Our northern wetlands: science to support a sustainable future

Briena Barrett and Clare Taylor, Northern Australia Environmental Resources Hub

In the midst of the wet season, northern Australia's wetlands come alive. As the rain continues to pour, an abundance of habitats and food becomes available for thousands of plant and animal species.

This is not only a critical time for biodiversity, but also for cattle producers, fishers and tourism providers who rely on wet season flows. Indigenous communities in the north too have fundamental cultural, social and economic ties to wetlands and the traditional resources they produce which are tied to this seasonal replenishment of water.

But increasingly, these prized water resources are sparking the interest of government, community and private investors for agricultural development. With so many competing interests in our tropical wetlands, how can we ensure that users, including the environment, get the right share of available water to be sustainable in the long term?

The National Environmental Science Programme's Northern Australia Environmental Resources Hub is providing research to help inform sustainable development in the north. Hub Leader Professor Michael Douglas said our understanding of the water needs of different users still has a way to go.

"For example – how much water might we need to support the abundance of fish species in the Daly River, or how might existing environmental and cultural assets in the Fitzroy River be impacted by planned development?" Professor Douglas said.

Top row, from left: Kowanyama floodplain (M Douglas). *Researcher with net* (ML Taylor)
Bottom: Paperbark swamp (M Douglas)

Research under the Northern Hub will address questions like these and lay strong foundations to inform sustainable policy, planning and management of tropical wetlands.

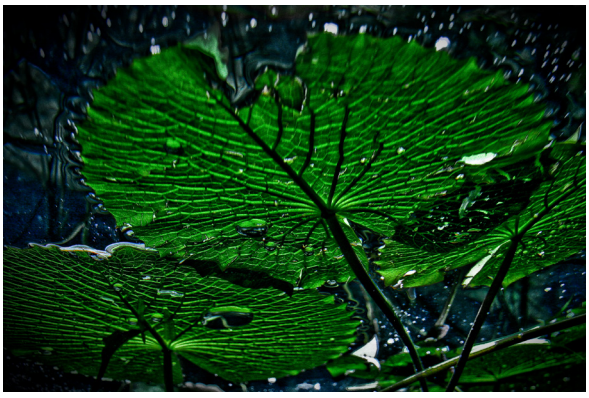
Wetland related projects under the Hub include:

1. research to improve our understanding of the flows needed to support natural assets in the Mitchell, Daly and Fitzroy Rivers
2. research to identify which rivers in the Gulf of Carpentaria region are making the most significant contribution to the health and productivity of the Gulf
3. research to improve our knowledge of Indigenous water requirements within the Fitzroy River catchment
4. research to mitigate the threats from feral animals to aquatic ecosystems in the Archer River Basin
5. research to guide improved management of riverbank (or riparian) habitats across the north.

"Science has a critical role to play in helping to determine the water requirements for all users so that trade-offs can be understood and negotiated," Professor Douglas said.

"This information is vital to ensure that water resources in the north are secured for all water users and that water-related development is sustainable in the long-term."

For further information about the NAER Hub, visit: www.nespnorthern.edu.au/nesp or contact Knowledge Broker Clare Taylor: clare.taylor@cdu.edu.au or (08) 8946 7476.



Left column, from top: Barramundi (ML Taylor). *Researcher taking notes* (ML Taylor)

Right column, from top: Northern dwarf tree frog (Litoria bicolor) (M Douglas). *Lilies from below* (M Douglas). *Centre pivot irrigation in the Fitzroy Valley* (M Douglas)

Predicting the occurrence of seasonal herbaceous wetlands in south east Australia

Phil Papas and Matt White, Arthur Rylah Institute for Environmental Research, Department of Environment, Land, Water and Planning, 123 Brown Street, Heidelberg VIC 3084

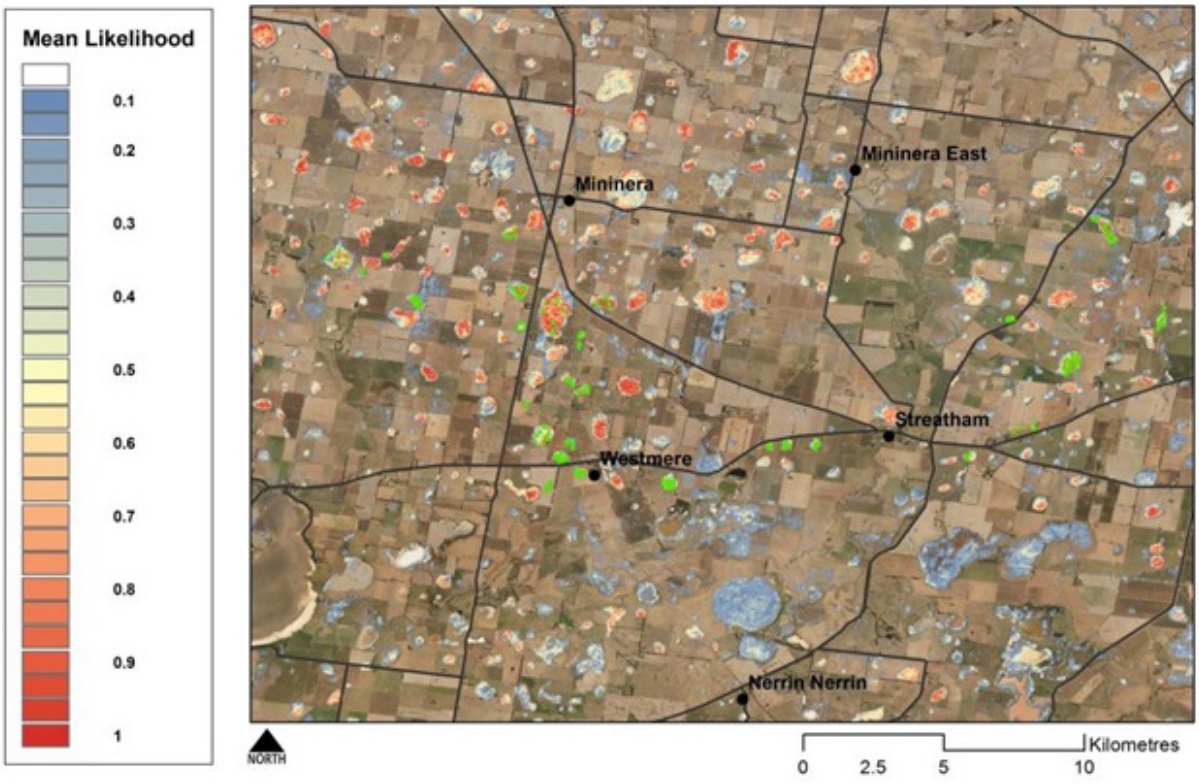
Seasonal herbaceous wetlands are listed as a critically endangered ecological community under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). They are temporary, freshwater, rainfall-fed and occur on fertile plains in south-eastern Australia. Their vegetation structure is open (woody cover is absent to sparse) and the ground layer is dominated by herbs (grasses, sedges and forbs) adapted to seasonally wet or waterlogged conditions. The community is particularly susceptible to impacts from agricultural and urban land uses because they occur on fertile plains and sometimes close to urban centres. Cropping, livestock grazing, forestry production, and urban, industrial and infrastructure development all threaten its existence and condition.

Management and prioritisation of seasonal herbaceous wetlands for conservation or rehabilitation requires good knowledge of their location. There is a high degree of confidence in the location of such wetlands in only a few, relatively small, areas in south-east Australia. The location of other potential seasonal herbaceous wetlands has been mapped but these maps were principally derived from modelled native wetland vegetation and vary in scale and accuracy and do not specifically map the defined EPBC ecological community. To address these issues, we used a new approach to modelling the likelihood of occurrence of the EPBC listed community across Victoria and adjoining areas of South Australia.

Using field observations and data derived from two satellite platforms, we modelled the spatial extent of the target ecological community at a resolution of 25 metre.

The resultant model fits the field observations well and model validation suggests that the model extrapolates successfully even when presented with novel field observations. Model outputs include the mean likelihood of seasonal herbaceous wetland occurrence at each 25 metre pixel and the uncertainty (the standard deviation derived from the set of model predictions at each 25 metre pixel). The likelihood and uncertainty values can be combined and/or thresholded depending on the decision making context.

A seasonal herbaceous wetland in the Victorian Riverina (Diane Crowther, DELWP)



Spatial expression of the mean likelihood model around Streatham on the Victorian volcanic plains in south-west Victoria. Green triangular markers highlight the location of model training sites. (DELWP)

The model outputs are available from www.data.vic.gov.au/data/dataset/Seasonal-Herbaceous-Wetland-likelihood-model-V1-output-(mean-and-standard-deviation) and a report that details the modelling approach is available at www.delwp.vic.gov.au/ari/reports

For further information, a report that details the modelling approach is available at www.delwp.vic.gov.au/ari/reports

The project was funded by the Water and Catchments Group, Department of Environment, Land, Water and Planning, Victoria.

Models of wetland connectivity: Supporting a landscape scale approach to wetland management

Kay Morris, Arthur Rylah Institute for Environmental Research, Department of Environment, Land, Water and Planning

A range of wetland management interventions such as livestock exclusion, revegetation, environmental watering and pest animal and plant control are used to improve or maintain wetland values and condition. The resources available to implement management interventions are limited and there is a need to strategically select wetlands where management benefits are optimised.

Several factors should be taken into account when prioritising wetlands for investment. From a site perspective, these include values and threats at individual wetlands and the feasibility, cost and effectiveness of the management. Landscape factors should also be considered as these can influence the effectiveness of management, the persistence of regional wetland biodiversity, or the spread of invasive species. Landscape patterns of biological connectivity among wetlands is one such factor.

Biological connectivity represents the ability of plants and animals to move between habitat patches in the landscape. Connectivity is an important consideration in spatially prioritising management investment as connections among wetlands strongly influence the assemblage of plants and animals that occur in these habitats and their resilience to environmental change. High levels of connectivity can: (i) provide opportunities for native and introduced species to expand their range and migrate in response to local and regional changes in habitat condition, (ii) facilitate re-colonisation following local extinction events, (iii) promote gene flow among populations, increasing genetic diversity and resilience to environmental change. Low levels of connectivity can also be important in maintaining wetland values because isolated wetlands may be less exposed to diseases such as Chyrtrid fungus or invasive plants and animals.

Seeds of typha dispersing by wind (Kay Morris)

The Department of Environment, Land, Water and Planning has been investing in better understanding how Victoria's wetlands are biologically connected. This knowledge has underpinned the development of state-wide maps that represent modelled patterns of wetland connectivity for waterbirds, amphibians and wind-dispersed plant seed. This work has been informed by an understanding of the dispersal pathways of wetland animals and plants, the distances they can travel, the features of the landscape that restrict or enhance movement, as well as the geographical arrangement of wetlands.

The application of these spatial layers to wetland management is supported by the *Wetland Connectivity Spatial Data: User's Guide. Version 1*. The guide describes the modelling process, spatial products and how they can be used to guide the spatial prioritisation of on-ground activities that aim to protect high-value wetlands, restore degraded wetlands, and protect wetlands from the spread of weeds and/or pathogens.

For further information visit:
www.delwp.vic.gov.au

Lake Eyre Basin Condition Assessment 2016

Sue Stefanoski, Communications Officer, Department of Agriculture and Water Resources

One of the biggest inland drainage systems in the world, the Lake Eyre Basin spans almost one sixth of Australia at 1.2 million square metres. From Longreach to Mount Isa, Alice Springs to Broken Hill, the Lake Eyre Basin is an area of high conservation importance and home to a variety of flora and fauna. Two Ramsar wetlands are located in the Lake Eyre Basin, Coongie Lakes in South Australia and Lake Pinaroo in New South Wales.

Every 10 years an assessment of the basin's watercourses and catchments is conducted in a joint initiative of the Australian, Queensland, South Australian and Northern Territory governments as required under the Lake Eyre Basin Intergovernmental Agreement.

The first Lake Eyre Basin Condition Assessment occurred in 2008 and was a desktop analysis of the limited data available at the time from government agencies, natural resource management boards and research reports. The 2008 condition assessment found that the rivers and catchments in the basin were in generally good condition.

The 2016 State of the Basin condition assessment reports on the current status of the hydrology, fish, water quality and waterbirds of the Lake Eyre Basin and on the current and emerging threats and pressures to the basin.

"The assessment allows everyone to consider how the Basin's environment may or may not be changing, based on scientifically-credible information. It provides a vital benchmark against which progress can be assessed in future years, and a view on the effectiveness of current management efforts", Dr Morton, Chair of the Lake Eyre Basin State of the Basin Steering Committee and Chair of the Lake Eyre Basin Scientific Advisory Panel said.

The State of the Basin report is developed in consultation with the Australian, State and Territory governments along with natural resource managemstent bodies, research institutions, Lake Eyre Basin Community Advisory Committee members, Lake Eyre Basin Scientific Advisory Panel members, communities and landholders.

For more information visit www.lakeeyrebasin.gov.au and subscribe or email lebsecretariat@agriculture.gov.au.

Strzelecki Corellas, Lake Eyre, South Australia (A. Emmott)

"Where are the wetlands in NSW?" A new semi-automated method for mapping wetlands

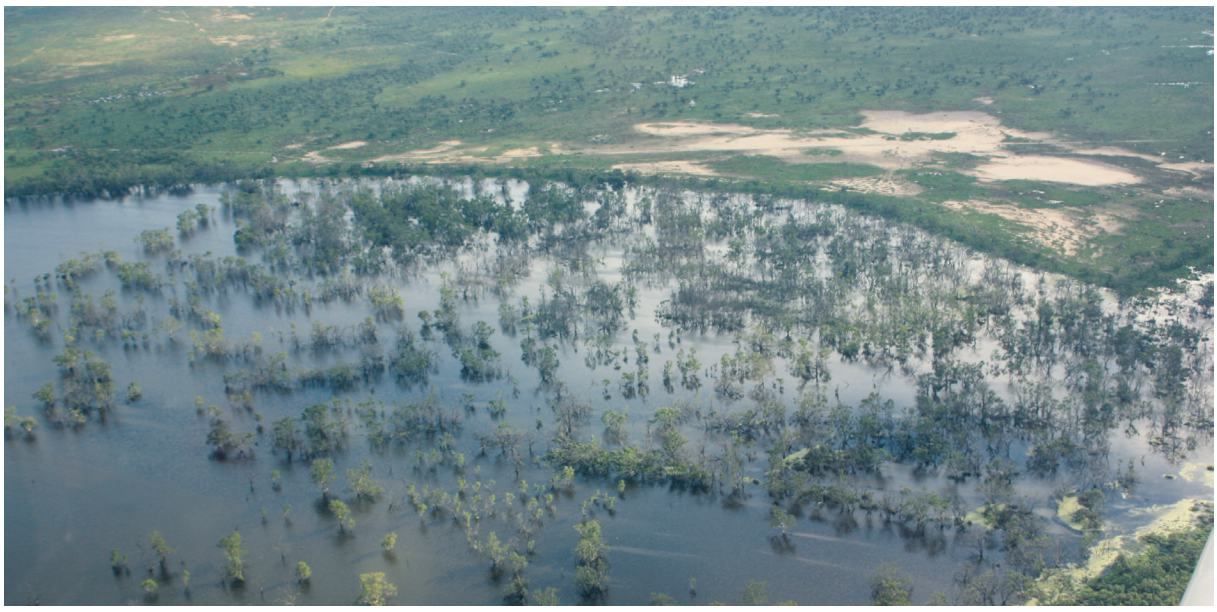
Joanne Ling, Megan Powell, Grant Hodgins, David Tierney and Michael Hughes, NSW Department of Planning and Environment, Office of Environment and Heritage

The development of semi-automated techniques for wetland mapping and assessment is a key step toward development of a state-wide inventory and a more coordinated approach to wetland management across NSW.

We know that wetlands and their ecosystem services play a crucial role in environmental risk reduction, but we don't have consistent and comprehensive maps of where these valuable wetlands are. An inventory of NSW wetlands is a fundamental tool for threat risk assessment and adaptive management. It also provides an opportunity to identify wetland recreational value for the people of NSW.

In **2015–16** we completed a pilot project to develop semi-automated techniques for rapidly generating inundation histories (a key-driver for wetlands) over large arid and semi-arid areas. This level of automation requires management of uncertainty, which can only be satisfactorily achieved with a rigorous field validation program. Regional stakeholders and the historical knowledge that they hold are also critical for accuracy assessment and management of uncertainty, because any field validation exercise represents only a snapshot in time within a dynamic wetland landscape.

Where to next in 2016–17? Through lessons from the pilot project, and by field validation this year, we will finalise our wetland mapping products for the Lachlan River Catchment. To maximise their utility these products will be tailored to suit requirements of end-users engaged in environmental water planning and governance. We will also make the data publicly accessible through the environmental data portal SEED: Search Engine for Environmental Data. We will continue to engage funding bodies and potential partners to build and extend the wetland inventory across the state including exploring the use of the automated mapping methods in a coastal region such as Hunter River Catchment wetlands.



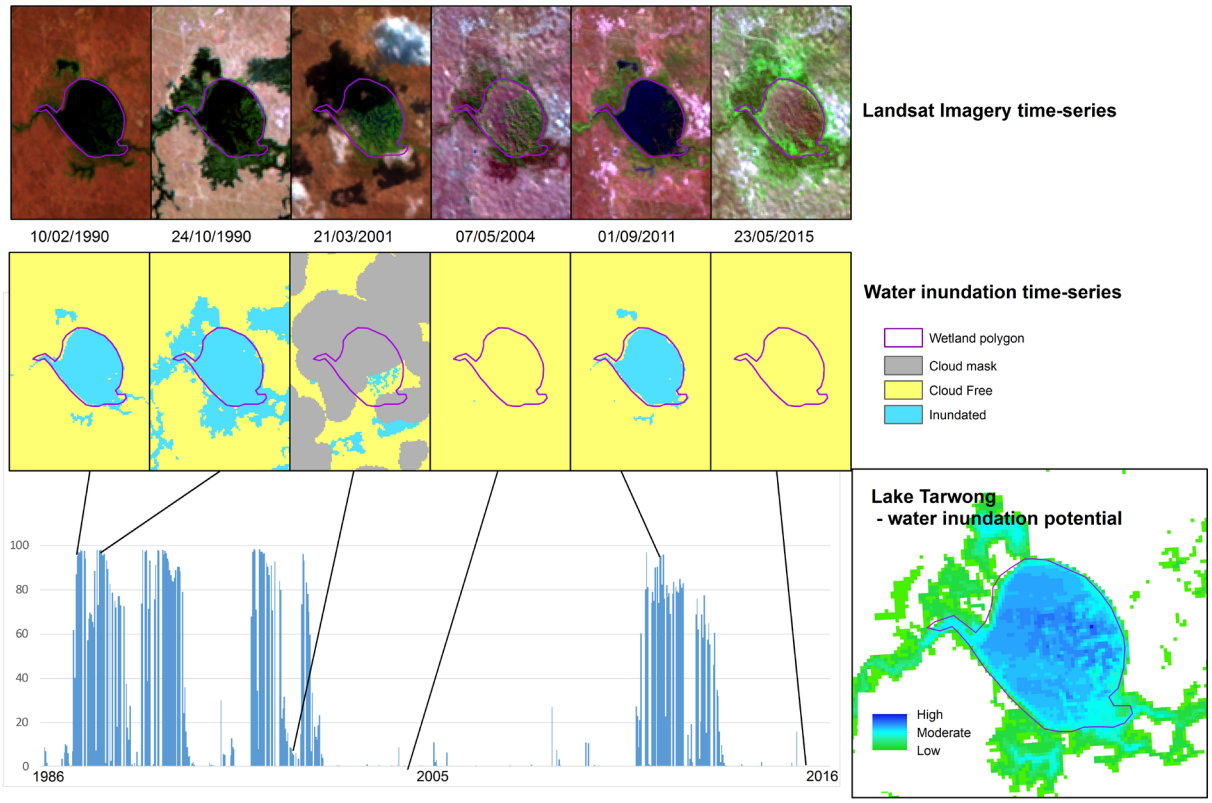
Aerial photo of Lake Tarwong Lachlan River Catchment, 2012 (Paul Packard)

The potential uses for a NSW Wetland Inventory are extensive. Examples range from identification of environmental assets, through monitoring and evaluation of wetlands over time, to comparing similar wetland types to prioritise them for protection. State-wide management of wetlands will benefit from consistent and comprehensive mapping of wetland locations, extents and types across the state.

How can you be involved?

Are you a potential end-user of our products? We'd like to find out how to better design the products to match your needs! Do you have data or information that could be used in the inventory?

For more information, please contact Joanne Ling, Office of Environment and Heritage at joanne.ling@environment.nsw.gov.au, or visit the OEH Website at www.environment.nsw.gov.au/



The pilot study developed semi-automated techniques to identify wetland boundaries and applied remote sensing water-indexing techniques to generate data on percent inundated for each Landsat capture. This figure illustrates the principles behind the wetland mapping method using a time-series of remote sensing inundation observations. This example of Lake Tarwong has a graph along the bottom showing how much of the lake was inundated for each Landsat satellite images from 1986 to 2016. The series of images along the top are examples of Landsat images used in the analysis, and the second row of images shows the area of inundation or cloud obscured data respective to those images. Finally the larger image (on the right) shows the inundation potential across the wetland based on the 30 year archive of inundation observations. This inundation information can then be rapidly generated within the defined wetland boundary, and graphed to show percent inundated observations over time. The technique and data will be used to characterise wetlands and to understand the processes keeping them healthy.

Method for the long-term monitoring of wetlands in Victoria

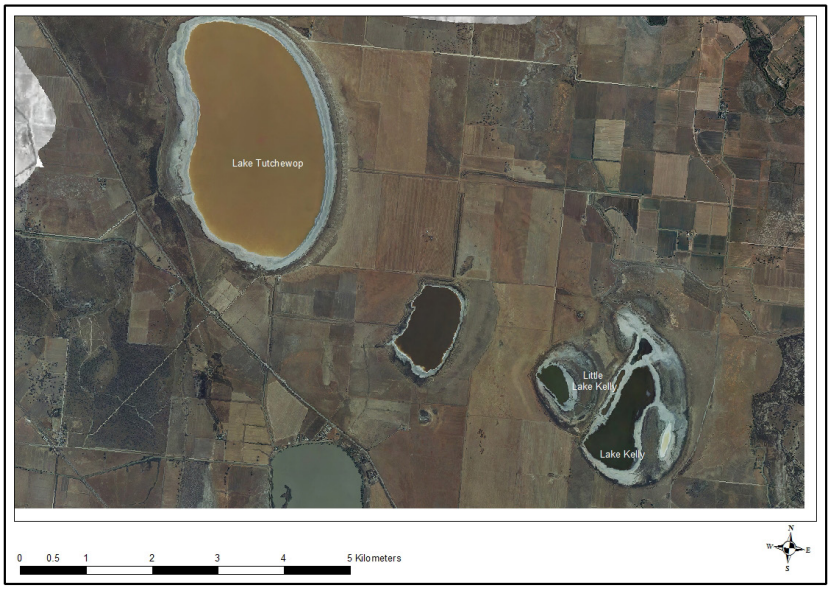
Janet Holmes, Department of Environment, Land Water and Planning and Mark Stacey, Alluvium Consulting Australia

The Department of Environment, Land Water and Planning (DELWP) funded a project to identify an efficient, cost effective method to monitor wetland water regime and vegetation. This project was undertaken by Alluvium Consulting Australia in partnership with CSIRO.

Selection of the most appropriate monitoring method was undertaken by first specifying the monitoring requirements in detail. These were that the method should be affordable and rely on ongoing data supply which is frequently collected across Victoria. A review was then undertaken of potential methods applied previously in Australia and internationally. This allowed a systematic evaluation of how well each potential method would achieve the specific monitoring requirements in Victoria. Utilising optical remote sensing data, in particular Landsat Thematic Mapper (TM) imagery, was identified as the preferred method. The way that light is reflected from vegetation, water and other parts of the landscape provides valuable information. 'Reflectance values' of the landscape are recorded in 25 X 25 metre pixels at each satellite pass. These values can be analysed to determine the unique signatures of water and vegetation in each pixel. The project trialled this method for wetlands in the area near Kerang in north west Victoria.

Use of this imagery had many advantages. The imagery is proven as the basis for operational vegetation and inundation monitoring systems in Australia. It is readily available, extends back to 1988 and has a forward plan for ongoing acquisition. It is relatively cost effective. For Victoria, the cost was estimated at $230,000 to $400,000, depending on the intensity of the data collation and classification tasks. It provides consistent measurement of changes over time and over the landscape. The same imagery is used to monitor both inundation and vegetation cover.

There are some limitations to the method. Dense vegetation in wetlands can result in errors of omission in detecting water. The method only detects change in vegetation cover, but not between different types of vegetation. This highlights change but cannot be used to explain it.



Three of the wetlands in north western Victoria where the method was trialled

There are several products that can be generated by using the method. These include temporal summary inundation plots (Figure 1) and time series inundation plots (Figure 2). Wetlands can be assigned to a water regime category in Victoria's wetland classification system (permanent, seasonal, intermittent or episodic) for a particular period of time. Trends in change of wetlands from one category to another can be explored.

For vegetation, statistics, datasets and maps can be produced to indicate vegetation change at individual wetlands. This helps wetland managers to identify wetlands undergoing a change in vegetation type which can be further investigated in on-ground surveys.

For more information, contact Janet Holmes at Janet.Holmes@delwp.vic.gov.au or visit www.depi.vic.gov.au/water/rivers-estuaries-and-wetlands/wetlands to read the project report

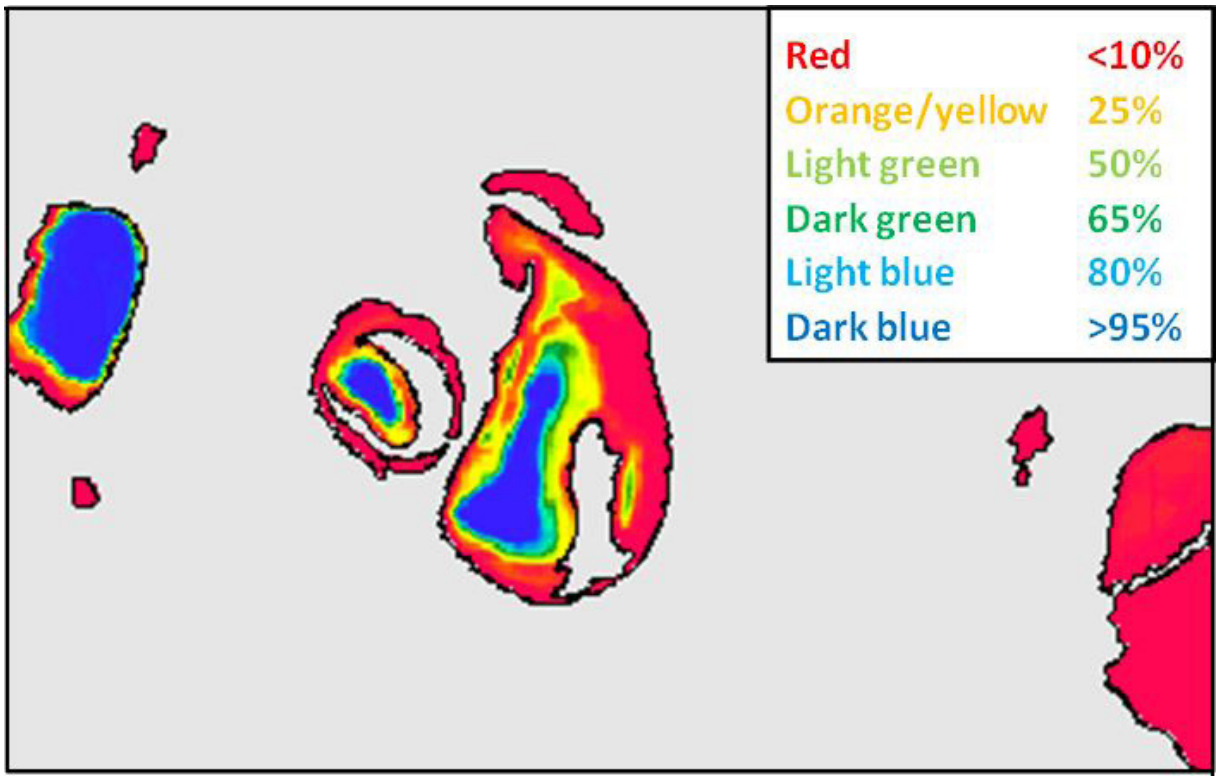


Figure 1: Temporal summary inundation plot for Lake Kelly and Little Lake Kelly near Kerang, Victoria. The colours indicate the % of wetland classified as wet over the time period of interest.

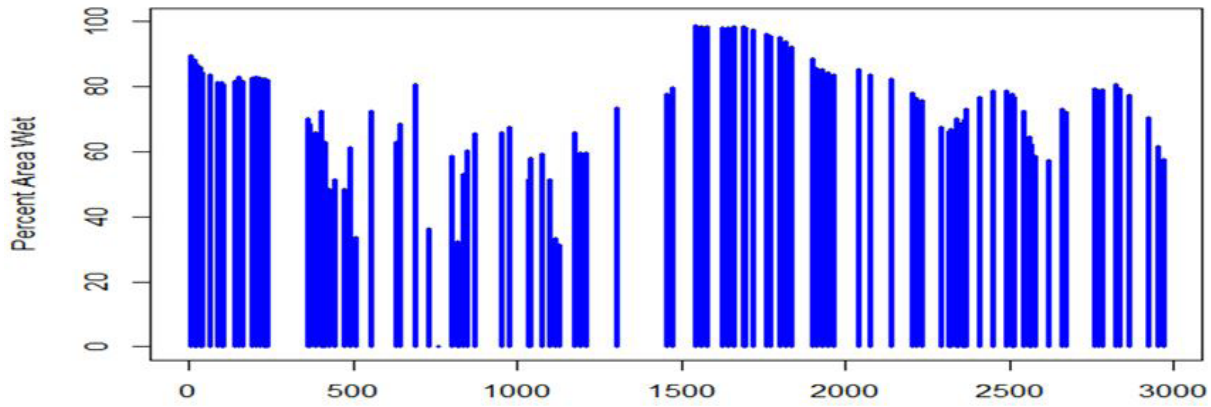


Figure 2. Time series inundation plot for Lake Tutchewop near Kerang, Victoria from January 2007 to March 2015 (116 images). Each 25 × 25m pixel in the wetland is assigned 'wet', 'dry' or 'missing' for each 16 day Landsat pass and the % of wet area in the wetland is calculated for each pass. Blue dots on X-axis indicate '100% dry', gaps on the X-axis indicate periods of missing or cloudy imagery.

Muir-Byenup Ramsar wetlands: Are they changing?

Melita Pennifold, Research Scientist, Western Australian Department of Parks and Wildlife

Many wetlands globally, including Ramsar sites, are impacted by threats (human and natural) and are currently at risk of losing their ecological character. The Muir-Byenup wetlands is one such Ramsar site where a possible change in ecological character has been reported.

The Muir-Byenup wetland system is a suite of over thirty lakes and swamps. There is a large diversity in the natural communities from permanent to seasonal lakes, freshwater wetlands to primary salt lakes and rare peat systems. Many of the wetlands are listed in the Directory of Important Wetlands in Australia and in 2001 the southern suite of wetlands were declared a Ramsar site of international importance.

Over the years, various wetlands within this system have been threatened by salinity, acid-sulfate soils, eutrophication, grazing, introduced species, pests, inappropriate fire regimes and illegal vehicle access. In more recent years, there has been the added threat of water level change, as a result of a drying climate.

Since being listed as a Ramsar site there have been a number of changes within the wetland system relating to aquatic invertebrate communities, distribution of some fish species and condition of fringing vegetation. Although these lakes are naturally highly variable, long-term monitoring (~35yrs) has indicated changes in depth, pH and salinity occurring in several lakes. One peat lake in particular, Tordit-Gurrup Lagoon, has had record low water levels in recent years resulting in a dramatic increase in salinity and acidity. After an acidification event in 2013, the ecological value of this wetland is under threat and requires assessment.

Tordit-Gurrup Lagoon (J. Higbid)

An investigation is underway to obtain a better understanding of the ecology and hydrology of the Muir-Byenup wetland system, so the status of the site can be updated and management better informed to maintain the site's ecological character. In 2014–2015 an invertebrate survey (along with water chemistry) was carried out to determine if changes have occurred in the invertebrate composition since previous surveys (1996–97 and 2003–04). Data analysis is incomplete, however preliminary findings indicate some changes in invertebrate composition and richness may have occurred in some wetlands.

While some management works can be implemented now, planning for many interventions depends on understanding the hydrological changes within the system and the chemistry of the wetland sediments. In 2015, a three year investigation into the hydrodynamics and hydrogeochemistry of Byenup Lagoon system was initiated.

The Muir-Byenup wetlands are a complex set of unique and highly important wetland assemblages with an equally complex hydrology. An important challenge over the next decade will be to successfully model and manage the key wetlands to maintain these highly important biodiversity assets.

For future information please contact Melita Pennifold, Department of Parks and Wildlife Western Australia: Melita.Pennifold@dpaw.wa.gov.au)

Peat cracking (M. Pennifold)

Looking below the surface of the Vasse Wonnerup wetlands

Emily Hugues dit Ciles, South West Catchments Council

The Vasse-Wonnerup wetlands system is a shallow series of lagoons that intermittently open to the sea. They are located near the town of Busselton, Western Australia. The wetlands are internationally recognised as a Ramsar site and support over 30 fish species and over 37,500 waterbirds from 90 different species.

The system is highly modified and endures extreme seasonal variations making it a highly complex system to grasp or interpret.

Management of Vasse-Wonnerup wetlands system needs to be underpinned by a sound scientific understanding of ecosystem structure and processes, but also needs to align with social and political realities and community expectations. Holistic research into the Vasse Wonnerup Ramsar wetlands is proving increasingly important to better understand and untangle the system's intricacy to assist with its management.

In collaboration with agencies, local governments and leading researchers, South West Catchments Council (SWCC) has identified key knowledge gaps and management questions for the system. Through funding from the Australian Government's National Landcare Programme, SWCC has fostered a strong partnership with Murdoch University and Edith Cowan University. In an innovative and collaborative research program a suit of projects was developed to answer key priority management questions for the wetland system.

Key questions targeted by the research include: "Nutrients—Where do they come from? Who eats what in the Vasse Wonnerup? How does the community value the wetlands?

Importantly, whilst focussed on a single ecosystem, the integrative nature of the program's research projects will be broadly applicable to other estuaries and wetlands.

The program will further foster a better understanding of threats, management issues and will provide key management recommendations and strategies to protect these internationally important wetlands.

For more information visit the South West Catchments Council website at swccnrm.org.au

This project is supported by the South West Catchments Council, through funding from the Australian Government's National Landcare Programme.

Vasse Wonnerup Wetland System (Monica Durncan)