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On TRaCK

Tropical Rivers and Coastal Knowledge

Sensitive monitoring to prevent river degradation

By Kathy Grube

Australia's tropical rivers are the ecological backbone of the north but, with increased interest in mining and agricultural development in the region, keeping the rivers healthy over the long term has emerged as one of the nation's greatest public policy challenges.

TRaCK researchers are stepping up to this challenge, developing monitoring protocols and testing monitoring tools to see if they can detect impacts before they get big enough to cause irreversible damage to river catchments.

Implementing an effective monitoring program is not easy when the river catchment covers vast areas of remote and sparsely populated land. The researchers also have to contend with seasonal climate extremes—a wet season when rivers are frequently in flood, and a dry season when most rivers stop flowing.

Dr Simon Townsend is leading two TRaCK projects that are developing locally relevant guides to help water monitoring programs in northern Australia, and trialling the Framework for the Assessment of River and Wetland Health (FARWH)—a nationally consistent way to measure the condition of Australia's rivers—for the wet/dry tropics of the Northern Territory and Western Australia.

Dr Townsend says the real challenge is to be able to detect small changes in the river catchment before they become major problems that are costly to fix.

'We need to be able to link any changes in the physical and chemical attributes detected through water monitoring back to the cause of these changes', he says.

'Most monitoring methods can detect large impacts, but we need to be able to detect small changes before they become large problems. Monitoring needs to be holistic. It should monitor activities in the catchment, how these may affect the river directly, and how this in turn affects the river's health.

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Photo: Jenni Metcalfe

Bayulu rangers Delton Cox (left) and Cainan Skeen (centre) work with researcher Marcus Finn (right) to set up photo monitoring points at Fitzroy River sites.

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Sunset, Flinders River catchment Photo: Jonathan Marshall

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Land & Water Australia

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TRaCK receives major funding for its research through the Australian Government's Commonwealth Environment Research Facilities initiative; the Australian Government's Raising National Water Standards Program; Land & Water Australia; the Fisheries Research and Development Corporation; and the Queensland Government's Smart State Innovation Funds.

TRaCK brings together leading tropical river researchers and managers from Charles Darwin University, Griffith University, The University of Western Australia, CSIRO, James Cook University, Australian National University, Geoscience Australia, Environmental Research Institute of the Supervising Scientist, Australian Institute of Marine Science, North Australia Indigenous Land and Sea Management Alliance, and the governments of Queensland, the Northern Territory and Western Australia.

Foreword

Ruth O'Connor
TRaCK Knowledge and Adoption Coordinator

Welcome to the fourth issue of *On TRaCK*.

As much of our fieldwork winds up, key findings are emerging from the TRaCK research program. In this issue, we highlight the multidisciplinary nature of our research and how tools and techniques must be tailored to work in the unique environmental and socio-economic context of northern Australia.

Two of the principles underlying the TRaCK program are the belief that good research involves communities and other end users, and the acknowledgement of the special role that Indigenous knowledge has to play in our gaining a better understanding of how the rivers of northern Australia work and how we can best manage them. Three of the stories in this issue pick up on these themes. Firstly, by working with local communities we are developing new ways of monitoring the health of catchments—ways that incorporate Indigenous values. Secondly, we show how sustainable livelihoods, driven by cultural knowledge and practices, can be developed in northern Australia. A third story describes the ways we are pulling together the different strands of research to answer the questions resource managers pose, such as how will fish populations be affected if more water is extracted from rivers and aquifers of the north.

Everyone who lives or works in the north is familiar with the highly seasonal wet and dry cycles. Through our research we are now starting to tease out what this seasonality means for how rivers and estuaries work and what influence land use has. Answers are also emerging to the vexed question of how to detect small, early changes in river health in such a variable environment.

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'For example, in a catchment where there is intensive agriculture, we would like to know the area that fertiliser is being applied to. We would then monitor the nutrients in the river to see if the fertiliser is having an impact, and then monitor the river's algae to see if the fertiliser is causing an increase in the amount of algae in the river.

'This type of monitoring is called pressure-stressor-response monitoring, where response refers to the river's biology. It allows river managers to link causes and effects.'

Michael Lawton is a senior advisor in the Northern Territory Government's Natural Resources division and a member of the project steering committee for the wet/dry tropics FARWH trial. He says that outputs from the research projects will be incorporated into water monitoring programs for high priority Northern Territory rivers.

'These research projects aim to produce an agreed and consistent approach for data collection and interpretation together with a more holistic, ecologically based condition assessment—something that has been missing at times from previous efforts', he says.

Mr Lawton also sees an opportunity for outputs from TRaCK's Indigenous values research and the FARWH trial to be integrated via the TRaCK project that has developed a water quality monitoring framework for the Daly and Katherine rivers.

'The Daly River Management Advisory Committee has endorsed the implementation of a comprehensive water monitoring plan using the TRaCK framework as a basis', says Mr Lawton.

Adapting the national framework to the tropics

The FARWH was developed as part of a baseline assessment of water resources, *Australian Water Resources 2005*, and funded by the National Water Commission through the Raising National Water Standards Program. It aims to provide a nationally consistent way to measure the condition of Australia's rivers and has already been successfully tested in Victoria and Tasmania.

As part of trialling the FARWH for the wet/dry tropics, TRaCK researchers are posing a fundamental question: Can the monitoring tools currently available detect low-level impacts?

'A lot of monitoring is put in place that is not sensitive to low levels of impacts', Dr Townsend says. 'The FARWH trial will be testing some standard and new methods to see if they are responsive to different levels of grazing and feral animal impact.

'In the north, to detect degradation of river health at low levels may require significant resources. But a feature of the north, of course, is the low population and limited resources. This is compounded by the vast areas that need monitoring. So it will be quite a challenge, but one I am sure can be met. The work looking at Indigenous river values, by the CSIRO team led by Sue Jackson, can add to the more standard river health methods.'

TRaCK researchers are discovering that the FARWH needs to be adapted for use in the tropics because of some of the unique characteristics of tropical river ecosystems.

Charles Darwin University research fellow Ian Dixon is working with Dr Townsend's team on the FARWH trial. He describes the data they have collected as being like pieces of a giant jigsaw puzzle that the team will piece together to give an overall picture of the Daly and Fitzroy catchments.

The team surveyed water quality, riverside vegetation and aquatic animals at 41 sites in the Daly River catchment and 34 sites in the Fitzroy River catchment over the 2009 dry season.

Mr Dixon says that some minor monitoring issues that occur in temperate environments were accentuated in tropical rivers. For example, when probes for measuring dissolved oxygen were deployed in rivers for more than a few days, algae occasionally smothered the sensors, reducing the accuracy of long-term measurements.

'Some tropical rivers have very low alkalinity', adds Mr Dixon. 'Using field instruments to measure pH in these waters is often not practical because it can take hours for equilibrium to be reached between the pH probe and the water. So we need probes that have been specifically designed for such waters.'

Animal and plant monitoring

An integral part of monitoring the health of a river is recording what plant and animal species are present.

Recording the fish species in a river can also be tricky when the river is home to large predators that steal the fish caught in the researchers' nets.

'In the Fitzroy River, fish were being stolen overnight from our nets by crocodiles and turtles when the nets were set for 10–12 hours. So a shorter set-time may yield more fish', Mr Dixon explains.

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Researcher Ranid May (left) and NT Government Aquatic Health Unit officer Tony Boland survey fish along Stray Creek in the Daly River catchment using a backpack electrofisher.

Photo: Ian Dixon

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The presence of crocodiles also brings danger to the process of surveying the tiny insects and crustaceans living at the bottom of a river bed.

Mr Dixon's team trialled an innovative sampling method that uses non-biting midge insects to assess river health. The team collected skins shed by midges which were floating in the river on debris and in eddies.

'The pupal skins are trapped in back eddies as they flow down the river. So we can identify what midge insects are present in the river as a whole, rather than just taking samples from a limited number of accessible river edges', Mr Dixon says.

Indigenous river values

While Mr Dixon's team is focusing on whether the FARWH can be applied in the wet/dry tropics, another TRaCK project is looking at the same river catchments to identify monitoring tools that incorporate Indigenous values.

CSIRO's Dr Sue Jackson and her team have worked closely with Indigenous communities to better understand the social and economic significance of rivers to them.

Dr Jackson says that river country has important cultural significance and is a vital resource for Indigenous communities. Rivers are a traditional meeting place, a spiritual place and, in some instances, the only recreational site for communities.

Rivers also provide important bush food and fish resources. However, the team found significant differences in the species that were fished by Indigenous people and those that were fished by other groups, such as recreational and commercial fishers.

'The measure of a healthy river may be different for a recreational fisher and an Indigenous fisher', explains Dr Jackson. 'For example, black bream and barramundi are both important fish resources for Indigenous communities along the Fitzroy River. But recreational and commercial fishers are primarily interested in stocks of barramundi.'

Dr Jackson says these different values mean that traditional scientific monitoring tools, which help measure a river's health according to the western values, may not always measure the health of the river according to Indigenous values.

'In the Daly River catchment, long-neck turtles are an important part of the diet of some Indigenous communities', she says. 'The turtles lay their eggs underwater in the wet season, but the eggs will not hatch unless the edges of the wetlands where they laid their eggs are allowed to dry out.

'Each fish species has a different life history and therefore will be impacted differently by water resource development. This needs to be considered in any future river management decisions to ensure that species that are important to Indigenous communities are not put at risk.'

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Protecting the Fitzroy River for future generations

Two Indigenous rangers from the Kimberley have joined a TRaCK river monitoring project to help protect their favourite river spots for future generations.

Rangers Thomas Dick and Cainan Skeen are from the Bayulu Community near Fitzroy Crossing.

Working with TRaCK researcher Marcus Finn and other rangers, Thomas and Cainan have been surveying the Fitzroy River and planning ways to regenerate degraded sections of the river and protect it from further damage.

Both men fondly remember camping by the river with their families while they were growing up and, depending on the season, going swimming, fishing or hunting goannas.

Thomas says that parts of the Fitzroy River that are normally good for catching black bream and barramundi are no good for fishing when the water is muddied up from cattle or motor boats.

One of the main threats to the river, says Cainan, is cattle and pigs coming down to drink from the river and eroding the river banks.

'We're going to put a fence around the river in this part because too many cattle are going in there and getting stuck in the mud. It's really hard to get them out', he explains.

'Plus, they're destroying the place; that's the main thing. Cows and pigs get into the water and make it smelly and dirty.'

Weeds and rubbish are another problem that Cainan would like to see fixed.

'We are thinking we will put a sign here to tell people to put their rubbish in the bin and to clean up their own mess', he says.

Photo: Jenni Metcalfe

TRaCK researcher Marcus Finn and Bayulu ranger Cainan Skeen survey the banks of the Fitzroy River for cattle and pig damage.

Danielle Warfe collects samples of invertebrates from the Fergusson River, a tributary of the Daly River in the Northern Territory.

Bringing the research together for river managers

By Jenni Metcalfe

Photo: Jenni Metcalfe

What will happen to the barramundi available to Indigenous, commercial and recreational fishers if more water is extracted from the Daly River in the Northern Territory? And how will barramundi populations be affected if water is extracted during the wet-season floods?

These are some of the questions posed by river managers in northern Australia.

TRaCK's many research projects into the biophysical, social and economic nature of rivers in northern Australia are generating a wide range of new data and knowledge about tropical rivers and coasts. But no one project can answer the specific questions posed above.

For this reason, TRaCK is bringing together researchers and river managers to synthesise the research and create tools and knowledge that are useful to river managers. Three approaches are being taken:

- A knowledge and adoption team is bringing researchers together with each other and with stakeholders to make sure the products being developed meet the needs of river managers.
- Researchers are building the capacity of river managers to evaluate likely scenarios and examine the effects of their future decisions about how water and land can be used.
- Researchers are developing environmental flow tools that use TRaCK research findings to help river managers determine the flows needed to meet both community and river needs.

Bringing researchers and stakeholders together

TRaCK's Knowledge & Adoption (K&A) team aims to link the various research programs together so that research results are not generated in isolation. They also look for how different pieces of research can be combined to answer questions of interest to river managers. To do this, they help researchers to communicate across disciplinary boundaries with each other, with river managers and with the broader community.

'For example, some researchers look at river flows, some look at fish biology and ecology, and others look at the social and economic characteristics of communities living along the rivers. And they don't all speak the same language', says Ruth O'Connor, manager of TRaCK's K&A program. 'Researchers also need to listen to river managers and find out what knowledge and tools they need to help them make decisions.'

Last year, the K&A team brought researchers together with river managers at a workshop where the river managers learnt about what TRaCK did and identified what was useful to them. The researchers then met to look at the common themes that would help them synthesise their research outputs.

'The workshop sowed the seeds for getting researchers to think about and talk through the issues for river managers,' says Ms O'Connor. 'And this has led to TRaCK products that are more than the sum of their parts.'

Evaluating future scenarios

TRaCK recognises the need to integrate research findings into a single framework for river managers. The first cab off the rank for scenario evaluation is the Northern Territory's Daly River.

While researchers are finding out more about the Daly's flows, ecology, biology, social and economic characteristics, they need to bring these findings together in ways that provide benchmarks for both researchers and river managers for evaluating

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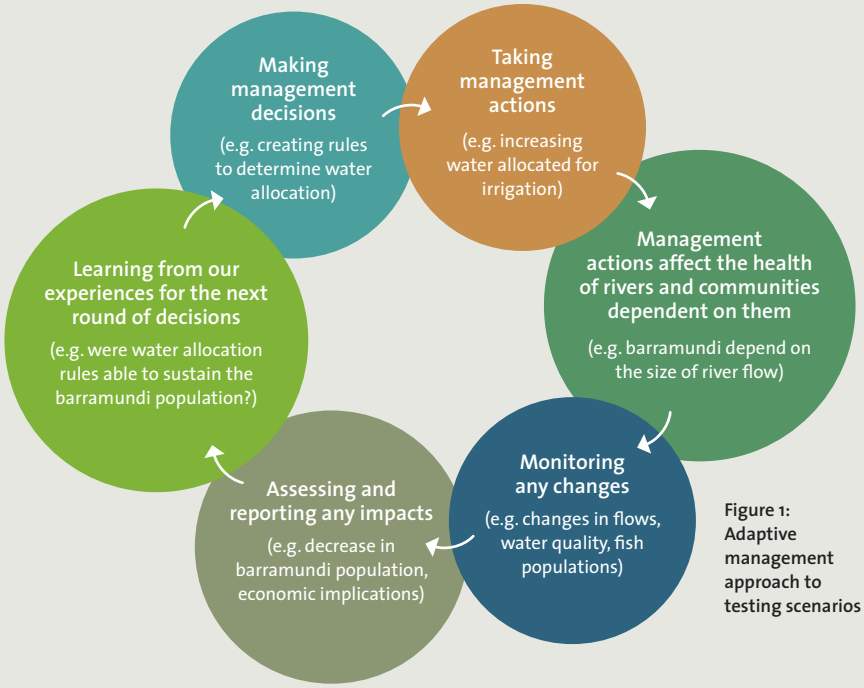

Figure 1: Adaptive management approach to testing scenarios

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the effects of current water use, ways to conserve natural heritage and future development options for the Daly River.

'This knowledge is being put together in a software package designed to answer questions that river managers most want answered', says TRaCK project leader Associate Professor Francis Pantus from Griffith University.

The software package uses an adaptive management approach (Figure 1) to help natural resource managers evaluate the consequences of future management actions. For example, if land managers reduce erosion of sediment into rivers, thereby increasing the amount of light available to algae and other plants, how will this affect fish populations, and how will the changes to fish populations, in turn, affect commercial and recreational fishing?

TRaCK is working with the Northern Territory Department of Natural Resources, Environment, The Arts and Sport to get a prototype software package ready for use by the end of this year.

'This software will be used by river managers and stakeholders such as the Daly River Management Advisory Committee (DRMAC) to look at the likely impacts of individual management actions as well the impacts from implementing a suite of management actions', says Assoc. Prof. Pantus.

Focusing on the issue of water allocation

Chris Makepeace is Executive Director of the Amateur Fishermen's Association of the Northern Territory Inc. and a member of DRMAC.

'We need to know the impacts on fish like barramundi of various scenarios of water extraction from the Daly River and the groundwater aquifer that feeds into it', he says. 'The question we need answers for is: How big is the consumptive pool of water that can be taken out before there are effects we can't live with?'.

TRaCK's environmental flows project is pulling together all the physical, ecological and biological research findings about river flows to give river managers the information they need to make decisions about how much water can be extracted from rivers, and when and where this is best done.

The research also provides a scientific basis for monitoring and assessing changes in the river, which is part of the adaptive management process (Figure 1).

'TRaCK research is providing the baseline information of what animals and plants are where in the rivers at various times of the year', says TRaCK researcher Dr Danielle Warfe from Charles Darwin University. 'We can then see what changes under various management actions that change the flow of a river.'

This information is being packaged in a way that suits river managers working for the north's state and territory governments.

'We wanted to avoid making assumptions about what we thought they wanted to know', says Dr Warfe. 'And on meeting with them, we found they wanted different things depending on their current stage of water planning.'

While the river managers are interested in most of TRaCK's activities, they have specific high priority needs. Queensland river managers want a conceptual understanding of northern river systems and the basic flow-ecology knowledge to assess the river flows needed to protect river values and assets. Northern Territory river managers want models that can assess the impacts of various water use actions on specific fish species. Western Australia's river managers want tools to help them assign priorities to their water management planning actions.

Synthesising TRaCK's scientific findings on river flows to come up with such products is complex.

'We try to visually map the effects of different river flows on different parts of the river—small rivers, larger rivers, floodplains, estuaries, during both the wet and the dry seasons—to identify which flow aspects are important for maintaining river assets such as barramundi populations', explains Dr Warfe.

'One of TRaCK's projects found that **two thirds of the fish species in the Daly River need to move throughout the river or between the river and the estuary to feed or reproduce.** This sort of information will go into the mix of findings from other projects to help develop an integrated understanding of how the whole river system works.

'If water is taken out of the river at various times of the year, we can look at the risk this poses to various animal or plant populations. Then it is up to the community to decide what level of risk is acceptable.'

Communities across the Top End will face similar decisions.

'We're stuck for the next five years with the decisions we make now about water allocation from the Daly River and its aquifer', says Chris Makepeace. 'We need the best available information to make those decisions.'

Creating livelihoods from traditions and culture

by Amanda Hodgson

Indigenous land and sea owners in northern Australia wear many hats.

In some cases they are people managers. For example, rangers in the Dhimurru Indigenous Protected Area in Arnhem Land provide permits to visitors who want to access the recreational areas. An Indigenous Protected Area, or IPA, is an area of land or sea owned by Indigenous people and protected by them to conserve the area's biodiversity and cultural resources. So the Dhimurru rangers also monitor visitor numbers and compliance to prevent overcrowding, conflicts between visitors and local communities, and degradation of the environment.

They can also be environmental conservationists. In the Djelk IPA in Arnhem Land, rangers help the Australian Quarantine and Inspection Service with biosecurity by monitoring and collecting marine debris and weed samples. And in West Arnhem Land, ranger groups work together to manage fire using traditional methods; small controlled fires are burned in a mosaic pattern, which prevents large uncontrolled fires and, as a result, reduces carbon emissions.

Yet another role for Arnhem Land Traditional Owners is that of facilitators of cultural learning. They pass on cultural knowledge locally by holding traditional ceremonies and giving school talks. The Dhimurru rangers shared their cultural experiences internationally in 2008 at the IUCN World Conservation Congress in Barcelona, Spain, presenting a paper about their management activities and how they are conserving and protecting their country.

The new vision for the north, according to Joe Morrison, CEO of the North Australian Indigenous Land and Sea Management Alliance (NAILSMA), is for a cultural economy built on this customary management of land and sea.

'NAILSMA is developing a strategic approach across the north regarding future development', says Mr Morrison. 'We want to develop an economy driven by our cultural knowledge and practices which will provide more opportunities for employment, income and business development in local communities. This vision is being driven by people on the ground, land councils and other Indigenous groups interested in the future of northern Australia.

'The idea is to establish markets for this customary management, such as payment for environmental services, which will then provide sustainable livelihoods on country for Indigenous people. So it's not just about creating jobs—it is about supporting people who aspire to live on country, so they can look after country and maintain socio-cultural practice, and thereby improve the health and wellbeing of local communities, as well as managing the environment responsibly'.

Supporting people to live and work on country

TRaCK researchers are embarking on three projects facilitated by NAILSMA to elicit how and why Indigenous people aspire to live and work on country, and to see if these people can be supported financially to do so by being paid for environmental services. Each project is a case study: one in Arnhem Land in the Northern Territory; another at Archer River, Cape York; and one at Fitzroy River in the Kimberley.

The Arnhem Land case study is being led by Dr Nanni Concu from the Centre for Aboriginal Economic Policy Research at the Australian National University in Canberra. Dr Concu is working with the Bawinanga and Dhimurru Aboriginal Corporations (Djelk and Dhimurru Land and Sea rangers respectively) to determine how much it would cost governments, non-government organisations and private enterprises to contract Traditional Owners to provide environmental services.

Dhimurru Miyalk Ranger Wangawuy Grace Mununguritj checks a mosquito sample for the Australian Quarantine and Inspection Service.

'We are using a number of different tools to estimate delivery costs', says Dr Concu. 'Firstly, we are collecting data on what the rangers do on their everyday land and sea patrols including, for instance, checking permits, campsite maintenance, weed control, or tracking crocodiles. This information is used to estimate the efforts and resources for each activity. We then estimate how much more time and resources are needed to improve environmental management. For example, how much more money is needed to eradicate weeds in a given area.'

The rangers have been keeping track of what they do each day by using *Cybertracker* software on handheld computers, or by writing it down on paper. Dr Concu and the rangers have also designed a questionnaire for visitors and tourists.

'We want to find out the demand for these environmental services, so we are collecting information on recreational users and what visitors value—what they enjoy and appreciate when they go into the IPAs. We also have questions about their daily expenditure on their holidays, where they've been and if they'd like to see any improvements made to the IPA.'

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Dr Concu will gather further information by interviewing Indigenous rangers and other stakeholders who would benefit from the protection of environmental values, such as mining companies, fisheries, and pastoralists. Mining companies, for example, might benefit through opportunities to buy carbon credits, while fisheries and pastoralists might benefit from the protection of rivers and wetlands.

Creating a market for environmental services

The project will also assess the challenges in creating a market for environmental services. Dr Concu says three issues have emerged so far.

'One is the need for a better interface with science to help rangers tackle issues such as invasive weeds, feral animals in billabongs and carbon pollution reduction.

'Another challenge that rangers talk about is that they see environmental conservation, heritage protection and cultural practices as part of a unique and single life project—**conservation of the environment and culture is one and the same.** However, environment and culture come under two different streams of government funding and it is hard to get funding that covers both. Things are slowly changing though.

'The third issue emerging is that rangers don't have much power to manage people. They can monitor compliance but if someone is doing something illegal, rangers have no way of stopping them; they can only file a report to police. Things are moving towards empowering rangers more and we will explore this further at the end of the project.'

The Archer River case study in Cape York is just beginning. TRaCK researchers aim to work with the Balkanu Cape York Development Corporation to develop a sustainable livelihoods plan by defining the opportunities for Indigenous livelihoods in the Archer River Basin, and the priorities and aspirations of Traditional Owners in the region.

In the Kimberley, TRaCK has partnered with the Nyikina Mangala people who are the Traditional Owners of the lower Fitzroy River in the west Kimberley.

Nanni Concu trains Dhimurru rangers in the use of handheld computers with *Cybertracker* software.

The Nyikina Mangala people are keen to build on sustainable livelihoods projects they have previously conducted through the Community Development Employment Program. TRaCK funding is supporting Senior Research Fellow Dr Virginia Falk to document what the Nyikina Mangala people have already done and then help them implement a cultural and natural resource management plan which they have already developed.

Dr Anne Poelina, Managing Director of Madjulla Inc., a non-government organisation based in the Kimberley, is the community representative for this project.

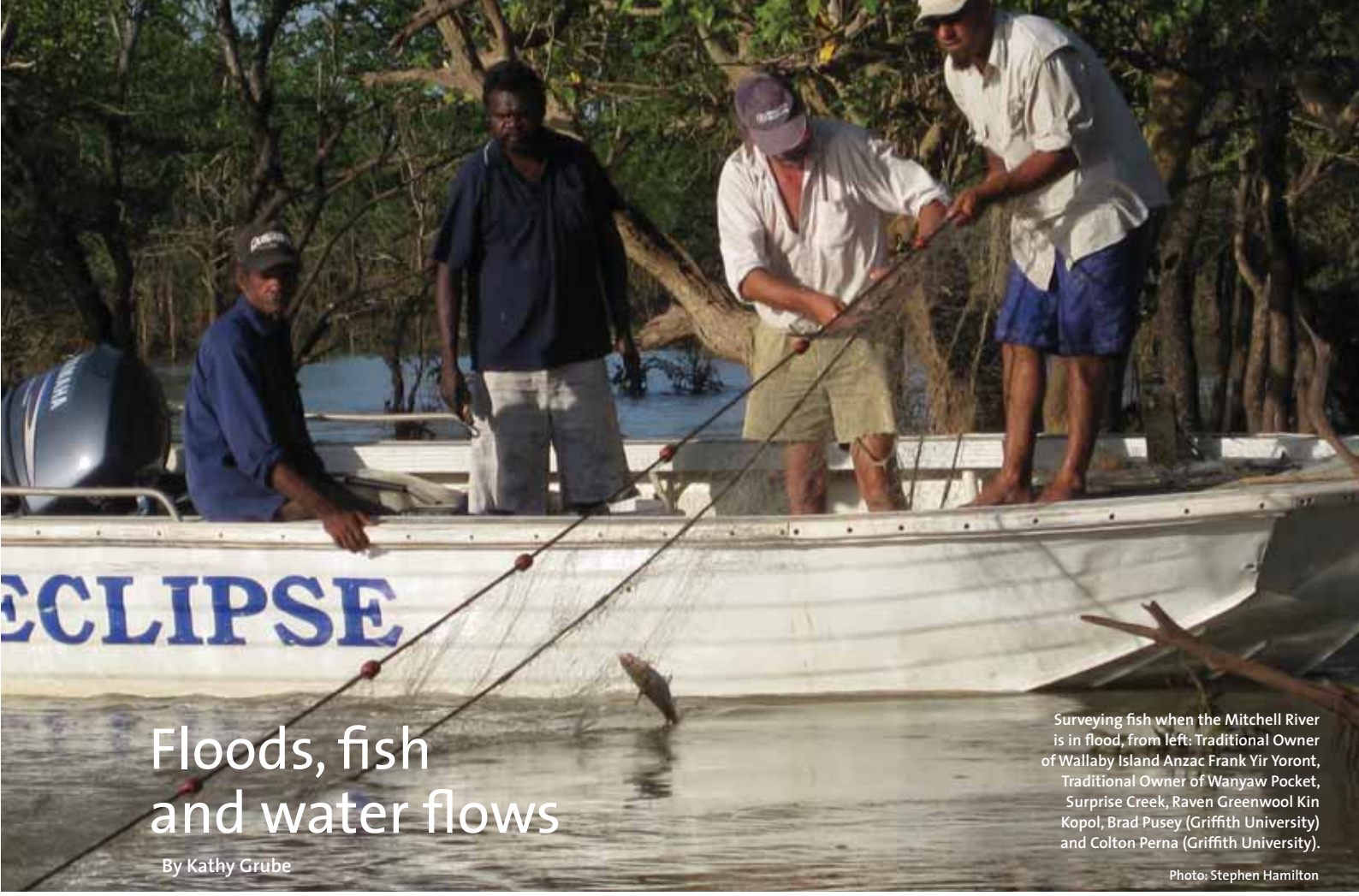
'As Traditional Owners, we're very excited about this investment. **We can now build a body of evidence around good science and traditional ecological knowledge to plan and build sustainable livelihoods on country', says Dr Poelina.**

'Another thing we're excited about is the opportunity to collaborate with other Traditional Owners across the north. Collectively, we want to shift Aboriginal people to entrepreneurial development and wealth creation.'

Dr Poelina believes that if Indigenous rangers are going to provide environmental services, they need to be multi-skilled: 'They need to provide integrated water management; landcare such as fire, weed and feral animal control; and cultural tourism opportunities. And they need the capacity to map and manage traditional ecological knowledge.'

She believes that the biggest challenge will be to develop sound business models that allow Traditional Owners to co-manage land with other land managers, scientists and industry. 'For example, if someone is going to put a mine on country, how do we work with them to make sure the mining is done in a sustainable way, so that it's a win for Traditional Owners, a win for the environment and a win for mining?'.

Dr Poelina says that the key to developing sustainable livelihoods in northern Australia is creating the right mindset. 'Indigenous people need to be seen as equal partners—as an asset rather than a deficit to Australia's economy. We have lived experience managing landscape in a sustainable way. We have the social, human, cultural and environmental capital but we don't have the economic capacity to build on these assets. We need to make sure that it's the Traditional Owners' capacity we build, not the government's.'



Floods, fish and water flows

By Kathy Grube

Surveying fish when the Mitchell River is in flood, from left: Traditional Owner of Wallaby Island Anzac Frank Yir Yoront, Traditional Owner of Wanyaw Pocket, Surprise Creek, Raven Greenwool Kin Kopol, Brad Pusey (Griffith University) and Colton Perna (Griffith University).

Photo: Stephen Hamilton

The enormous volumes of water that inundate floodplains and flow into the sea during the wet season in northern Australia are essential for sustaining tropical freshwater and estuary ecosystems for the remainder of the year, according to the latest TRaCK research.

The researchers have already proven that big floods equal big fish. Now they believe they know why.

Studies of four tropical river catchments—the Fitzroy in Western Australia, the Daly in the Northern Territory and the Mitchell and Flinders in Queensland—indicate that the main energy source for these aquatic ecosystems is microscopic algae that grow on the floodplain plants and soil in the wet season.

TRaCK research director Associate Professor Michael Douglas says that summer floods appear to provide most of the nutrients and energy that sustain tropical river ecosystems for the rest of the year.

'Despite the differences in rainfall, catchment area, river flow, water turbidity and geology, all animal life in northern Australia's tropical rivers relies heavily on this single-celled plant life', says Assoc. Prof. Douglas.

'River and estuarine species do much of their feeding on these productive floodplains during inundation. The floodwaters flowing into the sea then nourish the estuaries and encourage further algal growth, providing more food for important commercial fishery species such as prawns.'

Applying food-web knowledge

For a highly productive region like the Mitchell River delta, where barramundi and prawns are an important resource, knowing how flooding impacts the fish catch is vital.

Viv Sinnamon manages the Kowanyama Aboriginal Land and Natural Resource Management Office (KALNRMO). He says the scientific data being collected by TRaCK scientists helps them manage valuable natural resources and guide development.

'During the wet season, the floodplain and associated stringy bark forest are between 50 and 100 kilometres wide when flooding of the Alice River and Crosbie Creek coincide with flooding of the Mitchell River', says Mr Sinnamon.

'With high river flows and wet-season floods necessary to retain healthy fish stocks, we are very conscious of ensuring that future developments within the catchment do not impact on the Mitchell River delta country.'

Mr Sinnamon said establishing mining operations or extracting water for agriculture in the catchment could affect wet-season floods and therefore threaten the fish resources.

'Having scientific evidence showing the importance of river flows and floodplains is essential so that we can prevent a repeat of the Murray River disaster from happening in the Mitchell River catchment.'

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Fish biopsies reveal diet history

TRaCK researchers analysed fish tissue and confirmed that the main source of organic carbon entering the tropical river food web was from algae, but they did not know where the algae were coming from.

Using chemical forensics, the TRaCK team from Griffith University overturned the theory that tropical river fish feed on algae on the bottom of dry-season riverbeds.

Traditional methods for finding out what fish are eating usually involve analysing their stomach contents. However, this method only reveals what the fish have recently eaten and does not give a complete picture of their diet throughout the year.

Griffith University's Dr Tim Jardine explains that this diet mystery was solved by taking small tissue biopsies from fish. This also allowed the fish to be returned to the river.

'The fish tissues act as a chemical "fingerprint" with the history of the fish's diet being integrated into their flesh', says Dr Jardine.


Photo: Michele Burford

Raptis & Sons prawn trawler, *Sandpiper*. The company is collaborating with TRaCK scientists on prawn research in the Gulf of Carpentaria.

'All plant and animal tissues have their own distinctive carbon and nitrogen signature due to their diets having unique proportions of different types of carbon and nitrogen, called isotopes. Scientists can match the carbon isotopes to determine who is eating what. By analysing the nitrogen isotopes, you can determine how high up the food chain a consumer is.

'If a fish has the same ratio of carbon isotopes as the algae, then we can assume that the fish has got its carbon from this algae.

'The isotopes of nitrogen or carbon found in tropical river predatory fish – including barramundi, long tom, spangled perch, rainbow fish and archerfish – did not match the algae in the Daly River.'

Microscopic algae attach themselves to solid surfaces, such as rocks or sand on the bottom of a river, or on stems and leaves of aquatic plants. Invertebrates and small fish feed on this algae.

Isotope testing indicates that **microscopic algae growing on plants or soils of the floodplains are the major food source for northern Australia's tropical river ecosystems.**

'During the summer floods small fish like bony bream and catfish feast on the smaller animals which, in turn, have been feeding on floodplain algae growing on plants such as grasses and lilies. That frenzy of eating and reproducing during a big wet-season flood results in lots of smaller fish for predators like barramundi to feed on', explains Dr Jardine.

'As a result, many predator fish species also move onto the floodplains in the wet to breed and increase body mass, returning to the rivers and waterholes when the waters recede.'

River flows affect where food comes from

While algae drive all tropical river ecosystems, the source of algae differs between catchments and depends on the river's flow, according to TRaCK researcher Dr Neil Pettit from the University of Western Australia.

'During the dry season when river flows are low or have stopped, invertebrates and fish are dependent on algae from the bottom of river channels and waterholes.

'However, in the Daly River, which has a permanent flow fed by groundwater, fish seem to be getting their algae food source from further afield.'

Research indicates that there is a relationship between a food web's reliance on algae and whether a river flows year-round. When rivers dry up into isolated pools, fish rely on algae in the pools for food. In contrast, in rivers like the Daly River which flows all year round, algae food sources can come from either upstream or downstream.

Dr Pettit says the algae supporting the Daly River food web during the dry season may come from a marine source or from floodplain-derived sources in the wet season.

'This suggests that when fish are moving upstream they are feeding mainly for maintenance in the dry season, and putting on body mass when feeding elsewhere in the wet season.'

It was only through sophisticated chemical analysis of fish tissues that scientists were able to discover not only what fish were eating, but also reveal some of the complex connections between animals and plants in tropical rivers.

TRaCK researchers are analysing food-web structures in four catchments: Fitzroy River, Daly River, Mitchell River and Flinders River.

Photo: Ian Halliday

Photo: Michele Burford

Left: Julie Robins, Queensland Government, with a giant barramundi.

Above: Banana prawns caught in the Gulf of Carpentaria

Big floods equal big fish

With floodplains confirmed as the main source of food for tropical river ecosystems, it is not surprising to also find that studies of estuary ecosystems at the mouths of the Daly and Roper Rivers in the Northern Territory and the Mitchell and Flinders Rivers in Queensland have shown that the bigger the river flow, the bigger the fish catch.

Dr Ian Halliday and his TRaCK team from the Queensland Department of Employment, Economic Development and Innovation and the Northern Territory Department of Natural Resources, Environment, The Arts and Sport compared river-flow data with barramundi and king threadfin catches logged by commercial fisheries over the last 20 years.

'It's surprising how consistent the correlation is. Whatever estuary you look at, the higher the river flow rates the higher the catch', says Dr Halliday.

'In years of higher river flow, breeding success is higher and growth rates go up. Flow affects not only the number of juveniles but also their growth rate.

'Juveniles have a higher survival rate in years of high flow and once they get through that first year they continue on to maturity.'

Although high river flow generally increases the fish population, extreme floods could have a negative impact on fish survival.

'Young barramundi rely on banana prawns as a food source in estuaries. If flow rates are too high, the prawns move out of the estuaries and away from the reach of the juvenile barramundi', says Dr Halliday.

Dr Halliday's team, which is also funded by the Fisheries Research and Development Corporation, is now investigating the movement of barramundi between salt and fresh water.

Once the wet-season floods have receded, fish feeding diminishes for the rest of the season and many of the fish spread out to upstream reaches. **So what ultimately determines how big the barramundi will get is the amount of algae growing on floodplain plants in the wet season.**

Dr Jardine, who is undertaking surveys of the Mitchell and Flinders Rivers in Queensland, says barramundi quickly take advantage of any chance to eat during the short flood season. And because they eat only occasionally during the dry season, they need as much food as they can get in the wet season.

'Flood water comes and goes quite quickly in Queensland's tropical rivers like the Mitchell and Flinders', says Dr Jardine. 'That means there is only a short window of time to use nutrients brought by the floods. Bigger floodplains and longer floods mean more opportunities for barra to feed and grow.'

But changes in fish stock are not immediately apparent after a large flood.

'It takes a few years for the fish to get big enough to be caught. So there is always a time lag between the flood and the end result, which makes studying it very challenging.'

Prawns in the estuary also benefit from floods

Floods not only affect the fish catch within river channels, but also out in the sea.

Griffith University's Associate Professor Michele Burford and her collaborators at CSIRO have been studying why there is a relationship between flood size in the estuary and the banana prawn catch in the Gulf of Carpentaria.

Their research, which is also funded by the Fisheries Research and Development Corporation, has confirmed that nutrients brought by flooding of coastal areas are an essential source of energy for prawns.

'Although freshwater floods initially drive the prawns out of the estuary and into the fishery grounds, nutrients associated with flooding of coastal areas are an important new source for algal growth, with flow-on effects to the prawns', says Assoc. Prof. Burford.

She says that damming the north's rivers or extracting water for irrigation would result in less fresh water reaching the estuaries. This could affect the banana prawn fishery.

'We don't understand enough about the relationship between estuaries and freshwater flows, but we do know that water running out to sea is not wasted.'

Further studies by Assoc. Prof. Burford's team will clarify the effect of flooding on prawn growth and population size.

Where does the water go?

By Kathy Grube

Researcher Samantha Grover takes measurements from an evapotranspiration tower in a part of the Daly River catchment that has been under improved pasture for 28 years.

Photo: Lindsay Hutley, Charles Darwin University

What would happen to the water resources of northern Australia if graziers switched from running stock on native savannas to growing improved pastures or crops on cleared land on a large scale?

A team of TRaCK scientists is hoping to answer this question. The team members are studying different pieces of the water-balance puzzle using satellite technology, field measurements and mapping.

Water balance is a term used to describe the flow of water in and out of a catchment system and its components. It includes groundwater, water held in the soil within reach of plants, and surface water in rivers and lakes. Understanding the water balance helps us manage water supply and predict where there may be water shortages.

Researchers are pooling their results to provide an overall picture of how the water balance in a tropical river catchment is affected by changes to land use and rainfall, and by increased water extraction for irrigation.

The research will allow government policymakers and water managers to more accurately predict how pumping groundwater or clearing land in a tropical catchment will affect the total water resources in the catchment.

Research activity is focused on the Daly River catchment which covers 52,000 km^2, of which less than five per cent of land has been cleared. This percentage is predicted to increase with the Northern Territory Government now considering whether the catchment could support more agriculture.

TRaCK Project Coordinator Dr Richard Cresswell from CSIRO's Water for a Healthy Country Flagship says the research will improve our understanding of the fate of rainfall falling on a large catchment in the wet/dry tropics of northern Australia.

'Mapping water flows for a wide range of land types will help show the impact of land use change on water balance', he says.

'The data collected in the field is going towards testing and developing sophisticated modelling systems to assist government agencies with better water resource planning and to more accurately predict any impacts arising from further development.'

Dr Cresswell says the project's findings will be crucial if extensive areas of native savanna woodland are to be converted to agriculture in Australia's tropics.

'Our early results suggest widespread clearing will have a rapid impact on the catchment's water balance, with potentially significant increases in surface-water run-off', he says.

'Spatial water-balance mapping will also identify regions of high and low recharge and examine sensitivity of water-balance attributes of the Daly River to land clearing.'

The project encompasses remote sensing technologies, mapping and field work, and features experts from four institutions: Richard Weinmann, Guy Boggs and Lindsay Hutley from Charles Darwin University; Cuan Petheram from CSIRO; Renee Bartolo from the Environmental Research Institute of the Supervising Scientist; and Doug Ward from Griffith University.

What affects water balance?

A river catchment's water balance is affected by rainfall, soil evaporation and plant water use (collectively known as evapotranspiration), surface run-off, drainage and groundwater recharge. Dr Cresswell says changing any of these components will affect the available water resources of the catchment.

'To model a catchment's water balance, we need to know the fate of rainfall falling on catchments, how much ends up as evapotranspiration, how much goes underground and how much flows into streams', says Dr Cresswell.

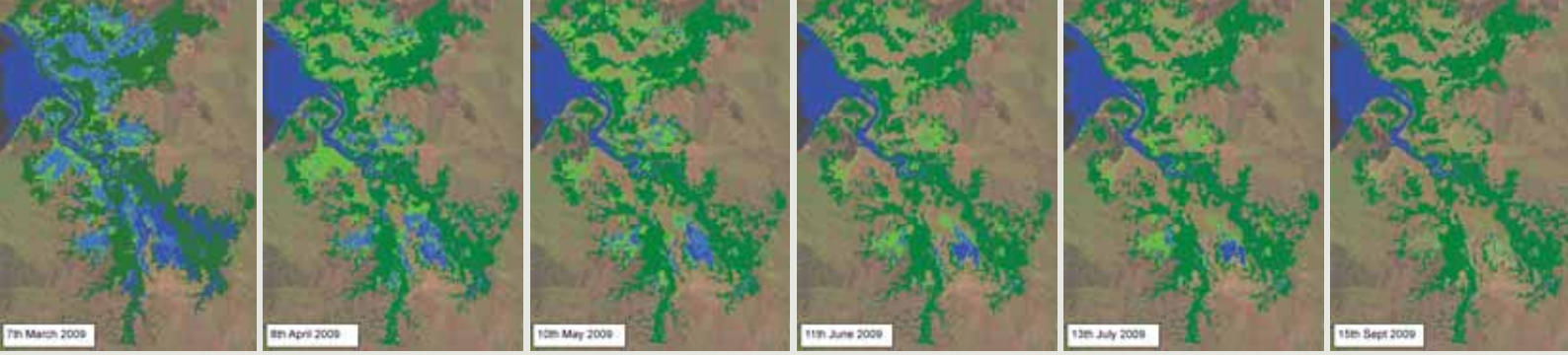


Figure 2. Flood inundation for the Daly catchment floodplain in 2009, captured using satellite imagery. Surface water and seasonal grasses contract from the end of the wet season (March) to the end of the dry season (September).

Legend
- Seasonal Grasses and Sedges
- Standing Woody Vegetation
- Surface Water / Seasonal Vegetation
- Surface Water

Source: Griffith University

Understanding the links between surface water and groundwater is an important but often difficult aspect of building a water-balance model. In some places, surface water flows into the ground to become groundwater, and in other places groundwater flows into rivers to become surface water.

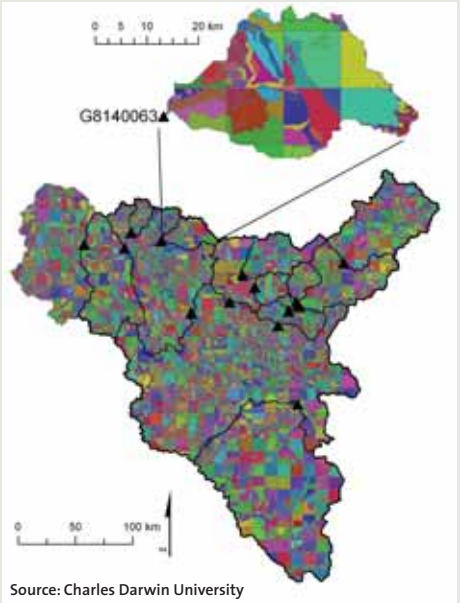
It is important that we quantify these flows because they are influenced by both vegetation and soils and, thus, land use.

Dr Cresswell's team will identify whether converting native vegetation to agriculture and extracting water from the catchment's aquifers or rivers for irrigation will change the balance between these components.

Modelling and mapping the water balance

One approach to understanding how water moves though a catchment, according to Dr Cresswell, is to map the hydrological properties that can affect the flow of water in the catchment, such as soil type, slope and type of ground cover.

CSIRO has developed a model, called WAVES, which predicts run-off, drainage and evapotranspiration for discrete units in the Daly River catchment (Figure 1).



Source: Charles Darwin University

Figure 1. The Daly Catchment (inset Douglas River sub-catchment). Different colours represent unique combinations of soil, climate and ground cover, which affect the flow of water in the catchment.

Comparing water use of savanna and pasture

Associate Professor Lindsay Hutley's team is helping calibrate the WAVES model by collecting and analysing three years of field data on climate, evapotranspiration rates and soil-moisture dynamics, for both cleared and uncleared land in the Daly River catchment.

Assoc. Prof. Hutley says the largest source of water loss from a catchment is from evapotranspiration.

'We need accurate field estimates of evapotranspiration to compare with the model predictions so that we can be certain that spatial mapping and modelling that predicts flow is accurate over the different seasons and for different land uses', he says.

'We need to know how much water is used during the wet and dry seasons by the dominant native vegetation, which is the savanna, and compare this to other land uses such as improved pastures. Once we know how much water is lost back to the atmosphere, we can ensure the models correctly calculate how much water makes it back into wetlands, swamps, aquifers and rivers.'

Evapotranspiration rates (which, like daily rainfall, are measured in millimetres per day) were very high during the wet season at pasture sites (6–8 mm per day), but dropped drastically in the dry season (0.5 mm per day) when soil moisture is very low and the shallow-rooted pasture and legumes die off.

Evapotranspiration rates of native savanna vegetation are lower and less seasonal than those for pasture. They range from 4–5 mm per day in the wet season to 1–2 mm in the dry season. Evergreen eucalypts continue to use water during the dry season because they can access water stored deep within the soil.

Another major part of the team's work is to compare the evapotranspiration rates measured in the field for three different vegetation types with evapotranspiration estimates from infra-red satellite imagery of the catchment (Figure 2).

'The use of satellite data is critical as it provides estimates of water use across the entire catchment and not just at a few locations', says Assoc. Prof. Hutley.

'Our results show the satellite estimates correspond well with the field results and confirms that satellites will provide an accurate and inexpensive method to measure evapotranspiration across other catchments.'

Surface water and seasonal patterns of inundation

While satellite imagery can be used to measure how much water is lost to the atmosphere through evapotranspiration, it is also being used to determine how rainfall affects the extent of flooding and to track the movement of surface water.

Radar satellite imagery of the catchment has been recorded since the early 1990s and Dr Bartolo and Dr Ward are using these images to measure how rivers expand and contract through the wet–dry season cycle (Figure 2).

They are analysing historical rainfall records to identify which wet seasons since 1990 had the highest and lowest rainfall and are then measuring the extent of land inundation under these different rainfall histories.

Using the satellite imagery, they can examine flows to seasonal swamps, floodplains and rivers through time and also across the catchment.

Dr Cresswell says bringing together the information from these different sources gives us a good understanding of how different elements are linked in a tropical river catchment's water balance.

Gooniyandi Traditional Owner Thomas Dick is interviewed by his young people and other Yiriman multimedia trainees for the River Change Stories project.

Photo: Yiriman Project

Kimberley update

Nine TRaCK projects have done fieldwork in the Kimberley since the regional research agreement was signed with the Kimberley Land Council in mid-2008. All have had a high level of community engagement and all have progressed well.

The research into the economic value of rivers is complete and the team is now reporting on its findings.

Fieldwork for the following projects is complete and the teams are now processing and analysing samples: the surface-groundwater interactions project, the project trialling the framework for assessing river health, the two food-webs projects and the biodiversity project.

The project on river flows and Indigenous socio-economic values is two-thirds of the way through its field program and has preliminary results from two rounds of field surveys. The researchers will continue working in the catchment until the end of the year.

The Kimberley-based Yiriman Project is working with Fitzroy River Catchment Traditional Owners on the River Change Stories project. The final round of community consultations is being undertaken in July and production of the DVD of river change stories will be finalised soon after.

The power tools project team is planning to work with members of the FitzCam Aboriginal Reference Group this year on a range of activities to build capacity in water planning.

A lead researcher has recently been employed for the project on sustainable livelihoods on country which is in the early stages. Researchers are collaborating with Nyikina Mangala people of the Lower Fitzroy.

All of the projects are reporting back to people in the region before the end of the year.

Mitchell River update

Many of the 14 research projects doing fieldwork in the Mitchell have collected all their data and are now in the analysis and reporting stage. Anna Straton has distributed her final report on the value of Australia's tropical rivers. Two of the projects studying erosion and sediment transport (led by Andrew Brooks and Gary Caitcheon) have also completed fieldwork and are analysing findings.

Natalie Stoeckl's work on socio-economic activity and water use is in the final stages of data collection. Some interesting findings about the economic interactions between Indigenous and non-Indigenous economies are emerging.

PhD student Jeff Shellberg is also finalising fieldwork this year. Jeff and Natalie have been the first TRaCK researchers to undergo cross-cultural awareness training with the Mitchell River Traditional Custodian Advisory Group. They have also had traditional custodians take part in their field activities.

The food-webs projects had two successful wet-season field trips in early March to the Flinders and Mitchell, and the last dry-season trip near Kowanyama. Ian Halliday has one remaining field trip to Kowanyama in 2010 for his work on how flow affects estuarine fish.

Marcus Finn and Sue Jackson began new research in the Mitchell delta at the beginning of 2010. This work is an extension of their research into Indigenous values and river flows and is funded by the CSIRO Water for a Healthy Country Flagship. Their work will continue beyond 2010.

Reporting is being planned in consultation with regional stakeholders.

Photo: Stephen Hamilton

Measuring the fat content of a gizzard shad during the wet season, from left: Traditional Owner of Wallaby Island Anzac Frank Yir Yoront, Tim Jardine and Traditional Owner of Wanyaw Pocket, Surprise Creek, Raven Greenwool Kin Kopol.

Daly River update

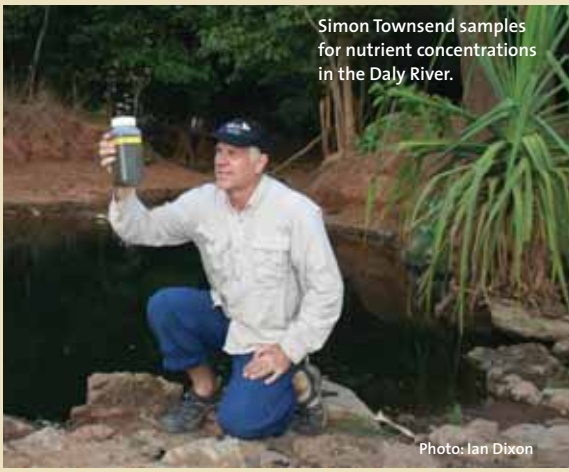
Many projects working in the Daly River catchment will complete their field activity during the 2010 dry season.

The team from Charles Darwin University have completed their fieldwork associated with testing the Framework for the Assessment of River and Wetland Health. The bedload transport project team have also completed fieldwork after measuring sediment movement at five sites on six occasions during the 2007–08 and 2008–09 wet seasons. They are now analysing the results.

During three wet-season field trips, the food-webs team collected algae, aquatic and terrestrial bugs, and stable isotope samples to determine seasonal peaks in movement, abundance and biomass of food-web components in permanent and temporary streams. This brings to an end the 15-month sampling program.

Water quality in the Daly River and some of the smaller streams that feed into it was also sampled intensively over the wet season so that researchers can investigate the contribution of tributaries to the productivity of the main channel.

In our social and cultural research, a number of Aboriginal people have been trained in collecting river-change stories and they expect to have gathered all their material by October. The economic survey of wild-resource use in the communities of Nauiyu and Pine Creek reached 75 per cent complete in March with the sixth of eight rounds of household surveys completed.



Simon Townsend samples for nutrient concentrations in the Daly River.

Photo: Ian Dixon

TRaCK researchers presented some of the results to the Daly River Management Advisory Committee at their February meeting in Darwin to illustrate how the research can be used to support the development of the Oolloo Water Management Plan.

Continued from page 4

Measuring river health according to Indigenous values

A year-long monitoring trial coordinated by Dr Jackson's colleague Dr Marcus Finn began in October 2009. The trial aims to identify some Indigenous indicators of healthy river country which can be used in monitoring programs.

Dr Finn has recruited four groups of local rangers to trial some conventional scientific and alternative monitoring tools along the Daly and Fitzroy river catchments.

The Wagiman and Malak Malak rangers are working along the Daly River while the Gooniyandi and Parkul/Bidijul rangers are studying the Fitzroy River catchment. Their goal is to see whether the information they collect is useful in measuring river health according to Indigenous values.

The four groups are monitoring sites that they identified as being significant to their local communities. The sites were chosen because they are good fishing spots, popular swimming holes, sites of spiritual significance or important sources of fresh water.

As part of the process of identifying sites, community members and local rangers identified some of the threats to these important sites and explored indicators to monitor the impact of these threats on the water resource.

'Water flow, weeds, erosion caused by cattle or feral animals, and overlapping river use by recreational and Indigenous fishers were identified as threats to the water resource', Dr Finn says.

So far, two monitoring tools chosen to record the impact of these threats have been tested—photographic records and plant surveys.

'Photographs provide information on a number of important river health values, including water levels, riparian vegetation such as the level of weed infestation or vegetation change, and riverbank erosion from cattle', says Dr Finn.

Surveys of sample strips of the riverbank are also being used to record the distribution of riparian vegetation and riverbank damage by stock and feral animals.

Dr Finn says it is likely that some conventional scientific indicators could also be used to monitor Indigenous values.

'Scientific indicators like pH and hardness may be able to measure and represent the quality of water at a site that is known by a community to have "nice sweet" water that makes a good cup of tea at certain times of the year', says Dr Finn.

'So, some of the values people place on water can be effectively represented and measured with scientific indicators, while others will be more difficult.'

Dr Finn says the Indigenous communities involved in the research were enthusiastic about learning ways to more effectively monitor their resources.

'Indigenous people can sometimes be bemused by western culture's separation of land and water management because they often view the land and water as a connected whole', he says.

'Combining traditional knowledge with information about river flows, and the value of plants and animals will help water managers make better decisions about looking after water catchments in the future.'

Fact sheets

The following fact sheets are available on the TRaCK website: www.track.gov.au

Scenario evaluation fact sheets
1: River futures in Australia's tropical north
2: Building better Indigenous participation
3: Collaborative water planning
4: Integrating knowledge to support adaptive management

Assets and values fact sheets
1: The economic value of rivers
2: Indigenous values and river flows

River and coastal settings fact sheets
1: People and the economy
2: Classifying river landscapes
3: Sorting Australian rivers by ecology and flow

Material budgets fact sheets
1: Sediment and waterholes
2: Sediment and nutrient loads
3: Nutrients in rivers
4: Water budgets
5: Water quality monitoring

Food webs and biodiversity fact sheets
1: River food webs
2: Waterhole food webs
3: Floodplain food webs
4: Healthy estuaries
5: Flows and ecological assets
6: Estuarine fish
7: Environmental flow tools
8: Diversity of river life
9: Northern Australia aquatic ecological assets

Sustainable enterprises fact sheets
1: Water markets
2: Indigenous rights in water
3: Sustainable economies: Arnhem Land case study

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About TRaCK

TRaCK was established in 2007 as a research hub under the Commonwealth Environment Research Facilities Program to provide the science and knowledge that governments, communities and industries need for the sustainable use and management of Australia's tropical rivers and estuaries.

The research consortium is led by Charles Darwin University, CSIRO, Griffith University, the North Australia Indigenous Land and Sea Management Alliance and the University of Western Australia.

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