures. Faeces counts indicated that the kangaroos used groves more frequently than open areas, while the opposite was true for sheep. Soil seed banks (assessed by seedlings emergence in a glasshouse study) were substantially different. There were also differences in the annual and perennial vegetation inside and outside groves. Irrespective of soil origin, more seedlings of *Carrichtera annua* emerged inside the groves, but there was no difference between fenced and unfenced plots. Overall, we documented substantial differences between the environment and the vegetation of the two landscape elements. Unsurprisingly we were unable to detect one single factor that accounts for the differences observed, but environmental conditions seemed to be more important than grazing regime.

José Facelli has always been interested in small-scale spatial and temporal heterogeneity in ecological processes in plant communities: what causes heterogeneity? What are the consequences of heterogeneity? José sees variability not as noise, but as the music of ecological systems.

The functional assembly of experimental grasslands in relation to fertility and resource heterogeneity

Jodi Price[1], Antonio Gazol[1], Riin Tamme[1], Inga Hiiesalu[1], Meelis Pärtel[1]
[1]University of Tartu, Department of Botany

Background/question/methods: Traditional species coexistence theory suggests niche differences among species are key drivers of coexistence (limiting similarity), and increased heterogeneity of resources enables more species to coexist (niche partitioning). Two predictions follow—co-occurring species should be more different than expected, especially in competitive conditions, and heterogeneity should increase species and functional diversity. However, no studies have examined the relationship between resource heterogeneity and plant functional diversity. We examined niche overlap in functional traits along a fertility and resource heterogeneity gradient in a mesocosm experiment to determine if species are more different than expected. Treatments included a gradient of soil nutrient availability (low, medium, high) and resource heterogeneity (all of medium fertility—homogeneous, small- and large-scale heterogeneous).

Results/conclusions: With increased fertility we found more niche overlap in leaf size and plant height, but the opposite pattern was found for specific leaf area. Greater niche overlap with increased fertility can be due to habitat filters restricting the range of trait values, and competition as weaker competitors are excluded, rather than limiting similarity. In the heterogeneity treatments (for some traits) niche overlap was greater than the in homogenous treatment of the same overall fertility, and was most similar to the high fertility treatment. Hence, if high resource patches are available, some species adapted to heterogeneity per se can access resource-rich patches. Increased similarity among species with increased heterogeneity supports heterogeneity as a separate niche axis theory, rather than niche partitioning. These modern community assembly theories will be discussed.

Jodi Price is a community ecologist interested in a broad range of topics including assembly processes, disturbance, invasion, and restoration ecology. Most recently Jodi has worked on grassland assembly at global scales.

Is the threat posed by coextinction overestimated in the world's biodiversity hotspots?

Melinda Moir[1], Peter Vesk[1]
[1]School of Botany, University of Melbourne

Coextinction, or the loss of dependent species due to declines in the population of the host, is possibly one of the greatest threats to biodiversity. This is particularly so in the 34 global biodiversity hotspots, where the number of potential host species is higher. We provide the first empirical evidence from a global hotspot (the south-west of Australia) to test these predictions of coextinction for areas of high floristic diversity are correct. We quantified the realised host use of insects on 104 plant species. The estimated host breadth of dependent taxa ranged from one to over 60 hosts, with few highly host-specific taxa suggesting that coextinction may have been over-emphasised for the majority of plant hosts and their dependent insect assemblages. However, coextinction remains a high threat for particular insect assemblages. We discuss the main factors contributing to a dependent assemblage and individual insect species being prone to coextinction.

Melinda Moir is a research associate working on coextinction, particularly in the context of insect-plant relationships.

Concurrent session 10E
Environmental management for species

Testing the effectiveness of habitat restoration targeted at grey-crowned babblers

Peter Vesk[1], Michael McCarthy[1], Doug Robinson[2], Rod van der Ree[3], Caroline Wilson[3]
[1]Quantitative and Applied Ecology Group, School of Botany, University of Melbourne, [2]Trust for Nature, [3]Australian Research Centre for Urban Ecology, Royal Botanic Gardens Melbourne

Background/question/methods: Effectiveness of habitat restoration and revegetation is rarely assessed sensitively. Sampling design, performance measures and analyses are often suboptimal. Demonstrating effectiveness is important to evaluate the state of knowledge about management and also to justify the considerable resources devoted to revegetation and restoration activities. The revegetation of temperate woodlands and the population status of birds that inhabit them provide a case in point. Here we assessed a restoration program targeted at the grey-crowned babbler, with a main hypothesis that habitat works increased group size. We used surveys 10 years apart and measured social group size at 117 sites stratified by presence/absence of works and detection or not of birds in the first survey.

Results/conclusions: Babbler group size decreased at sites without habitat works, but works stemmed declines. Groups at apparently colonised sites were influenced by local habitat quality, but not by habitat works. We attribute this to a delay in habitat resource development at recently colonised sites owing to targeting of sites for restoration based on babbler occupancy. Effectiveness of habitat works was only demonstrable by sampling through time and including controls. Without controls we would have concluded no change, ignorant of the good outcome that this was compared to decline at unmanaged sites. Without sampling through time we would not know that there is ongoing decline and maybe overestimate the effectiveness of works. Our work points to the improvements needed in evaluation of environmental management programs.

Peter Vesk is part of a bunch of folk who care about conservation and environmental management and being able to measure it.

Using Maxent to map potential nesting habitat of the Tasmanian wedge-tailed eagle

Amelia Koch[1,2]
[1]Forest Practices Authority, [2]School of Geography and Environmental Studies, University of Tasmania

Background/question/methods: The Tasmanian wedge-tailed eagle is an endemic subspecies that is listed as endangered and is dependent on forests for breeding. Eagle management in forestry areas involves placing reserves around known nests and restricting harvesting activities within 1km of a nest during the breeding season. Management is therefore dependent on being able to successfully locate new nests prior to commencing harvesting. Areas to be searched for eagle nests are currently determined from previous modelling which was done on a small data set. In recent years there has been an increase in the number of known nests across the state, due to greater search effort and possibly due to a change in areas being used by eagles. The current study uses the Maxent program to review the eagle nesting habitat model. The result is a map of Tasmania that predicts where eagle nests are most likely to be found.

Results/conclusions: Current modelling confirmed previous work which found that eagles nest in areas of tall mature forest that are protected from the wind. However, for a similar search area the new model identifies a greater percentage of the areas in which existing nests are located. This new mapping layer can be used by managers to help locate new or unknown eagle nests.

Amelia Koch completed her PhD on tree hollows at the University of Tasmania. She now works at the Forest Practices Authority conducting research to improve management of biodiversity in areas subject to forestry.

Ecological complexities of bell miner associated eucalypt forest dieback in a NSW World Heritage Area

Bryony Horton[1]
[1]National Parks and Wildlife Service, NSW Office of Environment and Heritage

Background/question/methods: Bell miner associated dieback (BMAD) is a threat to the eucalypt forests of the Gondwana Rainforests of Australia World Heritage Area (WHA) and leads to loss of ecological integrity. BMAD is the result of complex ecological and management factors including herbivory, predator-prey interactions, nutrient cycling, and past disturbances such fire history. Recent theories have hypothesised that eucalypt dieback is the result of an absence of fire in ecosystems adapted to a particular fire regime, and fire has been proposed as a treatment for BMAD.

To understand the mechanisms and effectively manage BMAD ecological data on bell miners, vegetation, and eucalypt crown condition was collected from 37 plots across nine WHA reserves. At five sites bird diversity and soil nutrition data were also collected. Linear regressions and multi-variate techniques were used to analyse the data.

Results/conclusions: Crown health declined with increases in bell miners, which was positively correlated to understorey, suggesting cover is important for habitat selection by bell miners. Rainfall was found to be a significant contributing factor to BMAD and likely important for eucalypt dieback in general.

Crowns were healthier at higher ammonium concentrations and lower nitrate, indicating nutrient cycling is important for eucalypt health. Contrary to expectation, crown health weakly improved with increasing time since fire and less frequent fire. Fire influences nitrogen availability which may help explain the trends between crown health and fire. As proposed, fire may not mitigate the effects of BMAD. Further research is required to assess the appropriateness of fire as a management tool for BMAD.

Bryony Horton works with NPWS to manage eucalypt dieback. Her research interests include forest ecology, ecosystem processes and function. Her PhD (UTas) investigated eucalypt forest decline in relation to mycorrhizae and nutrient cycling. Bryony was the inaugural recipient of the Jill Landsberg award.

Avifaunal disarray from a single despotic species: scale of the challenge and recommended responses

Martine Maron[1], ACEAS Noisy Miner Working Group[2]
[1]The University of Queensland, [2]various

Background/question/methods: The noisy miner is a native bird, but it markedly depresses the abundance of almost all smaller bird species within its territory. It is a key threatening process (KTP) in Victoria, with nominations currently being considered in NSW and nationally. Despite three decades of research establishing the species' impact on entire assemblages at a level unparalleled by a native species, there is no large-scale synthesis of the causes of and solutions to the problem. To address these information gaps, the Australian Centre for Ecological Analysis and Synthesis (ACEAS) supported formation of a working group. Drawing on its extensive experience with noisy miner impacts and management, the group developed conceptual models of noisy miner site occupancy and impact, and pooled bird survey data from over 2,500 sites in four states to test the postulated relationships. It also compared the cost-effectiveness of alternative management approaches.

Results/conclusions: This presentation will outline the findings of the working group's research. Despite the very large distribution of the noisy miner and apparently conflicting results from past research, a cohesive understanding of the factors leading to increased risk of negative effects from noisy miners was developed. A spatial model of noisy miner impact was developed. Direct culling of noisy miners was considered to be cost-effective in some circumstances, and would be most desirable where threatened species are affected and where development of a dense woodland structure is inappropriate. Management experiments are needed to test these ideas.

Martine Maron is a Senior Lecturer in Environmental Management at The University of Queensland. Her group works on the mechanisms behind species decline, the role of interspecific competition in structuring bird assemblages, and conservation policy, particularly relating to biodiversity offsets. She leads the ACEAS Noisy Miner Working Group.

A state-transition dynamic Bayesian network model for the management of willows

Yung En Chee[1], Ann Nicholson[2], Pedro Quintana-Ascencio[3]
[1]School of Botany, The University of Melbourne, [2]Clayton School of IT, Monash University, [3]Department of Biology, University of Central Florida, USA

Background/question/methods: Expansion of willows (*Salix caroliniana* Michx.) in the naturally mixed landscape of vegetation types in the Upper St Johns River Basin in Florida, USA, has undesirable impacts on biodiversity, aesthetic and recreational values. Managers need an integrated knowledge base to support decisions on where, when and how to control willows. Modelling the spread of willows over space and time requires spatially explicit data on willow occupancy, an understanding of dispersal mechanisms and how the various life-history stages of willows respond to environmental factors and management actions. We describe an architecture for a management tool that integrates environmental spatial data from GIS, dispersal dynamics from a process model and Bayesian Networks (BNs) for modelling the influence of environmental and management actions on the key life-history stages of willows. In this paper we focus on modelling temporal changes in willow stages using a form of Dynamic Bayesian Network (DBN). Starting from a state-transition (ST) model of the willow's life-cycle, from germination to seed-producing adult, we describe the process used to develop and parametrise a prototype State-Transition Dynamic Bayesian (ST-DBN) model for modelling the influence of environmental factors and management interventions on willows.

Results/conclusions: Scenario-based evaluation of the prototype ST-DBN model was conducted with our domain expert throughout the knowledge-engineering process. The interrogation of multiple scenarios designed to probe the encoded relationships for key environmentally-driven processes and expected responses to management actions verified that the structure of the prototype ST-DBN (i.e. its nodes, values and arcs) is appropriate.

Yung En Chee is a quantitative ecologist with research experience and expertise in statistical, spatial and ecological modelling. Yung's research interests and experience lie in applying ecological and decision-analytic theory, models and methods to conservation and ecosystem/natural resource management.

List of posters

Behaviours to populations

1 Managing the menace: the effects of control practices on the behaviour of common mynas (*Sturnus tristis*)
Marie Diquelou

2 The role of vegetation structure in influencing small mammal behaviour under differing predator control regimes
Nicholas Colman

3 A conservation perspective to species boundaries in *Grevillea* subgroup *floribunda*
Julie Atkinson

4 Ecology of lycosid and mygalomorph spiders, and implications for conservation of the pygmy bluetongue lizards
Jessica Clayton

5 Understanding synergistic effects of climate change and existing threats when managing extinction risk
Tracey Regan

6 Conservation management of the endangered Slater's skink, *Liopholis slateri*, in Central Australia
Claire Treilibs

Biogeochemical and ecosystem processes

1 Long-term fertilisation effects on microbial communities in arid mangrove sediments, Exmouth WA
Tegan Davies

2 Groundwater sources and bryophyte pools: water that maintains peatlands in the Bogong High Plains, Victoria
Victoria McCartney

3 Climate limitations on invasion by *Tipuana tipu*—is a national weed listing appropriate?
Melinda Trudgen

4 Tracking extreme hydroclimatic events in north-west Australia from physical and biogeochemical patterns in sediment archives
Alexandra Rouillard

5 How will climate change affect forest soil and surface litter carbon in south-eastern Australia?
Tonja Wright

Community assembly, diversity and dynamics

1 The generation and generalisation of plant functional types in fire-prone communities
Freya Thomas

2 An assessment of regional ecosystem land zones as a surrogate for floristic diversity
David Tucker

3 Long-term natural variation and turnover in a small mammal community of south-eastern South Australia
Amy Macken

4 Bioengineering by oysters across climatic gradients
Victoria Cole

5 Soil seed banks in arid Western Australia: density, composition and implications for post-mine restoration using topsoil
Eddie van Etten

Dispersal and distribution patterns

1 Using functional traits to explain distribution of woody plant species around frost hollows
Felix Lim

2 Predicting future range of the critically endangered grey nurse shark using species distribution models
Guanfang Su

3 Impacts of climate change on the distribution and abundance of understory species in Victoria's forests
Helen Vickers

4 Ant community composition along the Gwydir catchment elevational gradient
Sandia Wong

5 Investigating the dynamics of invasion: phenotypic plasticity in seed dispersal traits in the family Asteraceae
Samiya Tabassum

6 2-Way learning: science and Indigenous ecological knowledge of euryhaline elasmobranchs in the Roper River, Northern Territory
Sharon Every

7 Great mammals' distributions in a modified Brazilian landscape
Cintia Camila Silva Angelieri

8 Predicting climate change adaptability from phylogenetic and morphological signals in a key Australian plant genus, *Brachyscome*
Megan Hirst

9 AusPlots–Rangelands surveys two years on
Nikki Thurgate

Disturbance, recovery and resilience

1 Impact of ungulates on regeneration of plant species in forest ecosystems in northern New Zealand
Debashis Dutta

2 What drives the distribution of invasive mammalian predators in semi-arid Australia?
Catherine Payne

3 Bird alpha and beta diversity responses to pyrodiversity across spatial scales
Emma Burgess

4 Effects of fire regimes on vegetation and fuel hazard: a retrospective study
Annette Muir

5 The effects of fire on the abundance and population structure of terrestrial amphipods (Family: Talitridae)
Louise Menz

6 Do ant morphological traits related to liquid feeding respond to change in climate?
Katayo Sagata

7 Threatened grassland flora on the move: spiny rice-flower and matted flax-lily translocation
Wendy Jeffery

8 How much bushfire is too much for western Victoria's woodland birds?
Diana Kuchinke

Ecophysiology and environmental stressors

1 Keeping the ice away: ice barriers protect reproductive organs from frost damage in the alpine plant *Loiseleuria procumbens*
Veronica Briceno

2 Linking thermal tolerance traits to distribution limits in Australian alpine grasshoppers
Rachel Slatyer

3 How do legumes regulate nodulation and root architecture in response to variable soil nitrogen?
Chooi Hua Goh

4 Influence of urban landscape change on koala health and mortality in south-east Queensland
Brooke Mundey

5 Size does matter! Large trees are bird 'magnets' in modified landscapes
Darren Le Roux

6 What's driving male-biased offspring sex ratio in bridled nailtail wallabies, *Onychogalea fraenata*?
Emily Moore

Environmental policy and management

1 Fire, biodiversity and risk: towards best practice management of roadside reserves in south-east Queensland
Samantha Lloyd

2 ÆKOS: a new paradigm to enable discovery, access and re-purposing of complex ecological data
David Turner

3 The 'eco-cultural' revolution begins with a model for publishing government ecological data
David Turner

4 Optimal fire management to maximise animal diversity in Murray-Sunset National Park, Victoria
Katherine Giljohann

5 Is it easy or difficult to find? A general model of detectability using species traits
Georgia Garrard

Species interactions

1 Temperate grassland response to an extreme rainfall event under elevated CO_2
Anthony Manea

2 Additive basal area revisited: do emergent conifers avoid competition with their lower statured neighbours?
Bruce Burns

3 Are urban birds full of parasites?
Carlos Delgado-Velez

4 Run for cover! How species reintroductions influence termite biomass
Nicole Coggan

5 Arctic waders provide evidence that lemmings don't want to cycle anymore
Yaara Rotman

6 Associational refuge theory: can it facilitate revegetation in practice?
Rebecca Stutz

7 Snotty-gobble seedlings on a novel host
Elizabeth Maciunas

8 Light influences the responses of *Ulex europeaus* and *Leptospermum myrsinoides* to a native parasitic plant
Robert Cirocco

9 Can excluding cane toads from water provide biodiversity benefits for arid Australia?
Ben Feit

10 Predators and prey: a camera trapping survey of Wilsons Promontory's mammal community
Lucinda Gow

Abstracts—posters

Behaviours to populations

1 Managing the menace: the effects of control practices on the behaviour of common mynas (*Sturnus tristis*)

Marie Diquelou[1], Andrea Griffin[1]
[1]University of Newcastle

Background/question/methods: Common mynas have been introduced successfully to a large number of geographical locations across the planet, including to Australia 150 years ago. In the last three decades they have colonised most of the East Coast and their range continues to expand. Community perception of this urban species is highly negative. This has been a main driver of the widespread efforts to control the species at a local scale, which is done mainly through the use of baited traps.

Over 87,000 birds have already been culled across NSW and ACT. However very little research has been done to understand what effects this practice could have on common mynas. Recently, a small-scale study showed preliminary evidence of local movements and a behavioural switch towards risk-avoidance when the species is confronted to traps. This raises the question of whether mynas modify their behaviour in response to trapping, a form of human predation. This is of major importance as the spread of trap-aversion, and risk-aversion in general, could jeopardise future efforts to control the species and bias survey-based evaluations of the effectiveness of trapping control programs by changing the likelihood of detecting individuals. To investigate this question in more depth, we compared a range of variables related to risk-taking and detectability during surveys in heavily trapped and non trapped myna populations across NSW and ACT.

Results/conclusions: Differences between populations will be presented. Implications of our findings will be discussed with consideration to the success and sustainability of control practices in this species.

Marie Diquelou has been studying Common myna ecology and behaviour for the last two years and has recently started her PhD on this topic, mainly focusing on their responses to trapping.

2 The role of vegetation structure in influencing small mammal behaviour under differing predator control regimes

Nicholas Colman[1], Mike Letnic[2], Mathew Crowther[3], Chris Turbill[1], Aaron Greenville[3]
[1]University of Western Sydney, [2]Univeristy of New South Wales, [3]University of Sydney

Background/question/methods: Predators have conspicuous effects on prey when they kill them for food, but they also have subtle non-lethal effects on prey which may result in changes in their behaviour and diet. As primary productivity increases, these subtle non-lethal effects predators have on prey is predicted to wane due to: increased productivity of ecosystems, the diversity of species within them and the complexity of the vegetative structure thereby increasing the number of potential interaction pathways between predator and prey. Our study examined the influence of predator removal (fox and dingo) and vegetation structure on the behaviour of small mammals via a series of giving up density experiments (GUDs). Study sites were located in forested environments of eastern NSW.

Results/conclusions: Under differing predator control regimes habitat complexity plays a significant role in the behaviour of small mammals in forested environments. Predator controlled sites showed an increase in the removal of GUDs where vegetation complexity was low compared to those with no predator removal practices, thus demonstrating a lower predation risk at these sites. In conclusion, practices that involve the reduction of vegetation complexity (e.g. prescribe burns, bushland regeneration) should look to predator removal in order to decrease the predation of small mammals.

Nicholas Colman is currently enjoying a PhD at the University of Western Sydney. Where his project encompasses both the skull morphology of the dingo and the ecological role wild dogs/dingoes in forested landscapes of NSW.

3 A conservation perspective to species boundaries in *Grevillea* subgroup *floribunda*

Julie Atkinson[1], Susan Hoebee[1], Trevor Edwards[1]
[1]Department of Botany, La Trobe University

Introduction: Morphology, reproductive and genetic characteristics, as well as environmental constraints, all influence species boundaries. The study complex *Grevillea* subgroup *floribunda* consists of ten species, widely distributed from Queensland to Victoria. Floral divergence is evident within and among taxa but all are thought to be primarily bird pollinated. Boundaries between the three Victorian members of this subgroup (*G. alpina*, *G. celata* and *G. chrysophaea*) are taxonomically unclear. For example, numerous informal subspecific forms have been suggested for two of the species, both sexual and asexual reproduction is reported, and *G. celata* is potentially of hybrid origin with the other species suggested as its putative parental lineages. These species present an interesting scenario in which to study the processes promoting divergence and the scale at which species function.

Background/question/methods: We propose to examine this subgroup using a hierarchical approach based upon: 1) construction of a phylogeny using ITS, *matK*, *rbcL* and *waxy*, to assess the monophyly of the species, subspecies and forms; 2) exploration of the diversity within and among the Victorian species and evidence of gene flow using microsatellites (SSRs); and 3) floral phenology, floral traits, visual and olfactory cues, as well as pollinator observations, as evidence for any morphological and functional divergence among groups identified from the SSR analyses. Together these will allow us to tease apart the relative importance of different traits that underpin the evolution of elements within this subgroup.

Results/conclusions: No results or conclusions yet—the poster aims to introduce this PhD project.

Julie Atkinson completed her honours project (Evidence for and against regional structuring within the discontinuous distribution of Grevillea chrysophaea Muell. ex. Meisn (Proteaceae)) in 2010. Recently, she has begun a PhD project with Dr Susan Hoebee and Dr Trevor Edwards at La Trobe University.

4 Ecology of lycosid and mygalomorph spiders, and implications for conservation of the pygmy bluetongue lizards

Jessica Clayton[1], Michael Bull[1]
[1]Flinders University

Background/question/methods: The pygmy bluetongue lizard is an endangered species restricted to isolated fragments of native grassland habitat in South Australia. It uses empty spider burrows, constructed by mygalomorph (trapdoor) and lycosid (wolf) spiders as refuges, basking sites and ambush points. Research conducted to date has established the importance of these spiders to pygmy bluetongue lizards, in terms of burrow construction and maintenance between occupants. In order to maintain long-term conservation of pygmy bluetongue lizards, spider populations must also be maintained. This PhD project aims to provide information on the population dynamics of spiders associated with pygmy bluetongue lizard populations. It will identify patterns in the distribution of spiders and lizards on both spatial and temporal scales; the hole digging behaviour of spider species, and inter/intra species interactions spider species' and lizards. This will be achieved through field studies (observations of spatial and temporal distribution in natural habitat) and laboratory studies (observations of hole digging behaviour and intra-/inter-species interactions).

Results/conclusions: Twelve plots have been set up at the study site to identify the spatial and temporal distribution of spider species; changes in burrow use over time; and the impact of different sheep grazing regimes. Individual spiders captured from the site will also be monitored under controlled conditions. These spiders will be monitored to observe their hole digging behaviour and what environmental conditions are suitable for this. This research will provide valuable information on the role that these spiders play in the conservation of the pygmy bluetongue lizard, which to date is poorly understood.

Jessica Clayton commenced a PhD at Flinders University in February 2012. She studied a Bachelor of Applied Science and undertook an honours project (researching the spatial and temporal distribution of intertidal fish using Baited Remote Underwater Video) at Queensland University of Technology from 2006-2010.

5 Understanding synergistic effects of climate change and existing threats when managing extinction risk

Tracey Regan[1]
[1]The School of Botany, The University of Melbourne

Background/question/methods: As threats to biodiversity increase, there is a growing need to understand interactions between multiple threats. Threats are typically managed individually which could lead to inefficient and ineffective management actions. Effective conservation management requires an understanding of any synergisms between multiple threats and the overall impact on extinction risk, yet this is not well understood.

The aim of this study is to understand synergistic effects of three threats on a long-lived fire dependent mallee pine, *Callitris verrucosa*, and identify where management can be best directed to minimise overall impacts. Threats include grazing of seedlings, altered fire regimes and climate change that can cause changes in available habitat in the future. This is done by linking a dynamic species distribution model with a population viability analysis model and simulating various scenarios of grazing and fire return interval under a stable and changing climate.

Results/conclusions: Under a stable climate species persistence is maximised under a management regime that prevents grazing and ensures long fire intervals. Under a changing climate, the best management regime is still to prevent grazing but with a shorter fire interval constrained on ensuring continued reproductive success. Results also suggest a synergism between grazing and climate change, causing a large negative effect on population persistence.

These results highlight the complexities of managing for multiple threats and the need for a more comprehensive assessment of threats to identify any synergisms in order to devise management strategies that can reduce the overall extinction risk.

Tracey Regan is an ecological modeller with broad research interests encompassing ecological risk assessment, conservation biology, and decision theory. She is interested in developing formal decision-support tools for optimally allocating resources and eliminating arbitrary decisions.

6 Conservation management of the endangered Slater's skink, *Liopholis slateri*, in Central Australia

Claire Treilibs[1], Michael Bull[1], Chris Pavey[2], Mark Hutchinson[3]
[1]Flinders University, [2]CSIRO, Alice Springs, [3]SA Museum

Background/question/methods: The endangered Slater's skink, *Liopholis slateri,* is one of a suite of endemic species which inhabit the floodplains adjacent to the river channels of Central Australia. These alluvial environments are undergoing major changes in vegetation composition and structure because of invasion by the introduced buffel grass, *Cenchrus ciliaris*. This exotic pasture grass has become widely established since the 1960s, and continues to spread, particularly along watercourses. While the impact of the grass on native vegetation has been documented, its current and long-term impacts on floodplain-dwelling fauna are largely unknown. Consequently, a number of these species are now of conservation concern. To investigate the impact of buffel grass invasion on native fauna, I will study the interaction between Slater's skink and buffel grass at multiple scales. Specifically I will examine how lizard ecology, behaviour, and social dynamics are affected by the grass at the burrow, patch and landscape scales. I will investigate these aspects using a combination of observational, genetic, and remote sensing techniques.

Results/conclusions: Preliminary work has shown unique facial markings are a reliable, non-invasive means of tracking individuals over time. Here I will present some initial results of movement and burrow activity in a local population. Repeated ground-based observations combined with information from scat DNA and multi-spectral high-resolution imagery will build up a valuable temporal sequence. This project will provide a broader knowledge of endemic reptiles in the region and a stronger foundation for the management of other species at risk from exotic grass invasion in Central Australia.

Claire Treilibs is a PhD student within the School of Biological Sciences at Flinders University. Her research is funded by an Australian Research Council linkage grant with the Northern Territory Government and the South Australian Museum. Claire can be contacted at claire.treilibs@flinders.edu.au

Biogeochemical and ecosystem processes

1 Long-term fertilisation effects on microbial communities in arid mangrove sediments, Exmouth WA

Tegan Davies[1], Catherine Lovelock[3], Neil Pettit[2], Paul Greenwood[4], Pauline Grierson[1]
[1]Ecosystems Research Group, School of Plant Biology, UWA, [2]Centre of Excellence in Natural Resource Management, UWA, [3]Centre for Marine Studies and School of Integrative Biology, UQ, [4]Centre for Land Rehabilitation, School of Earth and Environment, UWA

Background/questions/methods: Mangroves grow at the boundary between land and sea, intercepting many land-derived nutrients. Consequently, excess nutrients associated with changes to catchment land use (e.g., fertiliser application to crops) may threaten coastal environments. While it is well-recognised that mangrove ecosystems are 'hotspots' for biogeochemical cycling, with microbes playing key roles in the turnover of carbon and nutrients, the sensitivity of microbial communities and their functioning to changes in nutrient supply is largely undescribed. Here, we assessed the responses of the sediment microbial community to long-term fertilisation of N and P of an *Avicennia marina* mangrove system near Exmouth, Western Australia. We measured microbial biomass and enzyme activity as well as nutrient concentrations and physiochemical variables of the sediments. Nutrient pore water concentrations were also measured for comparison.

Results/conclusions: Initial findings suggest that the microbial composition and biomass differs among fertilisation treatments, the extent of which depended on site and depth analysed. However, the significance of these changes to biogeochemical processes remains unclear. Future analyses will include a further detailed assessment of biolipids, 16S rDNA prediction and protein prediction, and phylogenetic and metabolic profiling of the microbial community coupled with in situ assessment of changes in rates of carbon mineralisation.

Tegan Davies grew up on a farm near Mt Barker, in the south-west of WA. She studied Bachelor of Science (Botany) at UWA, finishing honours in 2009. Tegan is in her first year of her PhD at UWA.

2 Groundwater sources and bryophyte pools: water that maintains peatlands in the Bogong High Plains, Victoria

Victoria McCartney[1], Ewen Silvester[1], John Morgan[1]
[1]La Trobe University

Background/question/methods: The headwater streams of the Bogong High Plains are a major contributor to flows in the Murray River. Many of these headwater streams originate from alpine peatlands, sustained by year-round groundwater inflows. Previous studies have revealed the existence of 'bryophyte pools' closely associated with groundwater sources, with floristic characteristics that are distinctly different to the broader peatland community.

This work has investigated the distribution and characteristics of bryophyte pools in three catchments on the Bogong High Plains (Whiterock Creek, Watchbed Creek and Cope Creek). Vegetation was surveyed in and around the bryophyte pools and the physical and chemical characteristics of the groundwater supplying the pools were quantified.

Results/conclusions: Thirty-two groundwater sources were identified in the three catchments across a range of aspects. *Blindia robusta* was found in groundwater source pools and appears to be a key indicator species. It is characteristic in pools with constant low nutrient water supply, constant water temperature (means 6°C to 9°C), low ionic composition of water, and elevated levels of CO_2.

Aquifers in the Bogong High Plains provide sustained flow during periods of low rainfall and support alpine peatland systems. Climate change may impact on these systems with altered groundwater recharge and precipitation regimes. Changed conditions through less reliable flows and culminating in unseasonal temperature variations, could allow competitive species to out-compete extant species.

Victoria McCartney is a PhD cadidate at La Trobe University Albury/Wodonga campus. My interests include plants and groundwater in relation to the alpine area in Australia. My work is based on the Bogong High Plains and three water catchments supplying water to the Murray River.

3 Climate limitations on invasion by *Tipuana tipu*—is a national weed listing appropriate?

Melinda Trudgen[1,2], Bruce Webber[2,1], John K Scott[2,3], Hans Lambers[1]
[1]School of Plant Biology, The University of Western Australia, [2]CSIRO Ecosystem Sciences and Climate Adaptation Flagship, [3]School of Animal Biology, The University of Western Australia

Background/question/methods: *Tipuana tipu* (Fabaceae) is an invasive non-native tree in subtropical southern Queensland and northern New South Wales, and is listed as a national alert weed. Despite high propagule pressure from horticultural plantings and street trees, the species has not naturalised in temperate climates. Is a national listing appropriate, given that considerable climatic and environmental differences across the country may naturally limit naturalisation and invasion in some regions? We hypothesise that climatic differences affect *T. tipu* germination rates and seedling establishment success. Test plots were established at a site in northern NSW and at sites across climatic gradients in south-west WA, areas previously identified as at risk of invasion. Seed and seedlings were planted at each site, and allowed to grow under natural climatic conditions without competition.

Results/conclusions: Germination rates showed a strong positive correlation with climatic gradients, particularly total annual rainfall. Seedling growth rates were also positively associated with annual rainfall. Overall, survival in WA was much lower than that in NSW. We hypothesise that this is a response to seasonal climatic variation as well as total annual rainfall. High soil nutrients may contribute to seedling establishment success in NSW, and a follow-up experiment is investigating the response of *T. tipu* to different nutrient regimes. Emerging evidence indicates the tree represents a serious invasion threat in certain regions of Australia. However, south-west WA may be climatically protected from large-scale *T. tipu* invasions. Further investigation is required to assess the overall risk *T. tipu* poses to temperate Australia.

Melinda Trudgen is a PhD candidate with the University of Western Australia and CSIRO Ecosystem Sciences. She has previous experience in taxonomy and environmental impact assessments. Combining aspects of invasion ecology, urban ecology and the effects of climate change, her current research aims to assess invasion processes for urban trees.

4 Tracking extreme hydroclimatic events in north-west Australia from physical and biogeochemical patterns in sediment archives

Alexandra Rouillard[1], Grzegorz Skrzypek[1,2], Paul Greenwood[2,3], Chris Turney[4], Shawan Dogramaci[5,6], Pauline Grierson[1,2]
[1]Ecosystem Research Group, School of Plant Biology, The University of Western Australia, [2]West Australian Biogeochemistry Centre, The University of Western Australia, [3]School of Earth and Environment, The University of Western Australia, [4]Climate Change Research Centre and School of Biological, Earth and Environmental Sciences, The University of New South Wales, [5]Resource Planning and Development, Rio Tinto Iron Ore, [6]University of Western Australia

Background/questions/methods: The semi-arid Pilbara region of north-west Australia is characterised by highly dynamic flooding events brought by episodic low-pressure systems. Current research suggests the north-west has experienced more extreme but less frequent cyclones and overall wetter conditions during the last century. Retrieval of well-preserved sediment archives to enhance climate records in the Pilbara is challenging because of the temporary nature of hydrological systems and complex interactions between surface and ground waters. Interpretability of paleorecords is also hampered by limited knowledge of pool and catchment functioning. Here, we use scanning hyperspectral imagery, granulometry and stable isotopes of cores obtained from the largest wetland in the region, the Fortescue Marsh, to track pulse-like events such as tropical cyclones and thunderstorms. Over recent decades, severe droughts have been followed by short-lived yet extreme rainfall events hat flush dry stream networks and inundate extensive low-lying areas (>500 km^2), evidence of which we expect to be conserved in the sediments.

Results/conclusions: Preliminary results demonstrate altered redox conditions, flooding intensity and the evaporative sequence of permanent pools through time. Relative abundance of macrofossils in the profile and $\delta^{13}C/\delta^{15}N$ values also reflect shifts between dominant sources of organic carbon in the system. Our interpretations are supported by three years of seasonal sampling of surface and groundwater (including measurements taken following tropical Cyclone Heidi, Jan 2012), which show great variation in water chemistry and isotopic content that reflect rainfall patterns. Our findings have significant implications for understanding of ecological water requirements and resilience of these ecosystems.

Alexandra Rouillard is from Canada with a background in Ecology (BSc, Universite de Montreal, Canada and Umea University, Sweden). Alexandra conducted diatom-based paleolimnological research in the Canadian High Arctic (MSc, Queen's University, Canada) and is currently doing her PhD at UWA on NW Australia paleoclimate.

5 How will climate change affect forest soil and surface litter carbon in south-eastern Australia?

Tonja Wright[1], Stephen Livesley[2], Craig Nitschke[1], Stefan Arndt[1]
[1]Department of Forest and Ecosystem Science, The University of Melbourne, [2]Department of Resource Management and Geography, The University of Melbourne

Background/question/methods: Climate change will have a profound effect on forest vegetation and soil carbon stocks. In general, climate change will lead to hotter and possibly drier conditions. Currently there is no scientific consensus on how climatic variations will change forest species distribution and productivity, and subsequently the quality and quantity of leaf litter inputs into the soil. We aim to investigate how soil carbon pools will respond to possible future changes in litter inputs due to climate change. Specifically, we will investigate (i) how changes in temperature and moisture will affect leaf litter decomposition rates; and (ii) how changes in leaf litter quality and quantity will affect soil carbon turnover.

Results/conclusions: We will present a detailed experimental design comprising of field manipulation experiments, and laboratory soil and leaf litter incubations, where we will manipulate temperature and moisture regimes as well as leaf litter mass and C:N ratios. The field study will consist of a unidirectional translocation of soil and litter along an environmental gradient in the Central Highlands of Victoria to simulate climate warming. The Rothamsted Carbon model will then be used to predict ultimate changes to soil carbon stocks as a result of future climate scenarios. This will help to determine whether the soil in native forests in south-eastern Australia will continue to act as a sink for carbon, or become a source and contribute to a positive feedback loop for climate change.

Tonja Wright completed her Bachelor of Science and Honours degrees, majoring in soil science, in the Department of Soil and Land Systems at The University of Adelaide, Waite Campus. She is currently a PhD candidate in the Melbourne School of Land and Environment at the University of Melbourne.

Community assembly, diversity and dynamics

1 The generation and generalisation of plant functional types in fire-prone communities

Freya Thomas[1], Peter Vesk[1], David Keith[2]
[1]The University of Melbourne, [2]New South Wales Office of Environment and Heritage

Background/question/methods: Fire management practices are often based on limited information, in particular subjective classification of time to maturity, for a small subset of plant species. There is a need to enhance the range of ecological data available to fire planners to improve decision making whilst trying to develop ecologically realistic generalisations for use in fire management.

To generalise vegetation fire responses, we need to design management strategies targeted at multiple species but based on detailed knowledge of relatively few.

My research aims to find a balance between generating relatively species-specific information and incorporating this into a generalisable framework. I plan to model relationships between plant functional traits (specific leaf area, stem density, basal diameters, seed size, canopy biomass) and species growth responses to time since fire (plant height, reproductive biomass), in an effort to link easily recognised and sampled plant traits to population dynamics attributes.

I will use a chronosequence approach, whereby I will visit 10 time-since-fire sites within The Murray Sunset National Park, Vic. At each site I will take measurements of height, biomass estimates and functional trait data on multiple common shrub species. I plan to incorporate these functional traits into a hierarchical Bayesian model of plant height growth through time since fire. Basing a model on functional traits enables estimations of growth characteristics of other unobserved species based on a few easily measured functional traits.

Results/conclusions: This will be a detailed project proposal, as I am at the beginning of my PhD and unsure that I will have data by ESA 2012. For this reason I would like to present my research in a Poster.

Freya Thomas is a PhD student in The School of Botany at The University of Melbourne. I am interested in making generalisations in plant ecology and my research involves considering how plant functional traits and types can be used to generalise plant responses in fire prone communities. Over the next few years I will be measuring plants and functional traits in the mallee and building models of their growth and reproduction.

2 An assessment of regional ecosystem land zones as a surrogate for floristic diversity

David Tucker[1], Susan Fuller[1], Tim Ryan[2,3], Peter Young[3]
[1]Queensland University of Technology, [2]Queensland Herbarium, [3]Department of Environment and Heritage Protection

Background/question/methods: The regional ecosystem framework is the foundation for biodiversity and conservation planning in Queensland. Regional ecosystems (REs) are the principal units in the framework and serve as a landscape-scale environmental surrogate for biodiversity. The regional ecosystem approach is based on land classification and is represented by a biotic (vegetation community) and an abiotic (land zone) component. Land zones serve as a surrogate for associated vegetation communities, and in turn, positions an RE's floristic diversity as a representative subset for overall biodiversity within that regional ecosystem. The study examined the efficacy of land zone surrogacy for floristic diversity in South-east Queensland, and considered the associated conservation planning implications. An array of paired remnant plots were identified over three distinct study areas in the South-east Queensland bioregion. These plots were categorised as two different regional ecosystems (RE 12.5.3 and RE 12.9/10.4) but possessed the same dominant canopy species (*Eucalyptus racemosa*), and were subjected to a series of comprehensive vegetation surveys in order to determine the floristic composition and structure of each RE.

Results/conclusions: Univariate and multivariate analyses indicated that geographical distance was driving floristic diversity across the broader study area, and that land zone had no significant surrogate effect. Our findings suggest that it would be inappropriate to assign conservation priority based on land zone classification alone, and prudent to protect all regional ecosystems with the same dominant canopy species over their geographical extent in order to maximise captured biodiversity.

David Tucker completed an honours degree in ecology in 2010, focusing on ecological surrogacy and the relationships between vegetation communities and abiotic environmental components. This interest has continued with a current PhD research project examining terrestrial ecological condition approaches.

3 Long-term natural variation and turnover in a small mammal community of south-eastern South Australia

Amy Macken[1], Elizabeth Reed[1]
[1]School of Biological Sciences, Flinders University, South Australia

Background/question/methods: Natural variation in the composition and structure of ecological communities is often associated with their long- and short- term resilience to disturbances, including climate change. However, recognising patterns of variation that may be considered 'natural' and variation that signals significant ecological change is challenging, particularly as there are few baselines against which to compare modern ecological changes. The vertebrate fossil assemblages of the Naracoorte Caves present an opportunity to form such a baseline for south-eastern South Australian faunas. In this research, patterns of variation in the composition and structure of Quaternary small mammal communities through the last glacial cycle were examined. To identify patterns of natural variation, fossil assemblages were analysed across a nested hierarchy of numerical scales: species relative abundance, rank order abundance and presence/absence.

Results/conclusions: The relative abundance of some species changed by up to 30% following the glacial maximum (e.g., *Pseudomys australis, Pseudomys apodemoides*), suggesting populations were highly variable in response to climatic changes of the past. Such variation contributed to significant community restructuring following the glacial maximum, reflected by change in the rank order abundance of species within the assemblages. Variation in species' presence/absence is also evident in an increase in richness following the last glacial maximum and significant, but moderate values of compositional similarity. Despite the demonstrated resilience of mammal faunas to past climatic changes from the Naracoorte Caves, the baseline provided here suggests that both individual species and, consequently, faunal communities, were at times highly variable resulting in faunal turnover and community re-structuring.

Amy Macken is a PhD student at Flinders University studying long term patterns of change within the small mammal community of south-eastern South Australia. Her work aims to link long term data available from fossil sites with the conservation of species and ecological diversity into the future.

4 Bioengineering by oysters across climatic gradients

Dominic Mcafee[1], Melanie Bishop[1], Victoria Cole[1]
[1]Department of Biological Sciences, Macquarie University

Background/question/methods: Bioengineers are key determinants of community development and influence the distributions of associated species by altering the availability of resources and ameliorating physical stresses. Ecological theory predicts that the positive influence of bioengineers on biodiversity will increase with the physical stress of the environment. We tested the hypothesis that the difference in communities of intertidal invertebrates between oyster-engineered and oyster-free habitat would be greater in warmer than cooler climates, the difference increasing with desiccation stress. We sampled adjacent habitat patches with and without oysters, on replicate rocky shores and mangrove forests within eight estuaries spanning a 1000 km latitudinal gradient along the NSW coastline. Within each habitat patch we quantified (1) invertebrate community structure and (2) temperature and humidity.

Results/conclusions: Across all latitudes we found that oyster-engineered habitat supported a much greater biodiversity and abundance of invertebrates than oyster-free habitat, with greatest dissimilarity in the northern rocky shore sites. Latitudinal gradients in abundance and richness were strongest in oyster-free habitats on rocky shores, while mangrove communities showed little influence of latitude at all. Furthermore, rocky shore oyster habitats provided a cooler refuge from temperature extremes than bare substrata, the significance of which was greater in northern latitudes. In contrast the influence of oyster habitat in shaded mangrove forests was negligible. These findings suggest that oyster habitat weakens the relationship between temperature and invertebrate assemblage under stressful conditions, the relationship weakening with reducing stress. Knowledge of how oyster-invertebrate interactions vary with climatic setting will assist us in predicting how, in a warming climate, these interactions will modify impacts to biodiversity.

Victoria Cole is a postdoctoral researcher interested in the complex ecological interactions that influence coastal biodiversity. She aims to understand how natural and anthropogenic factors (over small and large scales) influence biodiversity in these habitats. Victoria's research focuses on temperate rocky shores here in Australia, Europe and also Africa.

5 Soil seed banks in arid Western Australia: density, composition and implications for post-mine restoration using topsoil

Eddie van Etten[1]
[1]Edith Cowan University

Background/question/methods: Studies of soil seed banks have been widely used to improve our understanding of ecosystem dynamics and impacts of disturbance. Seed banks of desert ecosystems have been studied in many parts of the world, but are lacking for the large arid zone of Western Australia which is largely dominated by *Acacia* shrublands and *Triodia* hummock grasslands. At two study areas within this arid zone (one in the Pilbara bioregion and the other the Murchison bioregion), topsoil (0-10cm depth) was collected from 10-12 replicates of each major plant community present in the area. Topsoil samples were transported to Perth and then spread out on a bed of vermiculite in seedling trays placed in a well-watered glasshouse to determine the readily germinable component of the soil seed store. Subsamples of topsoil were treated with either smoke water, hot water or flooding to help determine seed store of species with dormancy mechanisms.

Results/conclusions: As with other studies of arid zone seed banks, large numbers of annual grasses and forbs emerged from topsoil, with relatively small numbers of woody perennial species present even in communities where such species were dominant. There were however a few exceptions where a reasonable density of dominant trees/shrub seed was present in topsoil. Few to no *Triodia* seedlings emerged from soil samples, suggesting either limited or transient seed bank. Soil treatment generally had limited effect on composition and density of emergent seedlings. Very few weed species were found in topsoil. Although floristic similarity between soil seed banks and corresponding above-ground vegetation was modest, there were clear differences in soil seed bank composition between communities. The implications of results for using topsoils to restore landforms of the study area after mining or other disturbance are discussed.

Eddie van Etten is a Senior Lecturer in the School of Natural Sciences at Edith Cowan University in Perth. His research interests focus on the patterns, dynamics and restoration of arid and semi-arid zone vegetation.

Dispersal and distribution patterns

1 Using functional traits to explain distribution of woody plant species around frost hollows

Felix Lim[1]
[1]School of Botany, University of Melbourne

Background/question/methods: Frost hollows may be characterised by the changes in vegetation structure and assemblage downslope from closed heathlands to grasslands as a result of cold air drainage. This distribution and turnover of woody species along the slope may be related to functional traits that may affect a species' sensitivity to extreme cold temperatures. In this research, I sought to determine what traits may be important to tolerating frost risk.

Plots were laid out along slopes leading into frost hollows within the Bogong High Plains (Vic) and shrub species occurring within each plot were sampled and measured. The cover abundance and height of shrubs were measured in each plot. I measured several species' traits: height, specific leaf area (SLA) and specific stem density, various xylem properties, and morphometric measures of leaf buds that may be important in protecting the apical meristems from frost damage.

Results/conclusions: An ordinal logistic regression model was used to estimate how different traits affected the probability of occurrence of each species along the slope, using species as random effects. Species occurring higher on the slope had greater maximum height and lower SLA and stem density; bud properties showed weak correlations. The relative contribution of intraspecific trait variation compared to that of species turnover was assessed for SLA and height and determined that species turnover was the dominant effect on community trait values. This study may increase our current understanding the role of plant traits in frost tolerance.

Felix Lim is currently doing a Masters in Science with the School of Botany, University of Melbourne.

2 Predicting future range of the critically endangered grey nurse shark using species distribution models

Guanfang Su[1], Barry Brook[1], Corey Bradshaw[1,2], Damien Fordham[1]
[1]School of Earth and Environmental Sciences, The University of Adelaide, [2]South Australian Research and Development Institute

Background/question/methods: Species distribution models (SDMs) are commonly used to forecast how threatened species will be influenced by climate change. The grey nurse shark (*Carcharias tauras*) is a critically endangered species inhabiting the east and west coasts of Australia, with negligible genetic interchange between the two populations. We used maximum entropy (MaxEnt), boosted regression trees (BRT) and generalised linear models (GLM) to characterise the environmental niche of the grey nurse shark's distribution. The data were a small sample of presence-only data, derived from the known grey nurse shark aggregation locations and fine-scale fishery data from the east and west coasts of Australia, with pseudo-absences generated and bootstrapped from a restricted background. We verified models using cross validation based on out-of-source sampling. We then tested the generality of using our Australian-based models by predicting grey nurse shark occurrence along the South African coast.

Results/conclusions: All SDM variants incorporating bathymetric slope performed well according to AUC (median, 5-95% quantiles ≈ 0.919, 0.902-0.921) and Cohen's Kappa (0.626, 0.554-0.646). In MaxEnt and GLM, models with only bathymetric slope were the best AIC_c- and BIC-ranked models, explaining 34% of total deviance. BRT prediction was sensitive to the number of pseudo-absences. We also detected a weaker non-linear relationship between presence and depth/slope with both MaxEnt and BRT. The model predictions in South Africa covered inshore and deeper-shelf waters where the prey species typically occupy. Our models captured useful information on the habitat of the grey nurse shark, which should be useful for long-term population conservation under a changing environment.

Guanfang Su is a second year PhD candidate. Her research interest is mainly about bridging species distribution modelling with metapopulation modelling.
Her presentation was funded by Russell Baudinette Travel Scholarship from the School of Earth and Environmental Sciences, The University of Adelaide.

3 Impacts of climate change on the distribution and abundance of understory species in Victoria's forests

Helen Vickers[1], Craig Nitschke[1], Alan York[1]
[1]University of Melbourne, Department of Forest and Ecosystem Science

Background/question/methods: Climate change is likely to affect the distribution, composition and abundance of species across the landscape. Past studies have primarily focused on the impact of climate change on canopy species; in contrast this study aims to assess the direct and indirect impacts of predicted climate change on *understory* species within forest ecosystems of Victoria. We hypothesise that changes in climate and related shifts in fire regimes will alter the composition, abundance and distribution of understory species communities by redefining community and species interactions with biotic and abiotic factors. This study will seek to highlight species and vegetation communities that are vulnerable to changes in climate and altered fire regimes. Using field sites located in the Central Highlands and Otway Ranges National Park, this project will establish a series of ecological plots in which climatic, edaphic and fire factors will be assessed in addition to auto-ecological traits of locally occurring native shrub species. This data will then be used to model the impacts of climate change and fire regimes on understory species and community distribution.

Results/conclusions: A predicted outcome of this study will be the provision of a conceptual framework with which to address the fundamental ecological questions of how climate and fire interact with understory species. Further, this study will provide the means to model the composition, abundance and distribution of selected species and communities in response to the direct and indirect impacts of climate change within Victoria.

Helen Vickers recently moved to Melbourne to begin her PhD with the University of Melbourne investigating the impact of climate and fire on understory species of Victorian forests. She has a BSc in Ecology, a BA in Psychology and Honours in Botany from the University of Queensland.

4 Ant community composition along the Gwydir catchment elevational gradient

Sandia Wong[1], Nigel Andrew[1], Ian Oliver[2]
[1]University of New England, [2]NSW Department of Premier and Cabinet

Aim: To examine the distribution of ant communities along three elevational gradients (tablelands, slopes and plans) of the Gwydir catchment and to assess ant community composition along a latitudinal gradient. In addition we will test the hypothesis, that change in ant community composition with elevation are related to changes in climate (temperature and precipitation). Thus, further our understanding of ant community patterns and factors that cause them the change, this may increase our understanding in ant community response to future climate changes.

Location: Gwydir Catchment, NSW, Australia.

Background/question/methods: 123 pitfall traps were placed along the east-west gradient of the Gwydir catchment, spanning 270km and altitudes 150-1050m. We compiled climate data from 12 nearby weather stations. We will use multiple regression analysis to examine annual and monthly precipitation, maximum and minimum temperatures on ant communities at each elevational gradient.

Results/conclusions: in progress.

Sandia Wong started a PhD at the University of New England in May 2012. She is focusing on the impact of climate change and the effects it has on ant communities located in the Gwydir catchment.

5 Investigating the dynamics of invasion: phenotypic plasticity in seed dispersal traits in the family Asteraceae

Samiya Tabassum[1], Stephen Bonser[1]
[1]School of Biological, Earth and Environmental Science, UNSW

Background/question/methods: The ability of species to move across a landscape is dependent on aspects of their dispersal. This is especially true for invasive species as part of their success is hinged on their capacity to disperse into new environments. However, selection on dispersal ability is probably related to the probability of offspring surviving in a given habitat. We tested the prediction that plants will express high dispersal ability in crowded high density habitats and low dispersal ability in uncrowded habitats. Using seeds collected from populations occurring in contrasting high and low density environments in the field, we investigated variation in dispersal ability (measured as the ratio of pappus to achene volume) in seven weed species from the family Asteraceae.

Results/conclusions: Of the seven study species, four showed a significant difference in dispersal ability between high and low density environments in the field. Of these, two species were found to produce seeds with low dispersal ability in the high density environments, contrary to our predictions. Plants not allocating to high dispersal ability in crowded environments may by employing a strategy of investing more resources into the achene, increasing the resource provisioning and competitive ability of their offspring. This ability to adapt the dispersal capacity of seeds according to the quality of the maternal environment may explain the propensity for Asteraceae species to become significant weeds.

Samiya Tabassum have just completed an honours project in the Plant Ecology and Evolution Lab at the University of New South Wales investigating phenotypic plasticity in seed dispersal traits. She is interested in studying the evolutionary ecology of invasive species.

6 2-Way learning: science and Indigenous ecological knowledge of euryhaline elasmobranchs in the Roper River, Northern Territory

Sharon Every[1,2], Peter Kyne[1], Karen Edyvane[1]
[1]Research Institute for Environment and Livelihoods, Charles Darwin University, [2]North Australia Marine Research Alliance

Background/question/methods: Northern Australia is a global stronghold for populations of euryhaline and coastal elasmobranchs, particularly rare, threatened, endangered and protected species, such as sawfishes and river sharks, including *Pristis clavata, Pristis microdon, Pristis zijsron, Anoxypristis cuspidate, Glyphis garricki* and *Glyphis glyphis* and also, the Freshwater Whipray *Himantura dalyensis.* These species, along with other sharks and rays are of major cultural, spiritual and totemic significance to the traditional, Indigenous coastal communities in northern Australia. While many of these species continue to be at risk, effective conservation and management is currently limited by an acute lack of data, particularly in the remote gulf rivers and inshore waters of the Northern Territory. Systematic monitoring of abundance and distribution, and also, improved understanding of biology, connectivity, habitat requirements, population genetic structure and key threats, are essential to inform population status, assessment and trajectories. In the intact, cultural landscapes of northern Australia, Indigenous ecological knowledge (and collaboration with remote Indigenous communities) also has the potential to provide invaluable knowledge and insights into population status, biology, movement and ecology.

Results/conclusions: As part of the recently-funded, NERP Marine Biodiversity Hub, this PhD project will adopt an innovative, cross-cultural approach to improving knowledge and understanding of euryhaline elasmobranchs in the Roper River region, in the remote western Gulf of Carpentaria. Building on previous surveys and research, this project aims to improve understanding of biology, distribution, habitat utilisation and movement, through systematic monitoring, tagging, close-kin genetic analysis and tracking of priority species. The project will also, undertake cultural studies, surveys and interviews to document Indigenous ecological knowledge of key species.

Sharon Every completed her undergraduate degrees at Deakin University in Science and Teaching. Her true passion is research in the marine environment and so has begun her PhD this year on euryhaline elasmobranchs. Sharon also completed her honours in the NT on disturbances on tropical rocky shores.

7 Great mammals' distributions in a modified Brazilian landscape

Cintia Camila Silva Angelieri[1], Marcelo Pereira de Souza[1], Christine Adams-Hosking[2], Clive Alexander McAlpine[2]
[1]University of Sao Paulo, Brazil, [2]University of Queensland

Background/question/methods: Large mammals' high patterns of distribution and capacity of migration could reflect effects of the land use alteration. For great Brazilian mammals, habitat loss and fragmentation and hunting pressure are the greatest threats. A heterogeneous landscape may still be able to support a considerable diversity of mammals, especially those with generalist habits such as the species studied in this research. But it needs methods to incorporate scientific criteria to land use planning and this subject is still in early stages in Brazil. We used occurrence records of three threatened species *Chrysocyon brachyurus* (maned wolf), *Puma concolor* (puma) and *Leopardus Pardalis* (ocelot) from *SpeciesLink* database provided by the Research Program Sustainable Conservation of Biodiversity—Biota/FAPESP in Sao Paulo State central region. The environmental datasets were prepared and visualised *in ArcGIS version 10* and the models were generated in *Maxent version 3.3.3*.

Results/conclusions: The most important variables for the three species were Mean Diurnal Range and distance from Protected Areas. The Puma's model also showed strong influence from the *Normalised Difference Vegetation Index* (*NDVI*) variable. Land use layers will be incorporated into the modelling. The results may have been influenced by lack of standardisation of the database used. However, they indicate areas with high environmental suitability for the three species studied and should be incorporated as scientific criteria for Brazilian land use planning.

Cintia Camila Silva Angelieri is a biologist with a MSc in Environmental Engineering Postgraduate Program, University of Sao Paulo. PhD student in the University of Sao Paulo and occupational trainee in University of Queensland. Interests: conservation planning, landscape ecology, ecological modelling.

8 Predicting climate change adaptability from phylogenetic and morphological signals in a key Australian plant genus, *Brachyscome*

Megan Hirst[1], Adam Miller[2], Neville Walsh[3], Ary Hoffmann[4]
[1]Department of Genetics, The University of Melbourne, [2]Department of Zoology, The University of Melbourne, [3]The Royal Botanic Gardens Melbourne, [4]Bio21 Institute, University of Melbourne

Introduction: A number of iconic Australian plant groups are thought to be threatened by rapid climate change but there is very little information to test if these groups possess inherent resilience, as the role of natural selection and evolution on trait differentiation can vary between species under the same selective pressures. This study examines the phenotypic, morphological and physiological characters in the genus *Brachyscome*, to explore a number of issues. Are threatened species related, or interlinked with more resilient widespread species? Is there a 'home' site advantage? To what degree does phenotypic plasticity and genetic differentiation affect distributions?

Background/question/methods: *Brachyscome* comprises >80 species of native daisies found in a wide range of habitats, and includes both highly restricted and widespread species. A detailed phylogeny of *Brachyscome* to determine evolutionary relationships at the molecular level, reciprocal transplants and common garden experiments testing for the presence/absence of shared environmental tolerances, will be linked to an assessment of the ecology of the different *Brachyscome* lineages. Through growth experiments the resistance of key life stages to thermal and other climatic stresses will be explored. This will indicate the level of resilience to climate change and also the extent to which the species are growing in conditions close to their environmental limits.

Results/conclusions: The preliminary result of the nuclear ribosomal ITS tree provides a promising start with strong support evident in many nodes. Interestingly, the ITS phylogeny places the recently established genus *Allittia* (*Allittia cardiocarpa* and *A. uliginosa*) (Short 2004) within *Brachyscome*. Also of interest is the support of the earlier molecular work (using ITS regions) by Field et al (2006) showing a separation of the *Brachyscome lineariloba* group into separate clades, which is not supported by earlier taxonomic and cytological studies. To obtain a strong phylogenetic signal an increase in characters are required. Currently ndhI, rpoC1exon1, trnL-trnF, trnS-trnfM and trnC-ycf6 are being screened to establish the set of markers. Transplant plots have now been established for alpine species. Seedlings are being grown to allow for morphological and physiological assessments.

Megan Hirst is currently a PhD candiate at The University of Melbourne under the supervision of Prof Ary Hoffmann, Dr Adam Miller and from The Royal Botanic Gardens Melbourne, the Senior Conservation Botanist, Mr Neville Walsh.

9 AusPlots–Rangelands surveys two years on

Nikki Thurgate[1], Andrew White[1], Jeff Foulkes[1], Benjamin Sparrow[1]
[1]TERN/Adelaide University

Background/question/methods: To develop and implement continental scale survey and sample collection methods for the rangelands to provide consistent, quality baseline soils and vegetation data.

Results/conclusions: AusPlots-Rangelands surveys are being rolled out across the rangelands with a target of 700 permanent plots by the end of 2013. The plot-based methods were purpose built to provide valuable information for varied disciplines and fulfil the needs of state/territory governments, conservation groups and land managers. The method has stand-alone modules to describe: soils to 1 m; soil carbon, bulk density and nutrients (multiple samples across each plot); soil metagenomics; vegetation—plant vouchers at each plot for definitive species identification and herbarium inclusion; leaf samples for DNA and isotope analyses (C13); plant cover, structure, demographic information and basal area collected using point intercept and basal wedge; and vegetation structure and composition context using photo-panoramas.

Innovation was used. Field data collection with a tablet/PDA and Android app enables downloading to the TERN Eco-informatics database with data accessible through a web portal for future tracking and adding biodiversity information. Unique barcodes are scanned for soil and vegetation samples tracking them from collection to identification and storage (herbaria, gene or sequence bank, CSIRO National Soil Archive). 3D plot photo panoramas are created to describe plots and providing searchable images. Leaf samples are collected for DNA sequencing and isotope analyses, and soil samples for metagenomic analyses. Methods were developed collaboratively with numerous relevant stakeholders and integral to AusPlots-Rangelands are collaborations with TERN facilities and wider e.g. universities, herbaria, National Soil Archive, government departments, Beijing Genomics Institute, BioPlatforms Australia. Survey training plus a detailed survey manual (downloadable at www.tern.org.au/ausplots) ensures data consistency.

A/Professor Nicole Thurgate has been a professional ecologist for over 20 years with an interest in reducing extinction. She graduated with a PhD in conservation biology from the University of New Orleans in 2006. She has also worked in both state and federal governments and has a strong backgroun

Disturbance, recovery and resilience

1 Impact of ungulates on regeneration of plant species in forest ecosystems in northern New Zealand

Debashis Dutta[1], Ryo Miyanami[1]
[1]Environmental Management, School of Applied Science, Bay of Plenty Polytechnic, New Zealand

Background/question/methods: In New Zealand, browsing by introduced ungulates, such as deer (Cervidae) and goat (*Capra hircus*), have had extensive negative impacts on indigenous forest ecosystems by suppressing seedling growth and forest regeneration. Control operations to eradicate or mitigate ungulate impacts on conservation land are therefore regularly undertaken. To assess short-term responses to such control, the seedling ratio index (SRI) method—relating a ratio of short seedling to tall seedling species richness with ruminant browse pressure according to ruminant-feeding preference—has been developed (Sweetapple & Nugent, 2004). This could possibly guide year-to-year management decisions. In this study, the current impacts of ungulate browse in two forests (Otanewainuku and Aongatete), in the Bay of Plenty region with similar vegetation, were investigated using the SRI method.

Results/conclusions: A comparison of tall seedlings at Otanewainuku and Aongatete showed a large percentage belonging to the high preference category in the former as compared to the latter where a larger percentage of tall seedlings belonged to low preference category. There was a strong positive correlation between species richness of short and tall seedling for Otanewainuku (r^2=0.488, P=0.0006) which was not so in the case of Aongatete (r^2=0.049, P=0.345). For high preference species, the SRI was positive for all samples and significantly (P<0.01) higher in Otanewainuku compared to Aongatete, where it was negative for 80% of the samples. Thus ungulate browsing impacts are low at Otanewainuku but comparatively high at Aongatete where sustained ungulate control is suggested to restore the health of the forest ecosystem.

Dr Debashis Dutta teaches plant ecology and botany at the Bay of Plenty Polytechnic, Tauranga, New Zealand. Prior to taking up his current position in 2003, he lectured at a university college in India. He has taught at the tertiary level for over 20 years.

2 What drives the distribution of invasive mammalian predators in semi-arid Australia?

Catherine Payne[1], Dale Nimmo[1], Euan Ritchie[1]
[1]School of Life and Environmental Sciences, Deakin University

Background/question/methods: Invasive mammalian predators have significant negative impacts on Australia's biodiversity. Understanding the ecology of such species is critical to managing and mitigating their effects. Despite this, few studies have investigated the factors that influence the distribution and behaviour of these species. Here, we study the distribution of the red fox (*Vulpes vulpes*) in relation to key environmental variables in the Murray Mallee region of semi-arid, south-eastern Australia. Specifically, we explore the role of three key disturbance processes: (1) Fire history and associated changes in habitat structure; (2) Proximity to road networks; and (3) Distance to habitat edges. We used baited camera traps to survey for red foxes and another sympatric mesopredator, the feral cat, in 108 sites across a 6630 km^2 study area, resulting in a total trap effort of 2247 trap nights. Sites were distributed across a range of fire age classes (0-105 years), distances from roads (28-1044 m), and distances non-mallee vegetation (1.95-19.45 km).

Results/conclusions: Foxes were widespread throughout the study area, being detected at 69% of sites, whereas cats were rare, being detected at only 4% of sites. Foxes were found across a range of fire ages and at varying distances from roads and non-mallee vegetation. Low cat abundance may reflect suppression due to high fox numbers. These results have implications for invasive species management, as well as post-fire recovery of native species.

Catherine Payne completed her Bachelor of Science in 2011 with a major in Zoology, and is currently involved in an Honours project working on invasive predators. She has a broad range of interests, including conservation biology, behavioural ecology, human disturbance and human-wildlife conflict.

3 Bird alpha and beta diversity responses to pyrodiversity across spatial scales

Emma Burgess[1], Martine Maron[1], Murray Haseler[2]
[1]Landscape Ecology and Conservation Group, School of Geography, Management and Planning, University of Queensland, [2]Bush Heritage Australia

Background: Wildfires and altered fire regimes continue to threaten global biodiversity. This has stimulated much research into the ecological impacts of fire and effective means of burning to maintain biodiversity focused on the broadly accepted paradigm that increased spatial pyrodiversity begets increased biodiversity. Much work has been carried out at the alpha diversity level in relation to the fire event. Uncertainty, however, remains regarding the relationship between beta diversity and the fire regime mosaic. Controlled burning for biodiversity conservation thus remains a controversial topic as the particular spatial and temporal patterns of fire that maintain or threaten biodiversity are poorly understood.

Broad question: How do bird alpha and beta diversity responses to pyrodiversity differ when considered at different spatial scales?

Methods: A systematic, nested hierarchical approach to sampling has been adopted in 24 study landscapes (each 1 km^2), selected to represent a gradient in fire history. The fire scars where reclassified into 9 fire history categories (FHCs) to assist in realising the 'visible' and 'invisible' fire regime mosaic. Generalised Linear Mixed Models will be used to investigate the relationships between the predictor variables and the alpha and beta diversity of birds, across spatial scales.

Results: Data collection in progress with preliminary results expected by December 2012.

Conclusions: The outcomes of this research will provide an understanding of the operational minimum level of spatial diversity, at appropriate spatial resolution for effective ecological fire management.

Emma Burgess started her PhD in 2011 after 2 years with IUCN, during which she worked on community-based natural resource management projects. Emma's main research involves investigating the interaction between fire regimes, biodiversity and fuel management activities.

4 Effects of fire regimes on vegetation and fuel hazard: a retrospective study

Annette Muir[1], Garreth Kyle[1], Josephine MacHunter[1], David Cheal[1], Geoff Sutter[1], Kasey Stamation[1], Meredith Kirkham[1], Richard Loyn[1]
[1]Arthur Rylah Institute, Department of Sustainability and Environment

Background/question/methods: Fire regimes need to be managed. DSE initiated studies to examine effects of fire regimes, including a retrospective study in Gippsland and analysis of data from what is now the Victorian Biodiversity Atlas (VBA). In Gippsland we surveyed 152 sites (in 22 landscapes 20 km square) with contrasting fire histories from two Ecological Vegetation Divisions (EVDs), and related vegetation and fuel hazard to fire history variables. The VBA analysis considered 27,000 vegetation quadrats with flora species data in a similar manner.

Results/conclusions: Many plant species showed different response patterns to fire history in different EVDs. Some native species were advantaged by long times since fire (and regimes of infrequent fire): these included serotinous obligate seeder shrubs (most prevalent in stands last burnt 21-40 years ago) and obligate seeder shrubs with long juvenile periods (best represented in stands older than 40 years since fire), consistent with expectations that they would be slow to re-establish after fire. Obligate seeder shrubs with short juvenile periods were best represented in recently or frequently burnt stands, as expected. Resprouter shrubs were least represented in long-unburnt stands, consistent with the hypothesis that they are well adapted to frequent fires and may be out-competed in the absence of disturbance. Obligate seeder herbs responded positively to fire frequency whereas resprouter herbs showed little effect. Fuel hazard increased with time to ~20 years post-fire. Diverse fire management regimes are needed to cater for these diverse response patterns.

Annette Muir works as an ecologist at ARI, and has led the vegetation work for the fire ecology retrospective project in Gippsland. She has worked in a range of policy and research roles at DSE. She recently completed an MSc on effects of fire on shrub reproduction and survival.

5 The effects of fire on the abundance and population structure of terrestrial amphipods (Family: Talitridae)

Louise Menz[1]
[1]La Trobe University

Background/question/methods: Fire is a key natural disturbance in the Australian landscape and alters biotic assemblages. Litter provides the main fuel for fires and is consumed even in low severity fires. Arthropods make up the majority of litter fauna and contribute to decomposition and nutrient cycling. However, little is known about the effects of fire on litter fauna. It is likely to be particularly problematic for moisture-dependent and dispersal-limited species, such as amphipods. We investigated the effect of fire severity on terrestrial amphipod abundance and population structure. We used 21 sites of three fire severity classes (unburnt, ground burn and crown burn) in the Kinglake Murrindindi Fire complex of 2009. We recorded habitat variables and counted numbers of amphipods in 6 litter samples collected along a 25 m transect at each site. The Mitochondrial CO1 gene was used to analyse population structure.

Results/conclusions: Preliminary results suggest that moisture, humidity and foliage cover are more suitable for amphipods at unburnt sites and that more amphipods are found in ground burnt and unburnt sites. Strong population structure indicated low dispersal of amphipods, indicating that recolonisation may not easily compensate for local extinctions. We thus suggest that, in the short term, canopy burn fires might significantly limit amphipod abundance, while ground burns do not. Future fire management should consider low severity burns as increased severity of fires under climate change may threaten dispersal-limited detritivores.

Louise Menz has completed a Bachelor of Conservation Biology and Ecology in 2011 at La Trobe University and now undertaking an Honours year in ecology and genetics.

6 Do ant morphological traits related to liquid feeding respond to change in climate?

Katayo Sagata[1], Heloise Gibb[1], David I Warton[2]
[1]Department of Zoology, La Trobe University, [2]School of Mathematics and Statistics and Evolution and Ecology Research Centre, University of New South Wales

Background/question/methods: The relationship between species traits and habitat characteristics is central to the existence of a species. However, global climate change is significantly altering how species interact with their habitats. *Iridomyrmex* is an ecologically important Australian ant genus with specialised morphological traits to feed on liquid diet. However, how these traits may be affected by changing climate is not well understood. We measured 13 morphological traits from replicate individuals from 16 species using museum specimens across Australia and collected their locality data. We used *manyglm* in *mvabund* package in R to test for the effect of the current annual mean temperature and rainfall on the ant traits for individual species.

Results/conclusions: Temperature, rainfall and their interactions had significant effect on the ant traits. Head size (length and width) was the most common trait affected. Hind femur length was another common trait affected followed by body size, funniculus and mandible length. Head size and mandible length are related to food intake and funniculus length increase foraging efficiency while body size and femur length are related to foraging success in a habitat. Thus, broad-scale changes in habitat complexity associated with temperature and rainfall are more likely to affect these traits and their functions.

Katayo Sagata is a PhD student at La Trobe University looking at effects of climate change on ant-scale insect-plant interactions.

7 Threatened grassland flora on the move: spiny rice-flower and matted flax-lily translocation

Wendy Jeffery[1], Adam Rigg[1]
[1]Kellogg Brown and Root Pty Ltd

Background/question/methods: KBR have been recently involved in two major rail infrastructure projects in grassland and grassy woodland vegetation to the west and north of Melbourne for the Regional Rail Link (RRL) and South Morang Rail Extension Project (SMREP). Both projects required translocation of threatened flora species in the path of construction. Spiny rice-flower is listed as 'critically endangered' and matted flax-lily is listed as 'endangered' under the Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act).

Results/conclusions: The translocations have achieved over 75% success rates and are recognised as 'best practice' by the Federal Department of Sustainability, Environment, Water, Population and Communities (SEWPaC).

The presentation will describe the translocation method, post-translocation monitoring applied to each species, difficulties experienced, how problems were addressed and suggested factors contributing to the successful outcomes.

Wendy Jeffery has been the Senior Ecologist at KBR since 2006, joining the company in 1993. Adam Rigg began as an Ecologist at KBR in 2006. Both have worked on field survey and reporting for many major infrastructure projects, particularly surrounding Melbourne and in Victoria.

8 How much bushfire is too much for western Victoria's woodland birds?

Diana Kuchinke[1,2]
[1]University of Ballarat, Collaborative Research Network, [2]Arthur Rylah Institute

Background/question/methods: Victoria's 2009 wildfires resulted in an increase in the levels of prescribed burning on public lands. Area of land now burnt is effectively double previous levels and will continue in this manner, irrespective of any wildfires. In the past we have seen prescribed burning occurring seasonally—now it is carried out all year.

What impacts will this have on the woodland avifauna? These birds are, in south-eastern Australia, already declining. Negatively impacted by urban development and the effects of climate change, changes to fire regimes are likely to add further pressure.

Frequent fire may result in vegetation species and density changes. This may impact on birds with vegetation dependence for food or nesting sites. Post-fire new growth vegetation in a woodland results in a relatively dense understory for a period. If this state is permanently maintained, what will this mean for those birds that normally inhabit open woodlands? If trees have permanent bark burn, what will this mean for birds that feed from the bark layer? Few studies have considered the effects of increasing bushfire frequency on avifauna.

Results/conclusions: Bird monitoring is currently under way on 84 sites in Western Victorian woodlands. From Linton in the west to the Brisbane Ranges in the south-east, these sites are nested in 14 mosaics, with different fire histories.

The project will survey the bird populations and will test predictions of the impact of fire on birds and their habitats considering time since fire, fire type (planned vs wildfire), as well as pre- and post-burn comparisons.

Diana Kuchinke has completed a BSc with Ecology and Aquatic Zoology majors, a Grad Dip in Applied Water Science and a Masters in Environmental Science. This research is her PhD research project.

Ecophysiology and environmental stressors

1 Keeping the ice away: ice barriers protect reproductive organs from frost damage in the alpine plant *Loiseleuria procumbens*

Veronica Briceno[1], Edith Kuprian[2], Manuel Pramsohler[2], Gilbert Neuner[2]
[1]Australian National University, [2]Institute of Botany, Innsbruck University, Austria

Background/question/methods: Plants living in alpine environments regularly face the risk of ice formation, which can be lethal, especially for developing and reproductive tissues. Hence, alpine species have evolved ice barriers against ice spread into susceptible tissues. Ice barriers can be of thermal (cushion plants) or structural (woody plants, grasses) nature. Here, we report on a structural ice barrier in the flower stalk of the alpine prostrate dwarf shrub *L. procumbes* and its changes during different reproductive stages related to the vulnerability against frost damage. Ice formation and propagation in twigs bearing reproductive shoots was monitored by infrared differential thermal analysis during various reproductive stages exposed to simulated night frosts.

Results/conclusions: Ice barriers are active in the flower stalk during the bud stage, anthesis and early fruit stages, allowing the reproductive organs to supercool. While the vegetative shoots are completely frozen at -6°C or even -4°C, the reproductive tissues stay ice free at mean down to -12°C, which is sufficient to survive the naturally occurring air temperature minima. However, fruits in an advanced reproductive stage froze more or less simultaneously with the vegetative shoots, indicating that the ice barriers had disappeared at this point. We suggest that buds, flowers and early fruits are very sensitive to ice damage, hence ice barriers are essential, however when the seeds are developed this barrier is not needed anymore as seeds can withstand lower temperatures and also snow cover insulates them. Ice barriers are thus an effective mechanism to protect developing offspring under episodic freezing events in this species.

Veronica Briceno is a PhD student from the Nicotra Lab at the Australian National University. She is studying drought and frost tolerances in Alpine seedlings from Mt Kosciusko living at different elevations.

2 Linking thermal tolerance traits to distribution limits in Australian alpine grasshoppers

Rachel Slatyer[1], Michael Nash[1], Ary Hoffmann[1]
[1]Department of Zoology, University of Melbourne

Background/question/methods: Australia's alpine environment is small, isolated and highly threatened by a rapidly changing climate. As dominant herbivores, grasshoppers form an integral component of the alpine ecosystem, yet little is known about how they might respond to environmental change. Four grasshopper species in the *Kosciuscola* genus occupy overlapping but distinct altitudinal ranges within Australian mountain areas. They are therefore expected to show different thermal tolerances, corresponding to experienced environmental temperatures. Furthermore, if physiology defines species' altitudinal limits, tolerance traits should relate to population genetic structure across the alpine landscape ('isolation-by-temperature'). This study will test both hypotheses by testing upper and lower thermal limits of individuals from populations at the centre, upper and lower edges of species ranges. Physiological traits will then be mapped onto landscape genetic structure.

Results/conclusions: If thermal physiology is closely linked to range limits, species are expected to track temperature changes by shifting to higher elevations, and populations are predicted to become increasingly isolated as isotherms move upslope to fragment currently contiguous alpine habitat. Alternatively, biotic or other abiotic factors may be more important than thermal tolerances for range limits. If so, warming is likely to cause complex changes in distribution and relative abundances of alpine grasshopper species. These results will thus guide future research on current distribution limits and future changes in the alpine environment.

Rachel Slatyer is a first-year PhD student at the University of Melbourne. She completed her BSc at the Australian National University in 2010, with an Honours thesis on the mating behaviour of fiddler crabs. She is now investigating the physiology and population genetic structure of alpine grasshoppers.

3 How do legumes regulate nodulation and root architecture in response to variable soil nitrogen?

Chooi Hua Goh[1], Adrienne Nicotra[2], Ulrike Mathesius[1]
[1]Division of Plant Science, Research School of Biology, Australian National University, [2]Division of Evolution, Ecology and Genetics, Research School of Biology, Australian National University

Background/question/methods: Plants are able to alter their root architecture in response to different nitrogen levels in soil. Most legumes have the benefit of a symbiotic relationship with nitrogen fixing bacteria, collectively known as rhizobia. The rhizobia are housed in the root nodules where they fix atmospheric nitrogen into a form that can be used by the plant for growth and sustainability. However the nodulation process is energy intensive and requires a control mechanism to prevent excessive nodule numbers. Legumes exhibit phenotypic plasticity in nodulation that is regulated via a feedback mechanism in the shoot called autoregulation. Previous studies indicated that mutations in the autoregulation genes restrict the plant's ability to regulate nodule numbers. We hypothesise that these autoregulation genes could also be regulating the root plasticity in other architectural traits in response to nitrogen availability. We tested this hypothesis using the model legume *Medicago truncatula*, where the wild type plant was compared to four known autoregulation mutants.

Results/conclusions: Root plasticity was compared between plants using the phenotypic plasticity index. The root length, lateral root numbers, nodule numbers, specific leaf area and plant dry biomass was compared between these plants. Preliminary investigations indicate an inverse relationship between lateral root numbers and nodule numbers in all genotypes except one mutant, *sunn*. This suggests that in addition to regulating nodule numbers, the *SUNN* gene may also play a role in regulating plastic responses of root architecture towards nitrogen. New insights into root architecture genes would reduce fertiliser usage to minimise environmental damage.

Chooi Hua Goh is a postgraduate student at the Research School of Biology, Australian National University. Her research focuses on root architectural traits in legume in response towards different nitrogen levels in soil.

4 Influence of urban landscape change on koala health and mortality in south-east Queensland

Brooke Mundey[1]
[1]University of Queensland

Habitat loss and fragmentation associated with human-induced landscape change have been identified as the primary drivers of rapid wildlife species declines and extinctions worldwide. Urbanisation is considered to be the most damaging, permanent, and rapidly expanding form of landscape change impacting wildlife population viability. South-east Queensland (SEQ) is home to one of the nation's largest koala populations, and it is also one of the most rapidly developing regions in Australia. This study investigates the potential link between urban landscape change and koala mortality, and individual health status and physiological stress. Using koala mortality data collected over 15 years and comprehensive health examination data from the study area, including cortisol analysis, detailed spatial and temporal analysis of key landscape and environmental variables was conducted to assess the relative influence of urban landscape change on koala health and mortality in the southern Gold Coast region. This information will help guide koala conservation strategies to minimise threats to koala health and mortality in the study area. In addition, understanding how the health status (e.g. disease), reproductive function and physiological stress of koalas vary in a fragmented urban landscape can be integrated into management plans for koala conservation on larger scales, including other areas of SEQ and Australia.

Brooke Mundey is a former Senior Zoo Keeper and has worked in both the United States and Australia. After obtaining her BSc in the USA in 2000, she has recently completed her Honours at the University of Queensland.

5 Size does matter! Large trees are bird 'magnets' in modified landscapes

Darren Le Roux[1], Philip Gibbons[1], Karen Ikin[1], David Lindenmayer[1], Adrian Manning[1]
[1]The Australian National University

Background/question/methods: The decline of mature trees in modified landscapes has been linked with urban expansion and agricultural practices, which has become a topic of global conservation concern. As a result, trees have become a limited resource in some landscapes, with implications for biodiversity conservation. We ask: what biodiversity values do native trees (*Eucalyptus*) of different size classes have in terms of bird abundance and richness across four different land-use types: 1. Nature reserves; 2. Grazed pasture; 3. Urban parks; and 4. Urban built-up areas. We use Canberra (ACT), a rapidly expanding city, as a representative landscape for this comparative study. We completed two separate 20 min bird surveys in Sept and Oct (2012) at 72 randomly selected trees, with equal numbers of small (20-50cm DBH), medium (51-80cm); and large (>80cm) trees in each of the four land-use types.

Results/conclusions: Preliminary findings highlight the magnetic effect that large trees have as they support more individuals and bird species per tree than smaller trees. These trends are especially evident in modified landscapes where mature trees are scarcer. In the light of our results, we formulate targeted management strategies that can be practically implemented to maintain and perpetuate mature trees and the resources (e.g. hollows and dead branches) they provide. This is important to prevent further biodiversity losses in modified environments.

Darren Le Roux is a PHD candidate at the Fenner School of Environment and Society (ANU). His research is focused on measuring the current and future availability of resources (e.g. mature trees) important to wildlife, including testing the viability of biodiversity offsetting strategies (e.g. hollow replacement methods).

6 What's driving male-biased offspring sex ratio in bridled nailtail wallabies, *Onychogalea fraenata*?

Emily Moore[1], Kylie Robert[1], Matt Hayward[2]
[1]La Trobe University, [2]Australian Wildlife Conservancy

Macropods are some of Australia's most recognised and loved fauna. Up until European settlement, 50 species of macropod were abundant in the Australian environment; of those 50 species, six are now extinct and eleven more are in decline. While there have been conservation attempts made to protect these species, problems such as male-biased sex ratios in captive breeding programs have hindered these efforts. The bridled nailtail wallaby, was once common in the semi-arid region of eastern Australia, but is now restricted to a few isolated populations. Scotia Sanctuary, in south-western NSW, is home to a large captive breeding colony of bridled nailtail wallabies. However, a male-biased sex ratio among the breeding colony may be hindering further reproduction in this polygynous species. Research has indicated that maternal body condition and physiological stress levels may promote male embryo production in eutherian mammals.

We identified a significant male-biased sex ratio. Contrary to previous studies examining sex ratio bias in the same species, there was no correlation found between maternal body condition and offspring sex. Maternal stress levels may be linked to offspring sex in this high density population. If stress is driving sex ratio bias, breeding programs should consider lowering population densities to reduce the proportion of male offspring produced.

Emily Moore recently completed a bachelor of animal and veterinary bioscience with honours at La Trobe University. Her key interests are mammal conservation and tropical fauna.

Environmental policy and management

1 Fire, biodiversity and risk: towards best practice management of roadside reserves in south-east Queensland

Samantha Lloyd[1]
[1]South East Queensland Fire and Biodiversity Consortium

Background/question/methods: In parts of South East Queensland (SEQ) there currently exists conflict between councils and private landholders wishing to burn roadside reserves, adjoining their own property, for fuel load reduction. Currently, no council (except South Burnett) has a process to manage roadside fuel load. At risk from a 'do nothing' approach are tracks of vegetation providing essential habitat and corridors through highly fragmented landscapes (notwithstanding agricultural values, homes and personal safety). In response to community concern and a lack of process, the South East Queensland Fire and Biodiversity Consortium (SEQFBC) was asked to draft a procedure for land managers to efficiently manage applications for roadside hazard reduction burns.

Results/conclusions: The SEQFBC developed a draft application process (based on the South Burnett model) and a report discussing the key issues of biodiversity, insurance, resourcing and local laws. The main biodiversity issue for councils is a lack of roadside biodiversity mapping, without which, application assessments would require site visits, inhibiting the process due to high costs. The SEQFBC proposed two alternative options: (1) commission roadside biodiversity mapping; or (2) develop an internal process using free mapping tools (e.g. ecological significance mapping). Dependant on application assessments, councils may approve a burn, subject to strict conditions and provision of a 'Permit to Light a Fire'. In conclusion, the SEQFBC (1) believe a 'do nothing' approach creates a greater risk than a well managed program; and (2) are currently working with SEQ councils on this process and hope to have further outcomes by the end of 2012.

Dr Sam Lloyd has thirteen years experience in the areas of ecology, entomology and natural resource management. She graduated from Wollongong University with a PhD in pollination ecology in 2006, worked as environmental manager for SEQ Catchments and on the Queensland Fire Ant Program. Currently, Sam manages the South East Queensland Fire and Biodiversity Consortium.

2 ÆKOS: a new paradigm to enable discovery, access and re-purposing of complex ecological data

David Turner[1,2], Paul Chinnick[1], Andrew Graham[1], Martin Pullan[1], Matthias Schneider[1], Anita Smyth[1], Craig Walker[1], Andy Lowe[1,2]
[1]TERN Eco-informatics, The University of Adelaide, [2]Department of Environment, Water and Natural Resources

Background/question/methods: Ecology is a data intensive science, with data generally expensive to collect and individual observations often irreplaceable. Many emerging problems in ecology now also require broad data coverage to adequately examine them, yet sponsorship for such collections is often challenging to obtain. In all cases re-purposing of suitable existing information may provide a satisfactory alternative to re-collection and will also help maximise the value of the initial collection effort.

For data re-purposing to be viable, information needs to be stored and presented in a manner that facilitates re-examination and manipulation. Current barriers that restrict re-use by third party researchers, include poor discoverability, access constraints, and a general lack of necessary contextual information around the data.

ÆKOS—The Australian Ecological Knowledge and Observation System is endeavouring to greatly reduce the time spent by researchers assessing, acquiring and employing third party data, allowing them to more rapidly discover and assess suitability for incorporation into their research. ÆKOS is employing a series of best practice and innovative approaches from a diverse range of disciplines to meet this goal.

Results/conclusions: ÆKOS has reduced many of the technical barriers to ecological data re-purposing by constructing a purpose built data warehouse which is accessible via a web based portal. Effort has been expended developing the information models, semantics, ecological ontology and establishing the necessary partnerships to draw together key ecological datasets from across Australia. It is expected that the first public beta release will occur at the end of 2012. See http://www.aekos.org.au for additional information.

Dr David Turner is the ecology subject matter expert and leads the data analysis and modelling team. All authors are colleagues within the Terrestrial Ecosystem Research Network (TERN) Eco-informatics Facility.

3 The 'eco-cultural' revolution begins with a model for publishing government ecological data

Anita Smyth[1], Craig Walker[1], David Turner[1], Andrew Graham[1], Matthias Schneider[1], Nikki Thurgate[2], Andrew Lowe[3]
[1]TERN Eco-informatics, The University of Adelaide, [2]TERN Multi-Scale Plot Network, The University of Adelaide, [3]TERN Associate Science Director, The University of Adelaide

Background/question/methods: Surveys indicate that ecological researchers strongly support open access to the raw data of published studies but very few are able to make their data publicly available. As a commodity, ecological data collected at the sampling unit level using plots, quadrats, transects, trapping arrays are 'blue chip' data and are in strong demand especially by quantitative ecologists in universities, governments and non-government organisations. Declines in funding for baseline ecology continue and so the demand for volumes of ecological data is predicted to soar in the 21st century just like the Aussie dollar. Since the mid 1980s, empirical studies have focused on barriers to sharing data but no studies have provided a roadmap to overcome them. We undertook a series of negotiations with seven state government environmental agencies to obtain, understand and on-deliver volumes of rich ecological data for open access via the Australian Ecological Knowledge and Observation System (ÆKOS) online data portal.

Results/conclusions: A number of mutually beneficial drivers lead to data sharing agreements and formal partnerships. A synthesis of these informed a novel model for guiding successful data publication. Our government case study shows the benefits of data sharing do outweigh the barriers of open access to raw ecological data.

Dr David Turner is the ecology subject matter expert and leads the data analysis and modelling team. All authors are colleagues of two Terrestrial Ecosystem Research Network (TERN) facilities based at The University of Adelaide.

4 Optimal fire management to maximise animal diversity in Murray-Sunset National Park, Victoria

Katherine Giljohann[1], Michael McCarthy[1], Tracey Regan[1], Luke Kelly[1]
[1]School of Botany, The University of Melbourne

Background/question/methods: Managing to maintain community diversity is complex when the conditions that promote persistence differ for the species within the community. This research considers the problem of managing a nature conservation reserve to minimise reductions in bird diversity in an environment characterised by stochastic and deterministic fire events. We present a reinterpretation of Richards' et al (1999) model of vegetation community succession, an application of stochastic dynamic programming, to determine the optimal fire management strategy to maximise bird diversity when species prefer different successional states. We develop a new objective function based on the extinction risk associated with each successional state to investigate the probability of maintaining maximum bird species in the Murray-Sunset National Park (MSNP) under (a) natural fire regimes and (b) when natural regimes are supplemented with the Victorian Government's 3% annual prescribed burning target for the Mallee region.

Results/conclusions: Using data from the MSNP on fire history and bird species abundances in three vegetation successional states, we found that, over a future 100-year period, the optimal management action to maintain maximum bird diversity is to fight fires. This is largely due to the association of maximum bird diversity with late-stage vegetation, and the risk of unplanned fire returning a large extent of the park to an early successional state. When factoring in the Victorian Government's 3% annual prescribed burning target, persistence of bird diversity will be reduced, however the extent of the reduction depends upon the incidence of unplannned fires.

Katherine Giljohann is a PhD student at The University of Melbourne. Her interests are in predominantly plant ecology with a particular focus on the influence that landscape disturbances, fire and invasive species, have on species dynamics and biodiversity.

5 Is it easy or difficult to find? A general model of detectability using species traits

Georgia Garrard[1,2], Michael McCarthy[1], Nicholas Williams[1], Sarah Bekessy[2], Brendan Wintle[1]
[1]University of Melbourne, [2]RMIT University

Background/question/methods: Imperfect detection is an important source of uncertainty in ecological surveys. Available modelling methods provide valuable detectability estimates, but these are typically species-specific. We present a novel multi-species detection model in which detectability is a function of plant traits and observer characteristics. The model is demonstrated for plants in a temperate grassland community in south-eastern Australia.

Results/conclusions: We demonstrate that detectability can be estimated using observer experience, species population size, and likelihood of flowering. The inclusion of flower colour also improves the capacity of the model to predict detection rates for new species. General models can be used to derive detectability estimates where repeat survey data, point counts or mark-recapture data are not available. As these data are almost always absent for species of conservation concern, general models such as ours will be useful for informing minimum survey requirements for monitoring and impact assessment, without the delays and costs associated with data collection.

Georgia Garrard is a post-doctoral researcher, whose research has focused on methods for estimating and accounting for detection uncertainty in biological surveys. She is also interested in improving biodiversity conservation in urban fringe environments through better design and planning.

Species interactions

1 Temperate grassland response to an extreme rainfall event under elevated CO_2

Anthony Manea[1], Michelle Leishman[1]
[1]Macquarie University

Background/questions/methods: The increase in the magnitude and frequency of climatic extremes such as extreme rainfall and drought is emerging as one of the key components of anthropogenic climate change. Yet our understanding of their effect on plant communities is still limited. Little research has been undertaken on the combined effect of climatic extremes on plant communities under elevated CO_2 conditions. In this study we asked whether community productivity and biomass allocation responses to an extreme rainfall event are modified by elevated CO_2.We grew grassland mesocosms consisting of ten co-occurring grass species common to the Cumberland Plain of the Sydney region under ambient and elevated CO_2 and subjected them to an extreme rainfall treatment. We predicted that the grassland communities grown under elevated compared with ambient CO_2 would have higher productivity under extreme rainfall conditions due to having more belowground biomass, particularly adventitious roots, that would enable the grasses to keep the soil better aerated and thus better withstand waterlogging.

Results/conclusions: We found that the allocation of biomass within the grasses was significantly altered by these factors at a community-level. Extreme rainfall significantly increased the relative allocation of resources to root biomass under elevated CO_2. Although biomass allocation was influenced by extreme rainfall and CO_2 concentration, productivity at a community, plant type (invasive exotic vs native, C_3 vs C_4) or species-level was not altered. The changes in biomass allocation are likely to affect competitive interactions between plants and may also affect other ecosystem processes such as carbon and nitrogen cycling.

Anthony Manea is doing a PhD in the Plant Invasion and Restoration Ecology Lab at Macquarie University. His aim is to develop a risk assessment framework for the endangered plant communities of the Cumberland Plain under future climates. He is currently studying grassland responses to extreme climatic events under elevated CO_2 levels.

2 Additive basal area revisited: do emergent conifers avoid competition with their lower statured neighbours?

Bruce Burns[1], Mark Ducey[2]
[1]School of Biological Sciences, University of Auckland, New Zealand, [2]Department of Natural Resources and the Environment, University of New Hampshire

Background/question/methods: Old-growth forests with large emergent conifers can achieve high levels of basal area. For some species, e.g. *Agathis australis* in New Zealand, *Araucaria hunsteinii* in New Guinea, and *Cryptomeria japonica* in Japan, this basal area accumulation has been observed without compensatory reduction in the basal area of the associated angiosperm-dominated forest matrix. Such adjustment in the basal area of other species would be expected if basal area is assumed to be a measure of biomass, and if there is a limit to the amount of biomass supported on any forest site. The observations of basal area accumulation of emergent conifers not affecting other forest components has been termed 'additive basal area', and used to hypothesise that large conifers avoid competition with lower-statured neighbours by vertical stratification and more efficient spatial packing. An alternative explanation is that much of this accumulated basal area in giant trees is heartwood that does not conduct water and therefore does not support living biomass. We alternatively hypothesise that sapwood basal area of emergent conifers varies in proportion to basal area of other forest components, and that the relationship between total basal area and leaf area index will weaken in high basal area stands.

Results/conclusions: We present results of a study in which we determine whether additive basal area can be detected in old-growth *Pinus strobus* stands in New England. We also measure sapwood basal area and leaf area index of stands and assess how these vary between different forest components and as total basal area increases.

Dr Bruce Burns is a forest ecologist from the University of Auckland, New Zealand particularly interested in the unusual forests dominated by the giant conifer Agathis australis, and equivalent old-growth forests elsewhere. A New Zealand native, his PhD was conducted at the University of Colorado.

3 Are urban birds full of parasites?

Carlos Delgado-Velez[1], Kris French[1]
[1]Institute for Conservation Biology and Environmental Management, School of Biological Sciences, University of Wollongong

Background/Question/Methods: Changes in host-parasite interactions have the potential to be one of the important consequences of urbanisation. Since the risk of parasitism and potential diseases might increase in urban areas, susceptibility to parasites may be an additional constraint that explains why some birds do not do well in cities. Parasite prevalence and intensity need to be linked with measures of inflammation and infection since parasites that do not influence hosts are unlikely to be factors in determining whether birds live in urban areas. Integrating ecological and immunological approaches, this project seeks to analyse the distribution of diverse parasites along an urbanisation gradient, and explore the potential role of parasites and immune status in determining the structure, maintenance and conservation of urban-bird communities.

Results/Conclusions: We present a brief outline of the planned project and include some preliminary data for a couple of species on the prevalence and intensity of ectoparasites and some haematological health indices such as Haemoglobin Concentration, Packed Cell Volume, and Sedimentation Rate which are considered potential measures of health, immune status and are likely to respond to parasite load.

Carlos Delgado-Velez is a Biologist from Colombia, South America. He hopes that his PhD time in Australia will bring him new concepts, firsthand experiences and cutting-edge techniques required to build up an integrative approach to the knowledge of urban and road ecology in his natal Neotropical region.

4 Run for cover! How species reintroductions influence termite biomass

Nicole Coggan[1]
[1]La Trobe University

Background/question/methods: Critical weight range (CWR 35g-5500g) marsupials were previously widespread throughout Australia. Their reintroduction into feral predator-free sanctuaries provides opportunities to discover how their activity shaped Australian habitats. Invertebrates contribute to many CWR species' diets: CWR disturbance should thus be avoided by invertebrates *via* redistribution into less disturbed habitats. Understanding these interactions will strengthen habitat assessments as the need for new sanctuaries increases. I tested the influence of reintroduced burrowing bettongs on termite abundance and biomass, comparing: 1) landscapes inside and outside three fenced sanctuaries; and 2) within four microhabitats: bare ground, under live foliage, dead leaf litter and logs. I hypothesised that termites would avoid disturbance, becoming less prevalent in the presence of bettongs, and also in microhabitats where bettong activity was highest. Trench sampling termites and line-tracking bettongs quantified termite abundance and biomass against bettong activity (% disturbance). GLM and Spearman's were used to explore interactions between termites and bettong activity.

Results/conclusions: Disturbance affected termite abundance and biomass at both spatial scales. Termite abundance was 56% lower on the inside of sanctuaries, although there was no effect on biomass. Bettong activity was negatively correlated with termite biomass, particularly around bare ground and logs. Termite biomass significantly decreased in bare ground and increased around logs by 37% and 28% respectively. Increased disturbance from reintroduced CWR species influences termite biomass by causing a shift into less disturbed habitats. Specifically, the preference of termites for logs, a low-disturbance microhabitat, increased when other microhabitats were exposed to disturbance by bettongs, supporting the disturbance-avoidance hypothesis.

Nicole Coggan is a PhD candidate at La Trobe University supervised by Drs. H. Gibb and M. Hayward. Nicole's project investigates the consequences of critical weight range marsupial extinctions and their subsequent reintroduction upon invertebrate-driven ecosystem processes and biodiversity.

5 Arctic waders provide evidence that lemmings don't want to cycle anymore

Yaara Rotman[1], Marcel Klaassen[1], Clive Minton[2], Mikhael Soloviev[3], Pavel Tomkovich[4], Chris Hassell[5]
[1]Deakin University, [2]Australian Wader Studies Group, [3]Department of Vertebrate Zoology, Biological Facility, Lomonosov Moscow State University, [4]Zoological Museum, Lomonosov Moscow State University, [5]Global Flyway Network

Background/question/methods: The alternative prey hypothesis suggests lemming cycles in the Arctic breeding grounds are indirectly responsible for inter-annual fluctuation in breeding success of geese and waders. Previous studies found such interactions in the East Atlantic Flyway. We studied whether lemming cycles may also indirectly affect breeding success of waders from the East Asian- Australasian flyway. To investigate whether breeding success in waders in general is driven by any large scale effects, such as lemming cycles on the breeding grounds, we (i) tested whether species from the same flyway show similar patterns in breeding success across years. Next we investigated whether variations in breeding success in waders are (ii) cyclical and (iii) possibly directly associated with year-to-year variations in lemming abundance as suggested by the alternative prey hypothesis.

Results/conclusions: We could not identify a link between juvenile percentages in Australia and lemming abundance on the breeding grounds. Most wader species did not show population cycles, as would be expected if they are under influence of lemming cycles, and breeding success did not correlate with lemming abundance in the different breeding areas. We interpret our results to be due to current changes in lemming cycles showing a tendency to disappear over the past two decades.

Yaara Rotman is a second year PhD student in the Centre for Integrative Ecology in Deakin University. Her background in geography and ecology from Ben Gurion University in Israel drove her to the main focus of her thesis, which includes various aspects of conservation and ecology in long distance migratory shorebirds.

6 Associational refuge theory: can it facilitate revegetation in practice?

Rebecca Stutz[1], Peter Banks[1], Clare McArthur[1]
[1]School of Biological Sciences, The University of Sydney

Background/question/methods: Feeding pressure from high herbivore densities can significantly impact vegetation structure, and potentially influence other components of an ecosystem through trophic cascades. Plants may be afforded protection from herbivory not only from their own characteristics but also via their neighours; termed 'associational refuge'. Such refuges have the potential to influence foraging patterns and thus feed back to shape the effects of herbivores on plants. Our study tests the utility of associational refuges in increasing revegetation success in Booderee National Park, NSW, by influencing macropod (largely swamp wallaby, *Wallabia bicolor*) browsing. Specifically, we monitored browsing damage of nursery-raised eucalypt *Eucalyptus pilularis* seedlings planted in a degraded area of the park. The initial trial examined the potential impact of surrounding natural vegetation on the rate of herbivory, while subsequent trials tested the impact of possible refuge plants on seedling survival.

Results/conclusions: The extent of canopy cover was the most significant factor explaining browsing damage of seedlings. This link was unlikely to have been directly causal, and as influencing canopy cover was not a practical option, we manipulated the second most important factor: below-canopy plant cover. In a trial using White Paper Daisy (*Coronidium elatum*) as a potential refuge plant, the rate of browsing was significantly lower among seedlings surrounded by the refuge plant. Associational refuge plants may be a useful tool in reducing the rate at which seedlings are browsed, but its practical effectiveness relies on the rate of escape exceeding the rate of browsing within months of initial establishment.

Rebecca Stutz has completed BSc(Conservation Biology)/Bsc(Environmental Science), Honours (Applying biodiversity metric to jarrah forest), Murdoch University. Currently PhD candidate, University of Sydney: foraging ecology of swamp wallabies, particularly manipulation of foraging patterns to facilitate revegetation

7 Snotty-gobble seedlings on a novel host

Elizabeth Maciunas[1], José Facelli[1], Jennifer Watling[1]
[1]University of Adelaide

Background/question/methods: *Cassytha pubescens* (Snotty-gobble) is a parasitic vine native to south-eastern Australia. Previous studies have shown that infection by this parasite have a stronger detrimental effect on the performance of invasive than on natives species. Little is known about the seedling stages of this parasite, and whether an invasive host species may favour the growth and survivorship of seedlings more than a native plant host.

In a glasshouse study we grew seedlings of the parasite in pots with *Leptospermum myrsinoides* (tea-tree, native) or *Rubus* agg. (blackberry, invasive). The experiment ran over 12 months, and the physiology of the host species and biomass of host and parasite were measured to assess host quality and success of the growth of the parasite.

Results/conclusions: Seedlings established and grew well on both invasive and native species, confirming the generalist nature of this parasite at all life stages. Infection significantly reduced the biomass of the blackberry, with a strong negative linear relationship between the biomass of the parasite and that of the host. However the light response of the parasite was higher on blackberry than on tea-tree, indicating that the invasive species is a higher quality host. Furthermore, the reduction of the invasive host biomass is in agreement with previous work on other invasive species infected by this parasite. This work also extends the number of invasive weeds that could potentially be targeted for biological control by snotty-gobble in south-east Australia.

Elizabeth Maciunas is a third year PhD student at the University of Adelaide working on the ecology of a native parasitic vine. Her project includes dispersal, host-parasite interactions and plant physiology. She also has an interest in paleobotany, a field in which she completed her honours project in 2009.

8 Light influences the responses of *Ulex europeaus* and *Leptospermum myrsinoides* to a native parasitic plant

Robert Cirocco[1], Jennifer Watling[1], José Facelli[1]
[1]University of Adelaide

Background: Parasitic plants can significantly affect the carbon economy of their hosts, but little is known about how light affects these relationships. We studied the effect of light and *Cassytha pubescens* infection on an invasive (*Ulex*) and a native plant (*Leptospermum*).

Methods: *Ulex* and *Leptospermum* were infected with *Cassytha* under glasshouse conditions. Plants were grown in full sunlight or 35% full sunlight. Plant performance was assessed as photosynthesis and biomass of hosts and parasite were quantified.

Results/conclusions: Maximum electron transport rates of both hosts were reduced by *Cassytha* infection and shade, which also reduced it in *Cassytha*. Biomass of *Ulex* was significantly reduced by infection and shade. Shade but not *Cassytha* reduced biomass of *Leptospermum*, while shade reduced the growth of *Cassytha*. Biomass of *Cassytha* was higher on *Ulex* than on *Leptospermum*. Relative parasite effect on biomass was stronger for *Ulex* than for *Leptospermum* regardless of light conditions. Overall shade and *Cassytha* infection had a stronger negative effect on the invasive *Ulex* than on the native *Leptospermum*. This may reflect different ecological strategies and tolerances. Invasive species are usually faster growing than native species and may provide a more rapid supply of resources to *Cassytha*. If *Cassytha* is able to sequester these resources, the parasite might grow more, thus becoming a larger sink, to the detriment of the invasive *Ulex*. On the other hand, slower growing native species such as *Leptospermum* may be better adapted to resource limitation and may also provide fewer resources to the parasite, allowing them to tolerate infection.

Robert Cirocco's aimis to pursue a career in science as a professional in the fields of plant ecophysiology and ecology. His passion is in discovering underlying mechanisms, processes and patterns of terrestrial plant interactions which have both practical and academic applications.

9 Can excluding cane toads from water provide biodiversity benefits for arid Australia?

Ben Feit[1], Mike Letnic[2]
[1]Hawkesbury Institute for the Environment, University of Western Sydney, [2]School of Biological Sciences, University of Sydney

The invasion of cane toads (*Bufo marinus*) across northern Australia has been an ecological tragedy. Cane toads contain novel toxins that are absent from Australian frogs, and consequently, many predators die after attacking or consuming toads. Populations of goannas, snakes, and northern quolls have severely declined following the arrival of cane toads and the toads are now expanding their range into semi-arid regions of the continent, where they pose a serious threat to the persistence of a rich suite of carnivorous reptiles. Efforts to control cane toad numbers have had little success, and we urgently need methods to mitigate toad impacts on native predators. Unlike native arid-adapted frogs, cane toads require regular access to water to survive the long-dry periods that occur in semi-arid Australia. Consequently, sites with permanent artificial water (bore-fed dams) function as invasion hubs for cane toads, allowing toads to survive dry spells and penetrate further into the arid zone after rain. A recent study demonstrated that landholders could eradicate toads from large areas by replacing their open earthen dams with above-ground tanks made of plastic or steel that gravity feed into raised cattle troughs. These tanks do not allow toads to access water. Landscape modelling suggested that this strategy could keep cane toads out of an area of one million square kilometers in the semi-arid zone, and could have enormous benefits to biodiversity. We evaluate the effectiveness of this toad control strategy to reduce toad impacts by comparing goanna abundances and lizard communities in regions where toads can access water in bore-fed dams, with regions where toads cannot access bore-fed water sources.

Background/question/methods: Abundances of goannas should be lower due to fatal poisoning in areas inhabited by toads. Consequently, abundances of small lizard species should be higher as they are among the preferred prey species of large goannas. We monitored the abundance of goannas during the dry season by sampling goanna tracks and recently used goanna foraging pits on six transects along roads (25 km each, three close to bore-fed dams, three close to plastic tanks). We monitored abundance and species richness of small lizard species using active searches for small lizards. For the active searches we walked aside roads at plots along the transects used for track counts (ten plots at each transect, ten minutes each plot) and counted and identified all small lizards encountered.

Results/conclusions: Goanna abundances are lower and abundances of small lizards, the preferred prey of goannas, are higher in regions where toads can access water in bore-fed dams in comparison to regions where toads cannot access bore-fed water sources. Consequently, plastic tanks could provide benefits for ecosystems in the arid zone.

Ben Feit is currently a PhD candidate at Hawkesbury Institute for the Environment. He received his Diploma in Biology (equivalent to Masters of Science)at the University of Wuerzburg, Germany, in cooperation with the Smithsonian Tropical Research Institute, Panama, and the University of Ulm, Germany.

10 Predators and prey: a camera trapping survey of Wilsons Promontory's mammal community

Lucinda Gow[1], John White[1], Euan Ritchie[1]
[1]Deakin University

Background/question/methods: In Australia, predation by the feral cat and the fox has severely impacted native biodiversity. Predator activity may vary in response to the threat of intraguild predation, but little is known about how activity is influenced by habitat structure or partitioned through time. Wilsons Promontory National Park contains foxes, cats and a possible isolated population of wild dogs. We set out to examine how the activity of these species may be affected by 1) activity of other predators; 2) habitat structure offering refuge/cover; and 3) time of day/night. 91 sites across 50 km^2 of northern Wilsons Promontory National Park were surveyed using baited infrared cameras, for a total effort of 2448 trap nights. Potential cover and refuge provided by vegetation and other landscape components was measured for each site.

Results/conclusions: Detection of feral cats and foxes was low, with cats photographed three times at 3.3% of sites, and foxes 13 times at of 11% of sites. No wild dogs were detected. A number of herbivorous species (potential prey of foxes) were also recorded: swamp wallabies 68% of sites, common wombats 49% of sites, eastern grey kangaroos 10% of sites and hog deer 8% of sites. Of those species for which we had sufficient data (>10 records), kangaroos and hog deer showed associations with vegetation cover, but foxes, wallabies and wombats did not. Further study is required to determine the drivers of these patterns, and the impact of pest and fire management on the dynamics of the Park's mammal community.

Lucinda Gow is currently midway through an honours year at Deakin University after completing a degree in wildlife and conservation biology. She has a wide range of interests within ecology but is currently focusing on predator interactions under the supervision of Dr Euan G Ritchie.

Index of presenting authors