Our Vision

Science for the environment

Our Mission

The Centre for Ecosystem Science (CES) aims to be a leader in research, its application and communication of environmental change. We aim to attract top quality students and form strategic partnerships with government, industry and the community.
Year in brief – Director’s report

In late 2013, we changed the name of the centre to the Centre for Ecosystem Science (CES), from the Australian Wetlands, Rivers and Landscapes Centre (AWRLC). This followed a long discussion within the Centre and its members about our current expertise and future direction. The new name reflected the considerable expertise that we had beyond the realm of freshwater ecosystems, as well as recognising that aspects of our freshwater work were more broadly relevant to ecosystem science and management. The CES has four main themes: Rivers and Wetlands, Terrestrial Ecosystems, Remote Sensing & GIS and Conservation Practice.

In 2013, the three year external review of the centre was highly positive, recognising that we had met all of our objectives, were supported by the School of Biological, Earth and Environmental Sciences (BEES) and had established a good operating culture with commitment to working with government and community on high quality research, its impact and advice. We were successful in attracting funding for three ARC Linkage Projects led by centre researchers: Red Listing of Ecosystems (Professor David Keith), Prey Naiveté (Dr Mike Letnic) and Remote Sensing of Environmental Flows (Dr Mirela Tulbure). Dr Jes Sammut established a major program on sustainable rice-shrimp farming on the Mekong Delta. We also continued to attract government funding for wetland and river research and mapping of vegetation. Postdoctoral Researcher Dr Mitchell Lyons joined us to work with the New South Wales Office of Environment and Heritage on the analysis of mapped vegetation communities across New South Wales. In October, Professor Lucas with expertise in remote sensing and vegetation dynamics, joined the centre supported by special purpose funding (SPF01) from UNSW. Professors Lucas and Keith were appointed as Deputy Directors of the centre.

Our key productivity metrics have continued to grow since establishment of the Centre in 2009 (Fig. 1-4). We have experienced more than a doubling in research income, more than an eight fold increase in peer reviewed publications and more than a doubling in postgraduate enrolments (Fig. 1-3). This reflects the growth in academic staff, research staff, postdoctoral fellows, research assistants and honorary research associates (Fig. 4)

We have continued to develop our postgraduate programs to ensure that emerging scientists benefit from our ability to increase their skill levels in particular areas, critical to their future scientific career. We offered two courses in 2013: a plant identification course and scientific writing workshop. The plant identification course was also open to the public (30 attendees). We also initiated the first full course of statistics for postgraduates and staff, taught by staff from the School of Mathematics and Statistics and BEES. We aim to make this an annual course. We are also actively involved with the Postgraduate Forum, coordinating the Great Debate in June (“Pure Science is better than Applied Science”), a light-hearted approach to the subject. Dr Mike Letnic successfully coordinated the Australian Mammal Society Conference at UNSW.

Our researchers were recognised with awards in 2013 including David Keith receiving the Australian Ecology Research Award from the Ecological Society of Australia; Dr Mike Letnic as part of a team received the Eureka Prize for Environmental Research; Sam Dawson receiving
the Peter Cullen Scholarship and; Rachel Blakey the first prize for a postgraduate at the 2013 Australian Limnological Society Conference. Staff in the Centre contributed across undergraduate teaching and also to outreach projects such as Science without Borders.

We continue to have a strong focus on providing scientific expert advice to governments on a range of key issues including the long term monitoring of waterbirds and wetlands, the management of the Murray-Darling Basin, Lake Eyre Basin, Environmental Flows and management of river red gum forests. Our collaborative projects with governments, particularly the NSW Government, continue to grow. We also expanded our terrestrial research projects focused on trophic cascades and vegetation. We are also strongly committed to outreach activities and outcomes to the community. This is achieved through the media and also workshops with communities, including a workshop held for government and community in the Macquarie Marshes and a conference on the future of the Lake Eyre Basin.

A particular focus of 2013 was attracting future honours students, strategies of which have been discussed at length in centre meetings throughout the year. In 2013, all six honours students (Alex Soderlund, Bradley Clarke-Wood, Chantel Benbow, Charlotte Mills, Justin McCann and Sarah Allison) achieved first class honours. We hope to uphold this high standard of achievement with future undergraduate students by supporting academics as supervisors and encouraging doctoral candidates to take on mentoring roles of these students. The development of our honours students as ecological researchers remains a high priority for the Centre.

Richard Kingsford

Professor of Environmental Science
Director of the Centre for Ecosystem Science
Year in brief - Summary performance in key productivity metrics

Figure 1. Revenue since establishment of the Centre in 2009. Category 1 funding (blue) and other funding (red).

Figure 2. Number of peer reviewed publications since establishment of the Centre in 2009.

Figure 3. Number of postgraduate enrolments since establishment of Centre in 2009.

Figure 4. Numbers of people associated with the Centre in different categories since its inception in 2009.
Rivers and wetlands

**Eastern Australian Waterbird Survey**  
*Project leader: Professor Richard Kingsford, Dr John Porter, Dr Kate Brandis*

The Eastern Australian Waterbird Survey is one of the larger wildlife surveys in Australia, surveying major wetland sites in the Murray-Darling Basin, providing invaluable information on the ecosystem health of wetlands and rivers. 2013 marked the 31st year the survey has run. The long term (31 years) of data provides the essential baseline information with which to assess changes and impacts on the environment, particularly wetlands and rivers. It is also providing some of the only long-term objective data on waterbird populations in Australia. This has proved particularly relevant in understanding the dynamics of environmental water needs for biodiversity purposes especially as they relate to waterbirds and wetlands. Changes in waterbird numbers provides a tangible way of indicating and measuring changes in the ecological health of river and wetland systems.

![Aircraft over wetlands](image)

*Figure 5. Aircraft are flown at low levels with two observers, one on either side of the aircraft, estimating and identifying total numbers of waterbirds on wetlands.*

**Waterbird Communities in the Murray-Darling Basin (1983-2012)**  
*Project leader: Professor Richard Kingsford, Dr Gilad Bino, Dr John Porter, Dr Kate Brandis*

We examined the effectiveness of using waterbirds as an indicator of wetland and river health in the Murray-Darling Basin. We showed that waterbirds were effective indicators at different spatial scales, from the entire Murray-Darling Basin, to the catchment and finally at the wetland scale. The ability to collect data on waterbirds at the entire wetland scale allows for the aggregation of wetlands in a catchment and then wetlands in the Murray-Darling Basin to provide an assessment of condition at the basin-scale. Further, there are more than 50 species that are reported, meaning that a range of different measures of the indicator can be collected including number of waterbirds, number of species, breeding (2 indices) and number of waterbirds in functional groups as well as individual species. The ability to divide waterbird communities into functional response groups (e.g. piscivores, herbivores) also provides insight into ecosystem functional changes in primary, secondary and tertiary productivity.
Wetland isotopes; ibis feathers and diets
Project leader: Dr Kate Brandis and Debashish Mazumder (Australian Nuclear Science and Technology Organisation)

Understanding the movements of waterbirds is essential for management of populations and the wetlands on which they depend. Stable isotopes represent a cost-effective means of linking the movement of birds among specific wetlands where the isotopic characteristics of prey items are retained within feathers. We sampled juvenile feathers from straw-necked Ibis *Threskiornis spinicollis* along with a range of potential prey items from two of the most significant nesting sites for ibis in the Murray-Darling Basin, eastern Australia: the Lowbidgee Wetlands and the Macquarie Marshes. We found that the consistent depletion in δ¹³C of prey in the Lowbidgee wetlands was reflected in the depleted δ¹³C of feathers of birds fledged within this wetland. Carbon isotope ratios may therefore be useful in identifying birds originating from the Lowbidgee wetlands where insufficient discrimination is possible for other isotopes.

Database management and quality assurance of Eastern Australian Waterbird Survey Data
Project leader: Dr Kate Brandis, Professor Richard Kingsford, Dr John Porter, Sharon Ryall

The annual aerial survey of waterbirds in eastern Australia (EAWS) is one of the most important long-term wildlife surveys conducted in Australia (1983-present), spanning 31 years in 2013 and covering about one third of the continent. The survey is a state and Commonwealth collaborative program that recognises distribution and mobility of waterbirds and provides the opportunity to contextualise regional and jurisdictional conservation and management programs. The program provides uniquely detailed information for policy and management in different areas for Commonwealth and State Governments (e.g. State of Environment Reporting, Biodiversity Conservation Strategies, River Basin Management (e.g. Murray-Darling Basin Plan), Ramsar reporting, Shorebirds 2020 program). Survey data are collected annually. All waterbird species (~50) are counted on up to 2000 wetlands each October. After data collation, entry, quality control and assurance checking, they are uploaded into the spatial database.
maintained by the University of NSW. In addition, the data are provided to NSW OEH for the Wildlife Atlas. Twenty five years of data (1983-2007) are currently available via the Wildlife Atlas. Post 2007, there were insufficient resources available for mandatory database maintenance, verification and quality control. This precluded release of data for updating the Wildlife Atlas or other secondary data repositories. Prior to providing updated data (2006-2012) for the NSW Wildlife Atlas database maintenance and quality assurance was undertaken.

**Sustainable Rice-Shrimp Farming in the Mekong Delta**  
*Project leader: Associate Professor Jes Sammut*

Rice and shrimp have been farmed in rotation in the Mekong Delta for 40 years. In this region, rice is farmed in the wet season when water salinity is low and shrimp are farmed extensively and semi-intensively during the dry season when the water salinity is too high to continue with rice production. Rice farming is promoted by the Government of Vietnam to ensure demand for rice is met locally and to maintain an export market. Rice production is also an important component of the sustainability of the rice–shrimp system. Increasing salinity, as a result of changing environmental conditions and catchment-wide water management, has decreased rice yields in the normally productive wet season. Shrimp yields have been affected by recurrent disease outbreaks, exacerbated by stocking of poor-quality post-larvae and declining pond soil and water quality. Research is already underway to test redesigned rice–shrimp farming systems and new salt-resistant rice varieties, but the mechanisms underpinning the sustainability of rice–shrimp production systems are poorly understood. Further research is required on key factors, mechanisms and constraints that influence the productivity of new rice–shrimp farming systems. Our research will enable scientifically validated modifications to the farming system to increase profitability and ensure sustainable practices are promoted. Expected impacts include increased reliability of crops and in rice and shrimp yields and profitability, improved income and food security and reduced on- and offsite environmental degradation.

![Figure 8. Launch of our project on sustainability of rice farms and shrimp farming in Vietnam.](image)

**Sustainable aquaculture (Malaysia)**  
*Project leader: Dr Jenny Beer and Associate Professor Jes Sammut*

An ACIAR-funded aquaculture project was launched on 18-19 August 2010 in Goroka in the Eastern Highlands of PNG to develop fish farming packages based on scientifically-validated
methods. The project will develop site selection criteria and improve farming methods to enable farmers in the inland areas of PNG to sustainably farm fish for income and food security. Associate Professor Jes Sammut is coordinating the project with Mr Jacob Wani from the National Fisheries Authority. The team of researchers, government extension officers, aquaculture technicians and NGOs will work on all aspects of fish farming with a focus on delivering farming technologies that are simple to apply yet based on scientific studies.

Regulation’s impact on carbon availability: Larval fish Growth

*Luke McPhan – PhD candidate*

Carbon is the basal building block for life on earth and dominates the structure of different tissues in organisms. The aim of this project is to investigate the sources of carbon that promote growth in larval fish. Larval fish represent an important link between invertebrate and vertebrate aquatic trophic levels and an integral group of food web interactions in floodplain river ecosystems. Through the implementation of structures including dams, weirs, and diversions for irrigation purposes (regulation), wetland and river biodiversity and health has been impacted negatively with regulation disrupting the connectivity and linkages in floodplain river ecosystems. The present study is investigating the growth rates of larval fish based on exogenous carbon sources and the nutrition of food sources. Analysis is being performed using stable isotope analysis and DNA:RNA ratios to investigate the importance of specific carbon origins in regulated and unregulated floodplain river systems. This research will contribute to the literature of larval fish survival and growth with long term management and implementation of conservation efforts being better informed to support the growth of larval fish in regulated systems.

![Figure 9. Murray Cod larvae (10-15 days old) are highly dependent on different food sources, identified through stable isotope analyses.](image)

Aquatic invertebrate responses to drying

*Sylvia Hay – PhD candidate*

This project examines the effects of drying on aquatic invertebrate communities in intermittent river systems. Intermittent rivers, or rivers that periodically cease to flow, are the prevalent river type in Australia and occur across many climatic regions. It was historically assumed that intermittent rivers had low biodiversity value. However, intermittent rivers can support a diverse range of taxa, with aquatic invertebrates pivotal in the ‘boom and bust’ ecology of these
systems. We know little however about the tolerance of aquatic invertebrates to extended drying, the strategies they use, and limits to survival. Physiological and behavioural strategies to survive drying are being investigated in this project, across different climatic regions. These refugial strategies include persistence in pools, aestivation in dry sediment and aerial dispersal. The importance of understanding intermittent river dynamics will increase in regions that experience drying trends due to climate and land-cover change, and increasing water abstraction for human use. This study is part of a wider Australian Research Council linkage project (LP100200080) comprising innovative approaches to identifying regional responses of biodiversity to climate change.

![Figure 10. Invertebrates such as this blue yabbie Cherax destructor are highly dependent on the intermittent nature of flow in dryland rivers.](image)

Bats across biomes: flooding and structural influences on bats and their food webs
Rachel Blakey – PhD candidate

![Figure 11. Food web of bats.](image)  
![Figure 12. LIDAR (Light Detection and Ranging) image of a redgum Eucalyptus camaldulensis forest. LIDAR can be used to identify detailed structure of forests and provide understanding of how different species of bats use this complex habitat.](image)

Bats are the most diverse group of mammals in the Murray-Darling basin and play a key role in both aquatic and terrestrial foodwebs. Despite this, ecologists have a poor understanding of how bat communities respond to floodplain dynamics and variable forest structure in these ecosystems. We showed that bats respond to flooding history at the landscape scale with greater activity and diversity of bats in more frequently flooded habitats. At the wetland scale, we’ve discovered some bats altered their foraging preferences between different flooding
phases of a wetland. Our fieldwork has also uncovered a rare inland population of the threatened fishing bat *Myotis macropus* and a study investigating its foraging preferences across wetland flooding phases is underway. In addition to flooding, the variable structures of floodplain forest challenges bat communities with varying tolerances for clutter. We are using terrestrial laser scanning (LiDAR) to relate bat habitat use and prey availability to forest clutter. We are working with conservation, water and forestry managers to integrate our findings into better practices for the preservation of floodplain biodiversity.

**The ecological response of insectivorous bats to coastal lagoon degradations**  
*Bradley Clarke-Wood – Honours project*

Trawling insectivorous bat species have adaptations suited to preying on surface dwelling aquatic invertebrates and small fish, and so may be an especially good indicator of coastal lagoon degradation and restoration progress. *Myotis macropus* is Australia’s only trawling bat, which means its uses its large feet and a linear call to forage over different wetlands. It is listed as a ‘vulnerable species’ in the NSW Threatened Species Conservation Act (1995) and as a result of limited detection in the riparian habitats, it is considered to be sensitive to urbanisation. The degradation of coastal lagoons is predicted to impact on threatened and specialised species like *Myotis macropus*. This is likely to be an indicator of a larger trend towards the restructuring of bat communities as these ecosystems are degraded by factors such as contamination and eutrophication.

![Figure 13. The fishing bat *Myotis macropus* is threatened and highly dependent on wetlands in good condition. Our study investigated food webs in coastal lagoons.](image)

**Amphibian community response to river flow and rainfall in the Macquarie Marshes**  
*Joanne Ocock – PhD candidate*

Through their multiple life-stages, amphibians occupy predator, prey and consumer roles, influencing various ecosystem processes due to high densities and biomass and significantly contribute to wetland foodwebs. To effectively manage environmental flows, managers require an understanding of the relationship between river flow, flooding patterns and biotic responses, preferably supported by quantification. For amphibians with relatively poor information, it is important to identify the relationship between amphibian ecology and flow regimes, including effects of variable inundation regimes, habitat associations, and cues for movement or breeding.
We identified relationships between flooding and different species of amphibians in the Macquarie Marshes. Just as different groups of waterbirds have different associations with the flood pulse and floodplain habitat, there was not a single flood-characterisation that fitted all amphibian species. Among the amphibians inhabiting the Marshes, we showed relationships between species and their habitats varied with the flood pulse, a product of different life-history, behavioural and physiological characteristics of each species. We also showed that amphibian species strongly associated with flooding were more numerous and comprised the largest proportion of the total frog biomass, during the early stages of the 2009-10 and 2010-11 floods, indicated a positive response to flood conditions and timing.

![Image](image.png)

Figure 14. Green tree frog *Litoria caerulea* tracked in the Macquarie Marshes to determine its responses to weather and environmental flows.

**Temperate highland peat swamps on sandstone**

*Project leaders: Dr Tanya Mason and Professor David Keith*

Upland swamps are dynamic and diverse ecosystems that support mosaics of shrub and sedge-dominated plant communities, often within a forested matrix. The spatial configuration of these vegetation mosaics may reflect current and antecedent conditions of hydrology, nutrient availability and disturbance regimes such as fire, as well as interactions between the component species of the system. They offer important opportunities to study how the interaction between environmental gradients and disturbance regimes influence the persistence of biodiversity. This can significantly advance theory and practical outcomes for conservation management.

In Dharawal National Park, south of Sydney, floristic changes across permanent transects have been monitored periodically since 1983 as part of Australia’s Long Term Ecological Research Network. High resolution hydrological monitoring has recently been established across the regional rainfall gradient across which the swamps are distributed. This will improve understanding of the hydrological sensitivity of swamp vegetation. A remote sensing change detection study is monitoring the spatial dynamics of landscape vegetation patterns from the 1940s to present. These show late 20th century expansion of swamps, but recent modelling suggests that their distributions are likely to contract under future climate scenarios. And a biogeographical review is underway to characterise regional variation in swamp systems across...
eastern Australia. The work will support conservation planning and management of swamps, improve understanding of regional variation, assess risk status and model distributions with climate change.

Figure 15. (a) Permanent transect in upland swamp at Dharawal National Park, south of Sydney (b) Automated Weather Station in swamp vegetation which monitors hydrological and climate change

**Community stability of upland swamp vegetation**

*Chantel Benbow - Honours project*

This study applied diversity-stability theory to investigate spatial and temporal patterns of community stability in two upland swamps in Dharawal Nature Reserve, NSW. Data collected from vegetation surveys spanning three decades were used to examine changes in community and stability across a species richness and environmental stress gradient, as well as over two time frames related to the site fire regime. Stability was measured using indices of temporal change in species’ richness, species’ composition and relative abundance. The results showed that diversity does not appear to promote stability in upland swamps, rather the environmental gradient explained more of the variation in stability. Communities in the wet core of swamps were more stable than those near the dry margins. This may be explained by stress-tolerant traits of species in the wet core, and/or by the influence of spatial processes occurring across the swamp-woodland boundary at the margin.
Long term ecosystem dynamics
Project leader: Professor David Keith

David Keith leads three studies within Australia's Long Term Ecological Research Network. The studies are centred on upland swamps, mallee woodlands and temperate grassy woodlands. In 2013, the Centre hosted Honours student Chantel Benbow to investigate temporal trends in plant diversity along an environmental gradient within upland swamps. She found that diversity was more stable under conditions of environmental stress where the availability of soil oxygen was most limiting. The work will help understand the consequences of hydrological change in the swamps driven by underground mining and climate change. Monitoring of long term plots continued in the mallee woodland study during 2013. The plots implement fire and grazing treatments in which different combinations of herbivores are excluded during the post-fire recovery process. This work will help reinforce and improve management strategies to conserve the unique biota of mallee woodlands.
Figure 17. Tracking vegetation growth and health in long term vegetation exclosures in Tarawi, western NSW.

Temperate Highland Peat Swamps on Sandstone
Project leader: Dr Tanya Mason and Professor David Keith

Upland swamps are dynamic and diverse ecosystems that support mosaics of shrub and sedge-dominated plant communities, often within a forested matrix. The spatial configuration of these vegetation mosaics may reflect current and antecedent conditions of hydrology, nutrient availability and disturbance regimes such as fire, as well as interactions between the component species of the system. For research, they offer important opportunities to study how the interaction between environmental gradients and disturbance regimes influence the persistence of biodiversity. This has potential to produce significant advances in theory and practical outcomes for conservation management.

A number of research strands will resolve these questions. In Dharawal National Park, south of Sydney, floristic changes across permanent transects have been monitored periodically since 1983 as part of Australia’s Long Term Ecological Research Network. High resolution hydrological monitoring has recently been established across the regional rainfall gradient across which the swamps are distributed. This will improve understanding of the hydrological sensitivity of swamp vegetation. A remote sensing change detection study is monitoring the spatial dynamics of landscape vegetation patterns from the 1940s to present. These show late 20th century expansion of swamps, but recent modelling suggests that their distributions are likely to contract under future climate scenarios. And a
biogeographical review is underway to characterise regional variation in swamp systems across eastern Australia. The work will support conservation planning and management of swamps, improve understanding of regional variation, assess risk status and model distributions with climate change.

Figure 18 - Spatial variation in vegetation communities, Dharawal National Park

**Orange pipeline environmental assessment**
*Justin McCann - Honours project*

There is increasing pressure on Australia’s rivers and groundwater resources to meet demand for irrigation and urban water supplies. The proposed Macquarie Pipeline was the main component of a drought relief strategy for Orange, aiming to meet current water demand and secure allocated supply for projected urban demand. Our project aimed to investigate the adequacy of the Environmental Assessment process, specifically because of the potential for ongoing cumulative impact to the already stressed downstream river system and particularly the Ramsar-listed Macquarie Marshes. We modelled flows in the Macquarie River, including the effects of increasing populations in the catchment. We then compared these modelled estimates for diversions to those in the models from the Environmental Assessment, and examined the potential for increased diversions once the infrastructure for pumping is established. The likely environmental impacts of any disparity, particularly in terms of reduced flows to downstream
ecosystems, were assessed using published literature. We examined the potential options for accessing water, given current supply and demand constraints, and identified the implications of increased diversions from a stressed river of the Murray-Darling Basin and its internationally important Ramsar-listed wetland, given current water management planning frameworks and the Murray-Darling Basin Plan. Link to pdf.

Figure 19. The Macquarie River, where the proposed pipeline is to be developed, reducing flow downstream to the Macquarie Marshes.

Terrestrial Ecosystems

Role of predators in ecosystems
Project leader: Dr Mike Letnic, ARC Future Fellow

The importance of top-order predators in maintaining ecosystem function has been demonstrated in many marine and terrestrial systems. Top-order predators often positively affect biological diversity by limiting populations and reducing impacts of their prey and/or subordinate competitors. Consequently, restoring and maintaining populations of top predators is a critical imperative for the conservation of biodiversity and ecosystem services. This project investigates how Australia’s largest predator, the dingo Canis dingo, affects the diversity of ecosystems by considering the lethal and non-lethal effects they have on other species. The dingo is subject to intense baiting, trapping and shooting given their predation of some livestock species. However, removal of top order predators from ecosystems doesn’t come without repercussions. In the absence of dingoes, the red fox Vulpes vulpes and feral cat Felis catus thrive due to the lack of top-down suppression, known as the mesopredator release hypothesis. Our research currently investigates the role that top predators play in sustaining biodiversity by considering the direct and indirect effects they have on Australia’s flora and fauna. Some of the questions we ask are:

- Does the dingo act as a "guard dog" for small mammals?
- What role do dingoes and hopping mice play in shrub encroachment?
- How do different dingo management strategies affect the relative abundance of mammals and the complexity of understorey in forested areas?
Figure 20. Australia's top predator, the Dingo Canis dingo, plays an important role in ecosystems in arid and temperate Australia. Clockwise: Bearded Dragon Pogona vitticeps, Eastern Grey Kangaroo Macropus giganteus, PhD students Ben Feit and James Rees digging in pitfall traps, Dingo, Spinifex Hopping Mouse Notomys alexis.

Cane toads marching on

Project leader: Dr Mike Letnic, ARC Future Fellow

Following their introduction to new environments, invasive species often thrive in the absence of population regulation by predators, parasites, and diseases with which they have coevolved, and may undergo rapid range expansions. The subsequent disruption to ecological processes caused by the novel interactions of invasive species has been identified as one of the most
serious threats to biodiversity at a global scale. The invasion of cane toads across northern Australia has been an ecological tragedy. Populations of many of their predators including monitor lizards and snakes have severely declined following the arrival of toads.

Cane toads contain bufotoxins, absent from Australian frogs, and consequently, most native Australian predator species lack evolutionary history of exposure to these chemicals and many of them die after attacking or consuming toads. The aim of this study is to investigate the direct impacts of cane toads on freshwater crocodiles and monitor lizards, and the resulting indirect effects on their prey species.

Figure 21. The introduced cane toad *Rhinella marina* is putting Australia's native biodiversity under threat, such as the sand monitor *Varanus gouldii*.

Our research also focuses on how cane toads affect the abundance of dung beetles. Dung beetles from Hawaii, Africa, and Europe have successfully been introduced to Australia to control polluting effects of cattle dung. By manipulating dung during the feeding process and the resulting soil fertilization, dung beetles play an essential role in the nutrient cycle and increase primary productivity. Additionally, dung beetles suppress the breeding success of parasites of livestock. Cane toads readily consume dung beetles and because of their high population sizes and predilection for dung beetles, they could suppress dung beetle populations and thus diminish the services they provide for pastoral ecosystems.

**Tackling prey naïveté in Australia's threatened mammals**

*Project leader: Dr Mike Letnic, ARC Future Fellow*

Predation from introduced cats and foxes is the major factor responsible for the extinction of wild native mammal populations and the failure of reintroductions of endangered mammals in Australia. The primary mechanism leading to extinctions of wild populations and the failure of reintroductions has been the inability of threatened mammals to mount effective anti-predator
responses. While Australia has a rich history of native predators, the introduction of red foxes and cats, with the widespread extirpation of native predators, has created new, potentially novel experiences for Australian mammalian prey. Animals isolated from predators either evolutionarily or throughout their lifetime may not possess appropriate anti-predator behaviour. Attempts to train naïve threatened species to avoid predators have focussed on pre-release training of captive populations but there is little evidence to suggest this leads to improved reintroduction success in the wild. The aim of this project is to improve the survival of extant and reintroduced threatened species populations by exploring prey naïveté to introduced predators and developing strategies for improving predator-avoidance behaviour. We will evaluate the levels of prey naïveté present in Australia’s threatened mammals by comparing predicted and actual responses of prey species to predators; test the effectiveness of in situ predation as an effective method of predator avoidance training in reintroduced mammals and identify individual behavioural or physical traits that lead to improved predator-avoidance and which can be used in selective screening and breeding programs.

Our project will advance understanding of prey naïveté to introduced predators and provide novel strategies to help wildlife managers re-establish populations of endangered wildlife.

![Figure 22. The Hastings River Mouse *Pseudomys oralis* is one of Australia’s threatened mammals, preyed on by introduced predators.](image)

**Trophic cascades in Myall Lakes forests**

*Charlotte Mills – Honours project*

In this study, evidence for a trophic cascade mediated by dingoes in the forests of the Myall Lakes area of New South Wales was investigated. Differences in dingo control intensity at three sites in the area generate a gradient of dingo control. Camera trap surveys and dung surveys were used to index dingo and macropod activity across this gradient, and vegetation structure and composition were compared between paired exclosures in recently burnt areas. It is anticipated that macropod activity should be greatest at sites with sustained dingo control and lowest at sites with no dingo control. Conversely, it can be expected that the difference in vegetation structure and composition between grazed and ungrazed plots should be greatest at the sites with sustained dingo control and least at sites with no dingo control. The results showed that dingo activity was lowest at the sustained baiting site and greatest at the unbaited site. Despite evidence of an impact of macropod activity on vegetation structure and a strong negative correlation between dingo activity and macropod activity, the effect of herbivores on vegetation did not scale with dingo control.
Remote sensing and GIS (Geographic Information Systems)

Mangrove dynamics
Project Leader: Professor Richard Lucas

Throughout their range, mangroves are responding to human-induced and natural events and processing including those associated with climatic fluctuation. Using time-series of Landsat sensor data acquired over Australia’s north coast, significant changes in the distribution and state of mangroves has been observed in an area where human interference is minimal. Research from 2013 is establishing the reasons for these changes, such as sea level rise and increased rainfall associated with high intensity events. We are also making use of baseline maps of mangrove extent, height and species composition from aerial photography and hyperspectral data obtained in 1991 and 2002 respectively.

On a more global level, time-series of Japanese Earth Resources Satellite (JERS-1) Synthetic Aperture Radar (SAR) and Advanced Land Observing Satellite (ALOS) Phased Array L-band SAR (PALSAR) have been compared to establish areas of mangrove colonisation and loss (e.g., through erosion or direct deforestation). Such information as been included in a report by the World Conservation Monitoring Centre (WCMC) that highlights areas of mangrove loss across their range.

![Figure 23. Flooding along the Gulf of Carpentaria leads to sediment transfer to the coastal margin and expansion of mangroves, illustrated by satellite image analyses.](image)

Statewide classification and mapping
Project Leader: Dr Mitchell Lyons, Professor David Keith and Professor Richard Kingsford

The NSW Office of Environment and Heritage (OEH) and CES have formed a collaborative project to work on scientific aspects of the NSW Regional Native Vegetation Classification and Mapping Project. Classification refers to the methodology for grouping survey sites into vegetation community types, and mapping refers to the methodology for mapping the distribution of these communities. The first major goal of this work is to examine and quantify
the error and uncertainty in vegetation community classification and distribution mapping and modelling. The second major goal is to develop new approaches that might address some aspects of error and uncertainty. Two major contributors of this error and uncertainty are spatial and temporal variation (including cross-scale variation) and the type of analysis technique used (e.g. distance metric based approach vs. a model-based approach).

Figure 24. On ground data assists to improve accuracy of mapping distribution of vegetation communities..

**Seagrass biomass monitoring**

*Project Leader: Dr Mitchell Lyons*

Seagrass habitat is an important component in coastal ecosystems across the globe, but under increasing threat and being lost at accelerating rates. Seagrass has a significant capacity for carbon storage and biomass is also a key indicator for critical ecosystem services. We developed an approach that enables a) rapid estimates of above ground seagrass biomass from field photos, and b) spatially continuous biomass level maps, without the aid of visual assessment by a human interpreter. These methods require only a small number of destructive samples for calibration, require minimal time resource, and are suitable to almost any seagrass environment. We have successfully applied the methods to thousands (> 15,000) of field photos and a time-series of seagrass maps, providing a time-series analysis of seagrass biomass at a combined spatial and temporal scale not yet seen in published literature.
Figure 25. Field sampling seagrass beds to allow biomass to be estimated by using aerial photography.

Tools for the spatial analysis of biodiversity

Project leader: Associate Professor Shawn Laffan

Biodiverse is a tool for the spatial analysis of diversity using indices based on taxonomic, phylogenetic and matrix-based (e.g. genetic distance) relationships, as well as related environmental and temporal variations. Biodiverse links visualisation of data distributions in geographic, taxonomic, phylogenetic and matrix spaces. It also has a spatial moving window for analyses of richness, endemism, phylogenetic diversity and beta diversity. It can also cluster and constrain analyses. There is also a randomisation function for testing hypotheses. Biodiverse is open-source and supports user developed extensions. It can be used both through a graphical user interface (GUI) and through user written scripts. More than 250 indices are supported. 2013 saw the release of version 0.19, with major improvements to the software (see http://code.google.com/p/biodiverse/wiki/ReleaseNotes).

Figure 26. The Biodiverse software identified the spatial patterns of closely related Australian woody rainforest taxa. (Kooyman et al., 2013)

Fish tracker

Project leader: Associate Professor Shawn Laffan

Understanding animal home ranges and other patterns of space utilisation is an important component of spatial ecology, allowing researchers to explore and explain site occupation and habitat preferences, and also interaction and avoidance behaviour. Conventional analyses of animal home ranges use points at which the animals are observed, sometimes weighted by the time difference between sequential observations. This can assign undue weight to a sample point with a long time delay from the previous observation, as the full path from the preceding point is implicitly assigned to that point. Conventional analyses also do not account for physical constraints such as boundaries (e.g. rivers, roads, cliffs) or the cost of traversing alternate possible paths between points, typically inferring a straight-line path between sequential samples. This conventional approach has obvious limitations, especially in constrained environments such as for fish in rivers and estuaries. These limitations can be attributed in large part to a lack of available software tools.
Fish Tracker is a software tool that estimates animal home ranges by using the per-segment transit times along an inferred path constrained to remain between defined boundaries. The functionality of the tool has been demonstrated using a data set of an estuarine fish species Mulloway *Argyrosomus japonicus* movements from sampling the Georges River estuary in Sydney, NSW. The approach is, however, generic and can be applied to any environment where animal movements are constrained, such as fragmented agricultural landscapes. The tool can be downloaded from https://bitbucket.org/shawn_laffan/fish_tracker

![Fish Tracker Diagram](image)

Figure 27. The Fish Tracker tool models movements of fish in relation to their habitat, such as for this individual Mulloway *Argyrosomus japonicas*.

**Remote sensing of subtropical forests and woodlands**

*Project leader: Professor Richard Lucas*

Across Australia, spatial information on the structure, floristic composition, above ground biomass and dynamics of forests and woodlands is required at multiple scales, particularly given the requirements for conserving carbon stocks and biodiversity. Through a long-term study with the Japanese Space Exploration Agency (JAXA) Kyoto and Carbon (K&C) Initiative, the Queensland Department of Science, Information Technology, Innovation and Arts (DSITIA), Aberystwyth University in the UK and CES, continental scale mosaics of Advanced Land Observing Satellite (ALOS) Phased Arrayed L-band Synthetic Aperture Radar (SAR) have been combined with Landsat-derived persistent green cover in a segmentation processes that has generated millions of objects across the continent. By associating objects with ICESAT GLAS (spaceborne LIDAR), an estimate of the height of vegetation has been provided. Such information allows for the classification of structural formations typically associated with forests and woodlands and has the potential for estimates their biomass.

At a more local scale, CES is evaluating how time-series of LIDAR and optical remote sensing data can be compared over decadal periods to quantify changes in forest and woodland structure, biomass and species composition. The study is particularly focusing on whether certain tree species are more susceptible to human-induced or natural change, including that associated with climatic fluctuation.
Remote sensing of environmental flows

Project Leader: Dr Mirela Tulbure, Professor Richard Kingsford, Professor Richard Lucas and Professor David Keith (ARC Linkage Project, LP130100408)

Environmental flows represent water management activities that release flushes of water stored in dams on regulated rivers during dry periods. These flows aim to mimic natural flow regimes and maintain ecological health and function of rivers and wetlands. Assessment of water resources and understanding of the effectiveness of environmental flows requires understanding of temporal and spatial pattern of surface water dynamic in a synoptic yet detailed way and understanding the dynamics of the vegetation response to flooding. We focus on the entire Murray-Darling Basin of Australia. We are using Landsat data to synoptically map the extent and dynamic of surface water with an internally consistent algorithm and quantify the dynamics of surface water and vegetation response to flooding over decades. We are also focusing on the largest river red gum forest in the world, the Barmah-Millewa Forest, a site with considerable focus on environmental flow management and additional conservation management, to track the response of vegetation community condition to flooding in space and time.
Vegetation and water use response to wildfire in Sydney’s water catchment

Evan Webster - PhD candidate (ARC Linkage Project, LP0990137)

Intense wildfire regimes are prevalent within many Australian water catchment areas and the quantification of the complex relationship between forests, wildfire events and catchment yield is an important consideration for catchment managers. Seasonal, temperature and precipitation induced changes to vegetation condition further complicate the underlying trends in these relationships.

Within Sydney’s catchment areas, the post wildfire hydrological impact of the 2001/02 wildfires was investigated from a catchment streamflow perspective, with modelling performed using streamflow and radar rainfall data collated for the Nattai River catchment area. However, fire had no discernable impact on surface runoff at the large catchment scale.

This research investigated internal catchment variability through the development and analysis of evapotranspiration maps, modelled with respect to drivers of catchment water use (wildfire recency, rainfall, solar radiation, temperature and wind speed). By implementing an adaptive spatial model, we simulated a Kuczera function response to wildfire induced changes of catchment water use for individual land units (30m by 30m Landsat pixels). We modelled the impact of wildfire spatially with respect to vegetation structure, topography, geology and fire severity. We showed there was considerable variability in response of evapotranspiration.
Figure 30. Dams in the Sydney catchment (left) depend on catchment processes including runoff to calculate yield. This is highly dependent on how much water different vegetation communities use in recovery after fire, measured by remote sensing estimates of evapotranspiration.

**Niche segregation in the fourth dimension: does temporal variability in fine-scale hydrology promote plant species coexistence?**

*Andrew Letten – PhD candidate (ARC Linkage Project, LP100200080)*

Despite decades of research, ecologists continue to be puzzled by one simple question: how do so many plant species coexist when competing for the same finite suite of limited resources? While numerous purported theoretical mechanisms abound, general empirical support for any one mechanism remains enigmatic. In recent years, however, evidence has begun to emerge that niche-partitioning along fine-scale hydrological gradients may well reflect one of the most general mechanisms discovered to date. The aim of this study is to test for the first time whether the generality of this phenomenon extends beyond space to also include niche-partitioning through time. More specifically, the study addresses two main questions:

**a) Do herbaceous species segregate along fine-scale hydrological gradients?**

This component will assess the generality of previous research positing that niche segregation along fine-scale hydrological gradients is one of the most general mechanisms for plant species coexistence.

**b) Does temporal variability along fine-scale hydrological gradients promote species coexistence?**

This component will expand on the first question to explore for the first time if spatial niche-segregation is mirrored by associated temporal changes in plant demographics. For example, do plants occupying the more moist regions of the spatial hydrological gradient prosper under years of high rainfall?
Figure 31 - Monitoring of fine-scale changes in hydrological gradients, Royal National Park.
Conservation Practice

Risk assessment for ecosystems
*Project leader: Professor David Keith*

David Keith led a large international team of scientists in developing a new method for assessing risks to ecosystems. A monograph describing the scientific foundations of the method, with applications to a selection of terrestrial, freshwater and marine ecosystems from around the world, was published in PLoS ONE in May 2013. http://www.plosone.org/article/info%3Adoi%2F10.1371%2Fjournal.pone.0062111

The initiative attracted media interest from around the world and will be adopted by IUCN in 2014, as part of its strategy to develop a global Red List of Ecosystems to inform governments, industries and communities about progress towards biodiversity conservation targets. The new approach to risk assessment has also been influential within Australia, and will help to strengthen the scientific basis for listings of ecological communities under state and commonwealth legislation. Professor Keith is currently editing a special issue of Austral Ecology that will contain risk assessments of several Australian ecosystems.

Figure 32. Launch of the IUCN Red Lists project to assess the risk status of ecosystems around the world. The swamps, lakes and floodplains of the Murray-Darling Basin. Including the Macquarie Marshes (right) are assessed as endangered to critically endangered.
## Centre Members

<table>
<thead>
<tr>
<th>Position</th>
<th>Name</th>
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</thead>
<tbody>
<tr>
<td>Professor</td>
<td>Richard Kingsford (Director)</td>
</tr>
<tr>
<td>Professor</td>
<td>David Keith (Deputy Director)</td>
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<tr>
<td>Professor</td>
<td>Richard Lucas (Deputy Director)</td>
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<tr>
<td>Centre Manager</td>
<td>Sharon Ryall</td>
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<td>Paul Adam</td>
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<td>Dr Alistair Becker</td>
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<td>Dr Gilad Bino</td>
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<td>Senior Lecturer</td>
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<td>Dr Mike Letnic</td>
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<td>Adjunct A/Lecturer</td>
<td>Dr Isabelle Wolf</td>
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Outcomes

Grants

Brandis, K, Provision of data quality and assurance services for the 2006-2012 NSW Waterbird survey 2013, $36,333


Jenkins, K.M. Innovative approaches to identifying regional responses of biodiversity to climate change, 2013, $122,923

Jenkins, K.M. Monitoring the ecological response of Commonwealth environmental water delivered in 2012-2013 in the Murrumbidgee, $94,209

Jenkins, K.M. and R.T. Kingsford, Lower Murrumbidgee River environmental flow response monitoring, 2012-2013, $290,805

Keith, D.A., Delivering a Sustainable Long Term Ecosystem Research Network for Australia, 2012-2013, $760,000


Keith, D.A. and T.J. Mason, Vegetation, biogeography and conservation status of temperate highland swamps. 2012-2013, $223,730

Kingsford, R.T. Adaptive management of Ramsar wetlands, 2011-2013, $320,386

Kingsford, R.T., Waterbird Survey of River Murray Icon and hydrological indicator sites, 2012-2013, $373,389


Kingsford, R.T. and D.A. Keith, NSW Regional Native Vegetation Classification and Mapping, 2012-2015, $452,947

Kingsford, R.T. and S. Ren, Ecological Responses to Altered Flow Regimes, 2010-2013, $429,000


Sammut, J., Improving The Sustainability Of Rice-Shrimp Farming Systems In The Mekong Delta, Vietnam 2013-2016 $381,239 to UNSW with a project total of $1,519,566 including collaborative partner institutions in Vietnam and Australia

Tulbure, M.G. ASD portable field spectroradiometer (ASD FieldSpec) and accessories, 2013 $106,159


Financials

### Statement of Financial Performance
for the Year Ended 31 December 2013

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Conferences


Kingsford, R.T. and Bino, G. (2013) “Strategic adaptive management in the Macquarie Marshes...


Media


**Irrigation could be allowed on Lake Eyre rivers.** Richard Kingsford. ABC Radio, AM. 25th February 2013 [http://www.abc.net.au/am/content/2013/s3697177.htm](http://www.abc.net.au/am/content/2013/s3697177.htm)


**Radio Interview.** Richard Kingsford. ABC Western Queensland 07:30 News. 28th February 2013

**Radio Interview.** Richard Kingsford. ABC Western Queensland 08:30 News. 28th February 2013

**Radio Interview, Mornings.** Richard Kingsford. ABC Western Queensland, Mornings. 28th February 2013


**Self Improvement Wednesday: The theory and application of island biogeography.** Richard Kingsford. 702 ABC Sydney, radio. 3rd April 2013. [http://www.abc.net.au/local/audio/2013/04/03/3729212.htm](http://www.abc.net.au/local/audio/2013/04/03/3729212.htm)

**Criteria for 'Red List' of Endangered Ecosystems Released.** David Keith, Richard Kingsford. livescience, online (USA); Huffington Post, green, Online (USA). 8th May 2013.


Publications


Harmonization of the Land Cover Classification System (LCCS) with the General Habitat Categories (GHC) classification system. Ecological Indicators, 36, 290–300.


Letnic, M. and M. S. Crowther (2013). "Patterns in the abundance of kangaroo populations in arid Australia are consistent with the exploitation ecosystems hypothesis." Oikos 122, 761-769.


Ruiz-Colmenero M., Bienes R., Eldridge D. J. & Marques M. J. (2013) Vegetation cover reduces


For further information:

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