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On TRaCK

Tropical Rivers and Coastal Knowledge

One size does not fit all in the remote north

By Jenni Metcalfe

A child living in the Gilbert River catchment, a remote area south-west of Cairns in Queensland, is likely to speak only English among their small family.

The family earns $900 a week from grazing cattle on natural pastures. They own a car and have internet access. The child will attend school for at least 10 years.

Another child living in the equally remote Goyder River catchment east of Darwin in the Northern Territory is likely to have a very different experience. They are part of a large Aboriginal family whose members speak their own Indigenous language in their rented home where they have lived for at least five years. This family earns less than $600 a week, does not own a car and does not have internet access. This child will attend school for just a few years.

TRaCK has been researching the social, demographic and economic make-up of 60 catchments across northern Australia. Together, tropical river catchments make up about a quarter of Australia's land, but only two per cent of the population live there and residents are widely dispersed with the exception of Broome in Western Australia, areas in and around Darwin in the NT, and Mount Isa in Queensland.

Despite the remoteness, TRaCK has found considerable social and economic differences both between and within catchments in the north. These findings add to the knowledge that water planners need to make decisions.

'TRaCK has proven that knowledge gained through robust science can have an immediate influence on water management and planning', says says Chair and Chief Executive Officer of the National Water Commission Ken Matthews. 'As the impacts of climate change hit home in southern Australia, important socioeconomic analysis like this, combined with ecological and hydrological evidence, will inform development options for northern Australia.'

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The Darwin, Daly, Goyder and Gilbert catchments

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Dr Danielle Warfe collects samples in the Edith River near Katherine.

Photo: Jenni Metcalfe

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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

Associate Professor Michael Douglas
TRaCK Research Director

Welcome to the third issue of *On TRaCK*.

The north's potential as a food bowl for the nation is currently under debate. This debate needs to be underpinned by good information that allows people to make informed decisions about the benefits and trade-offs of future development in the north. Through TRaCK, we are finding out why people value tropical rivers. We are improving our understanding of the physical, biological and Indigenous cultural processes that sustain the rivers. We are examining economic opportunities for Indigenous people in developing the rivers. And we are bringing this knowledge together in ways that will help water managers make informed decisions.

Two of the research projects featured in this issue of *On TRaCK* explore the socioeconomic characteristics of our tropical river catchments. While most people appreciate the great diversity of river systems across the north in terms of river size and patterns of flow, we can now compare these catchments in terms of the make-up of catchment communities. For the first time, we can also consider the economic value that Australians put on the ecosystem services provided by tropical rivers.

Other stories in this issue describe new insights we have gained into how our tropical river systems work: how floodplains are major sources of sediments, not just sediment sinks; where nutrients in the rivers come from and how critical the balance of nutrients is to aquatic plants and animals; and how different populations of the same species of fish, such as Mouth Almighty, have evolved differently and adapted to local conditions.

Through this research, we are providing new ways of looking at our northern rivers, the services they provide and the communities they support, which is vital information for evaluating future options for the region.

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Characterising catchments

The TRaCK researchers characterised each catchment according to:

- population characteristics such as age, the percentage of people that have moved in the last five years and the percentage of Aboriginal people living in the catchment
- economic factors such as the type of employment and amount of income
- infrastructure and housing, such as the number of schools and the percentage of homes with internet access
- social factors such as educational levels and the number of people volunteering in community organisations
- the local environment, culture and land use, such as the number of listed heritage sites

The researchers then sought to find out what was different, and similar, about the characteristics of catchments. TRaCK researcher Silva Larson from CSIRO says there were some overall social and economic features of the north which appeared distinctive.

'For example, the percentage of people speaking Indigenous languages at home, rather than English, is relatively high. Only 42 per cent of homes have an internet connection, and government is the largest employer', she says.

'The region is the most remote in Australia, with limited basic infrastructure. Transport infrastructure is just a weak network of all-weather sealed roads and there are few all-weather airports and very few ports.'

Table 1 compares the Goyder and Gilbert catchments, which the children referenced above belong to, with catchments where the population is increasing—the Daly River catchment in the Northern Territory and the urban catchment around Darwin. We can see that children from the four catchments are likely to have very different experiences.

Comparing catchments

Having categories of similar catchments means river managers can better target and manage development opportunities.

'This avoids the one-size-fits-all approach to development and management, but requires less effort than in targeting each individual catchment', says Larson.

Despite not having all the data they would have liked, the researchers identified eight distinct categories of catchment.

They found, for example, that the child from the more affluent Gilbert River catchment would experience similar social and economic conditions as children from Settlement Creek, Staaten, Keep, Holroyd and Norman River catchments. This group of catchments has high levels of employment in agriculture, a relatively mobile population, and the mainly non-Indigenous population are likely to own their homes and cars and have internet access.

Catchment	Population	Economic	Infrastructure / housing	Social	Environment / land use
Goyder River	600–700 people 92% Aboriginal 0.1 people per km²	15% employed by government or services Median family income / week - $592	40% own car 20% internet access 0% own home	38% speak only English at home 20% have >10 years of school Average household size – 5.8	All land in natural condition and under traditional Indigenous use
Gilbert River	800–1000 people 1.6% Aboriginal 0.02 people per km²	25% employed by grazing the land Median family income / week - $910	100% own car 22% internet access 20% own home	96% speak only English at home 60% have >10 years of school Average household size – 2.8	All land use is grazing (agricultural production)
Daly River	10,000 people 27% Aboriginal 0.2 people per km²	35% employed by government or services Median family income / week - $900	>80% own car >60% internet access 25% own home	80% speak only English at home 60% have >10 years of school Average household size – 2.9	60% under grazing, some dryland and irrigated agriculture 30% traditional Indigenous use
Darwin (Finniss, Elizabeth and Howard rivers)	110,000 people 8.8% Aboriginal 12 people per km²	30% employed by government or services Median family income / week - $1,300	95% own car 79% internet access 40% own home	80% speak only English at home 78% have >10 years of school Average household size – 2.4	Urban environment

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However, the child from the less affluent Goyder River catchment is typical of children from the Fitzmaurice, Goomadeer, Koolatong, Liverpool, Moyle, Blyth and Walker catchments. In these catchments, there is a high proportion of Aboriginal people who are less mobile, and have lower incomes and lower rates of employment. People in these catchments are less likely to attend school, own a car or have internet access.

Addressing the disparity

It is this disparity between many catchment communities that concerns the TRaCK project team, given the push to further develop northern Australia.

'There is a very small group of "haves" and a much larger group of "have not" communities', says Andrew Taylor, a TRaCK researcher from Charles Darwin University. 'And much of the development in the north depends on "fly in, fly out" workers with expertise and resources imported from southern Australia.'

Australia's tropical rivers are central to what the north has to offer to the rest of Australia for economic development and water resources. But TRaCK researchers believe that people interested in improving the lot of the 'have nots' need to take a fresh look at what development means.

Dr Natalie Stoeckl from James Cook University who is leading the TRaCK project believes it is simply not financially viable to undertake the scale of investment that would be needed to make remote areas less remote.

'The alternative is to stop seeing remoteness as a problem that needs to be solved through large-scale development and population growth. Rather, remoteness constrains what is feasible and desirable development, but also offers lifestyle and cultural opportunities that are unique', she says.

Dr Stoeckl and her team pose three possible solutions for developing the remote and disadvantaged communities of the north.

The first is to support the communities to participate in regional development, giving people the opportunity to find jobs within new and existing enterprises.

'This may require new training schemes, new approaches to education, and more flexible human resource management systems that work with, rather than fight against, cultural differences', says Dr Stoeckl.

'Local communities also need to be given the opportunity to become an integral part of the supply chain of new and existing enterprises. This too may require training, education, and flexible purchasing systems.'

Andrew Taylor believes the second solution is to support development that is appropriate in remote areas where infrastructure is limited.

'This means avoiding pie-in-the-sky developments in favour of locally directed small-scale projects, such as providing fresh local produce or carbon trading opportunities', he says.

The third solution proposed is a more radical rethink of 'development', looking at the cultural and social wellbeing of local communities rather than just at financial wealth.

In the future, the child from the Goyder River catchment may grow up and choose their career from a range of options while still maintaining their culture. Perhaps they will teach others about their local environment by accessing new internet-based resources that showcase the activities of Indigenous ranger groups.

For a full report on the socioeconomic characteristics of northern Australia and short profiles on each catchment, visit: **www.track.gov.au/research-projects/301**

Ngan'gi seasonal knowledge immortalised

Ngan'gi language speakers know that when *yerrwire* (Darwin woollybutt) starts flowering, *akerre* (the native honey bee) will be attracted to its flowers and soon you will find *yerrwire*-flavoured *fungguli* (native honey) in tree hollows, old ant nests and ground hives—if you know where to look! Now this seasonal knowledge has been immortalised in the Ngan'gi Seasons calendar.

Eight Ngan'gi-speaking women from Nauiyu Nambiyu on the Daly River worked with TRaCK researcher Emma Woodward from CSIRO to document the interconnections between weather and bush resources which tell the story of the Ngan'gi seasons.

After ten months of work the calendar was launched at the Merrepen Arts Festival in May.

'Ecological knowledge contributor and Nauiyu resident Patricia Marrfurra McTaggart was keen to have this information documented before it was lost', explains Emma. 'Patricia and the other contributors are really pleased with the calendar and hope it can be used to educate local children about the Ngan'gi names for the plants and animals that they eat and see around them every season.'

For more information visit: **http://www.track.gov.au/publications/registry/429**

Ngan'gi Seasons calendar, Nauiyu – Daly River

Giant gullies threaten the Gulf of Carpentaria

By Melanie McKenzie

Kilometre-wide erosion gullies eating their way across thousands of hectares of Australia's northern landscape are proving likely culprits as the main source of the sediments that are flushed into the Gulf of Carpentaria each year.

Alluvial gully erosion typical of the land around the Mitchell River

Photos: Melanie McKenzie

The Mitchell River meets the Gulf of Carpentaria

These sediments could affect fisheries in the Gulf by smothering the prawn, crab and barramundi breeding and rearing habitats of the coast and estuaries. The gullies also mean landowners and managers are losing valuable land.

The Mitchell River in Far North Queensland deposits more sediment into the Gulf than any other river, but TRaCK researchers are not sure how much it is increasing by or what impact an increased sediment load will have on the Gulf.

Fishermen report that during the wet season the Gulf is full of sediment-laden freshwater plumes five kilometres or more out to sea.

The currents around the Gulf move in a clockwise direction, and the sediment that is carried into the Gulf by the Mitchell River moves southward down the coast toward the big seagrass beds on the southern and western sides of the Gulf. There is a danger that the seagrass feeding grounds of dugongs and turtles could be swamped by this sediment.

Different rules for gullies in the north

'An increase in sediment from the Mitchell is likely to affect the whole Gulf', says TRaCK researcher Dr Andrew Brooks from Griffith University.

This is why TRaCK researchers are trying to understand more about how the erosion starts, where the sediment comes from and how best to manage it. They have already found that the rules that apply to gullies in southern parts of Australia do not apply to gullies in northern Australia.

'We used to assume that sediment sources in tropical rivers were dominated by erosion from nearby hills—a type of erosion we know a lot about', says Dr Brooks. 'But from this TRaCK research we have found that heavy rain and flooding erodes the sediment within the floodplains themselves, creating "alluvial" gullies.

'Under the old model it was assumed floodplains were sediment sinks, or depositional areas, but now we know they are also major sources of sediment.'

This means that the current models used to predict where gullies might start, how much sediment they produce, and where the sediment ends up do not work for northern Australia.

'This is a problem for making decisions about how best to manage the impacts of sediment from a river flowing into the sea', says Dr Brooks. 'These findings could also have significant implications for managing sedimentation in the Great Barrier Reef, given that alluvial gullies have also been identified in the catchments flowing into the Reef area.'

Where is the sediment coming from?

TRaCK researcher Dr Gary Caitcheon from CSIRO is investigating whether sediment washed into the river through erosion comes from the surface or subsurface soils of nearby alluvial gullies or river banks. To do this, he looks for traces of Caesium-137 in the sediment, a product of nuclear weapons testing in the 1950–60s which was deposited on surface soils all over the planet.

'We get a "fingerprint" that can tell the difference between sediment from surface and subsurface sources', says Dr Caitcheon whose team has also been looking closely at the Daly River in the Northern Territory.

'It looks like more than 90 per cent of the sediment in both the Daly and Mitchell rivers comes from the subsurface soils', he says. This is the opposite of what might be expected if hillslope erosion was the dominant sediment source, as was previously assumed.

Dr Caitcheon says it is hard to tell whether the subsurface soils eroding into the rivers come from the adjacent river banks or are washed down from nearby alluvial gullies.

Alluvial gullies tend to be found in tropical environments where there is a lot of rain and high weathering rates, but the researchers are finding that climate is not the only driver of erosion. When they compare erosion in the two tropical environments of the Daly and Mitchell rivers, they are seeing a different pattern of results.

'We don't see nearly the same extent of alluvial gullies in the Daly—there aren't as many, and they are not as big', says Dr Brooks. 'Instead we think the dominant sediment source in the Daly is from riverbank erosion rather than nearby alluvial gully erosion.'

Remote sensing has shown that the channel of the Daly River is expanding and is causing the riverbanks to slump. Other TRaCK research in the Daly is looking at whether floods in the Daly have got bigger over the last 30 years due to increased rainfall in the area.

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Dr Andrew Brooks at the Mitchell River in the 2009 dry season

Photo: Melanie McKenzie

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'That's not to say that gully erosion isn't happening too—there is more work to be done to tease out bank versus gully erosion', says Dr Brooks.

'We're looking at all sources of erosion, but it looks like gully erosion is the dominant process in the Mitchell River. We think it's likely caused by land use instead of climate—partly because we don't see the same kind of flood changes in the Mitchell as we do in the Daly over the last 30 years, but also because geomorphic changes started much earlier in the Mitchell.'

The arrival of cattle in the Mitchell catchment in the 1880s appears to coincide with the start of a major phase of alluvial gully erosion, according to TRaCK researcher Jeff Shellberg, a PhD student at Griffith University.

Given the high level of grazing in the area, he hopes to determine whether it is possible to prevent gullies from starting, and, in particular, to slow them down once started.

The changing Mitchell delta

A new research question that the researchers are also pursuing is the relationship between increased sediments in the Mitchell River and recent changes to the river's delta.

'The northern side of the south Mitchell mouth has changed a lot in recent decades and is building out into the Gulf, whereas the southern side has eroded a lot', says Dr Brooks.

The shoreline erosion of the southern side is a concern for Kowanyama, with the ongoing loss of burial sites and other archaeological sites of significant cultural heritage.

Dr Brooks and his team have been building a relationship with the Kowanyama community since the beginning of TRaCK's research in the area.

'The people at the Kowanyama Lands Office have been helping us with our research by showing us around erosion sites and helping us get oriented to the area', says Shellberg. 'The Traditional Owners of the land often come out with us and make sure that we're not impacting any cultural sites.'

Anzac Frank and Phillip Mango, rangers from the Kowanyama Aboriginal Land and Natural Resources Management Office, helped the research team install a rain gauge, a time-lapse camera and a stage recorder that measures how high the Mitchell River gets. This helps the researchers keep an eye on how gullies are formed and how much they grow over time.

'The time-lapse pictures are great because we get to see what the flooding looks like in the Mitchell during the wet season', says Jeff Shellberg. 'The rangers' knowledge about the geography, waterholes and other water bodies in the area is invaluable.'

Kowanyama rangers are collecting river samples and measuring turbidity in nearby Magnificent Creek, downstream from the Mitchell River. This data is useful to the researchers because they can compare it with measurements taken upstream, and the rangers are getting training and experience in data capture and water quality monitoring.

Viv Sinnamon, Manager of the Kowanyama Aboriginal Land and Natural Resource Office ('the Lands Office') says that the relationship they have with the TRaCK research team is a mutually beneficial partnership.

'The work TRaCK is doing is very valuable to the north,' he says. 'Kowanyama is particularly worried about making sure that appropriate development projects recognise that a large slice of the north is Aboriginal land and waters.'

Kowanyama, 'the place of many waters', is under increasing pressure from outside interests, including mining.

'We see the research as informing the assessment of developments such as mineral exploration proposals for the Mitchell River delta in areas that are regularly inundated with water during the monsoon season', says Mr Sinnamon.

TRaCK's survey of the Kowanyama area includes satellite imagery, remote sensing and aerial photographs, which are being shared with the Lands Office.

Dr Brooks and his team have been using historical aerial photographs of the coast (some going back to 1943), the Kowanyama community and the wetlands to find out how much the area has been changing—information that Viv Sinnamon says is also useful for the Lands Office programs.

'Kowanyama maintains that the right combination of local and traditional ecological knowledge with western sciences from around the world is a powerful combination for making informed decisions. Some of the TRaCK scientists are members of the Wetlands Program Technical Advisory Group formed by Kowanyama this year', Mr Sinnamon says.

'As an Aboriginal land management agency, we are looking for partnerships like the ones we have with TRaCK that recognise and respect the need for the people of Kowanyama to develop their own programs to manage their own country.'

Pig-nosed turtle

Photo: Carla Eisemberg

Threatened pig-nosed turtle depends on nutrient cycles in northern rivers

by Tom Dixon

The Daly River in the Northern Territory is one of only two breeding grounds of the highly-specialised pig-nosed turtle.

Considered to be one of the best adapted aquatic turtles in the world, the turtle is on the IUCN Red List of Threatened Species. It feeds on aquatic insects and plants such as eel weed, which thrive in the Daly River.

Eel weed is just one of a number of plants in the Daly under potential threat from pressures such as diversion of water for agricultural irrigation, and increased nutrient load from agricultural run-off. These plants have evolved to grow with low nutrient inputs but, with an increase in farming around the Daly River, nutrient levels are expected to rise.

During the wet-season flooding, nutrients equivalent to 350 ten-tonne truck-loads and sediments weighing as much as 1500 Airbus A380s are washed into the Daly. While these are large quantities, it does not take much to upset the nutrient balance. Even a small rise in levels can increase algal growth in the dry season, and limit the amount of light and the available area which plants need to grow.

Before TRaCK's current study, very little was known about where these nutrients came from, where they went, and how they became food for fish and land animals.

'If we change the flows of rivers such as the Daly to irrigate crops, or we increase nutrient levels from agricultural run-off, we don't know what the effects on the plant and animal life will be', says TRaCK researcher Dr Barbara Robson from CSIRO.

Modelling nutrient and sediment flow

To understand the effects of changes to nutrient levels, TRaCK researchers are building a 'nutrient picture' of all northern rivers. Because not all rivers are like the Daly, which is relatively clear and flows all year round, they are also examining a contrasting river system—the Flinders River system in Queensland. The Flinders River carries more sediment and shrinks back to a series of isolated waterholes in the dry season.

By sampling and recording data for water quality, algal growth, insect feeding and fish numbers, the researchers are able to build computer models that give water planners a better understanding of how nutrients move through the two waterways.

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'Models of the nutrient and sediment flow are invaluable for ongoing monitoring of the northern rivers', says Ian Lancaster, Director of Water Resources in the Northern Territory's Department of Natural Resources, Environment, the Arts and Sport (NRETAS). 'Their primary use is to allow us to evaluate the impacts of the current low levels of development in the area, and predict what will happen with any new developments, such as increased tourism or more inputs from agriculture.'

Dr Robson's team is looking at how water flow and nutrients in the water control plant and algal growth, and how this growth changes in relation to changing flow.

'Whenever there's a change in land use near a river—either through diverting water away for irrigation, or switching from bush to grazing—the nutrient composition changes', says Dr Robson. 'And with this, the plants in the system change, affecting the quality and type of food available for animals such as the pig-nosed turtle and fish such as the rainbowfish and the sooty grunter.'

Ian Lancaster is keen to understand how land-use changes may affect the Daly River. 'The northern rivers are susceptible to even small changes in nutrient composition, especially in the dry season. Water planners and local users need to be able to predict what changing inputs will mean for the plants and animals in the rivers. We need to find acceptable, allowable levels of nutrients from human discharge, such as from farming and urbanisation of areas around the Daly', he says.

The contrasting environments of the tropics make predicting the movement of nutrients even more complex, and results from one river cannot be directly transferred to the other.

While the Daly River flows year round, animals and plants in the Flinders River system rely on waterholes to get them through the dry season. Flooding in the wet season 'resets' the system, flushing excess nutrients and decayed material into the ocean. **These seasonal cycles in the Flinders are critical to maintaining the nutrient balance that allows animals such as turtles to survive.**

Grazing versus nutrients

Grazing may have a large effect on the composition of aquatic plants and algae—not cattle this time, but fish and turtles. Associate Professor Michele Burford and student Stephen Faggoter from Griffith University are comparing the effects of nutrients on plant and algal growth with the effects of fish and other animals grazing in five waterholes in the Flinders River system. To establish the impact of grazing, they are using cages to exclude fish and turtles from parts of one of the waterholes.

'By establishing whether plants and algae grow more due to an increase of nutrients, or because of less grazing from fish and turtles, we can reveal clues as to how resilient the ecosystem will be against changes in the water availability—for example, if large volumes are diverted for irrigation', says Assoc. Prof. Burford.

Photo: NRETAS

Eel weed has evolved to grow with low levels of nutrients.

Insects carry nutrients into the larger food web

Nutrients that enter the river do not always stay in the river. Dr Erica Garcia from Charles Darwin University is investigating insects that start life as larvae feeding in the rivers and waterholes. These insects transfer nutrients to land-based systems when they emerge as adults and move onto the land.

'Aquatic insects are thought to stay quite close to the rivers from which they emerge', says Dr Garcia. 'But there is evidence to suggest that some insects are found up to 120 metres away from the river. So they may be more important than we thought as a food source for the surrounding birds, bats and lizards.

'The further from the river bank you get, the less aquatic insects are found. But not much has been done in the tropics looking at this, especially not in the wet season. We need to find out if more insects emerge in the wet season, and also what species are around. We simply don't know how important the wet season is for the insects around here.'

The future

With water becoming an increasingly valuable commodity, gaining knowledge about the pressures exerted on aquatic ecosystems is important to their survival. The north of Australia experiences heavy rainfall during the wet season, and its unique ecology depends on water reserves to survive the dry months.

'Large-scale diversion of water from the northern rivers to the southern states is highly unlikely in the short term', says Ian Lancaster. 'But, by understanding the underlying biology of the area, we can begin to understand the effects of diverting large volumes of water away from the systems should the need ever arise.

'We can use this understanding to ensure that our northern rivers remain productive, and that animals such as the pig-nosed turtle can live here into the future.'

Biodiversity—you've got to know where it is to manage it

By Mary O'Callaghan

Photo: Michael Hammer

Five genetically divergent lineages of Mouth Almighty have been found in the north, one of which appears to be restricted to Queensland's Tully River.

When five identical-looking Mouth Almighty fish are each found to be genetically different, you know you cannot rely on physical traits alone to assess biodiversity. Clearly, what you see is not always what you get.

Some populations of freshwater fish and shrimp species in northern Australia have evolved in ways that are only apparent by looking closely at their genetic makeup.

The key to this genetic diversity is the complete isolation of a river from other rivers for millions of years—a situation to which water grids and pipelines which connect catchments pose a huge risk.

What genetic analysis can tell us

Populations that have been isolated over millions of years gradually accumulate genetic differences. Eventually they can become so genetically different from one another that they become what scientists call 'genetically divergent lineages'. Representing millions of years of independent evolution, these genetic lineages are a significant component of biodiversity. In some cases, they can turn out to be previously unknown species.

'If we know where these genetic lineages are, we can help protect them by selecting appropriate management regimes', explains Dr Mark Kennard, a fish ecologist from Griffith University who is working to identify areas of high conservation value in the north.

'Grids and pipelines are not the only human threats to endemic species. There might be threats from agricultural development, such as pesticides in farm run-off. If we can't take the development somewhere else, we can at least mitigate the risk if we know the area has a high number of endemic species.'

TRaCK researcher Dr Ben Cook from Griffith University has been using genetic analysis over the past two years. **'The aim of our project is to find areas that need to be managed as separate units', says Dr Cook. 'If we don't know where the biodiversity is, we can't manage it.**

'It's important that animals are not moved between these units because it poses risks of hybridisation and potentially extinction. Hybridisation can cause animals to lose some of the adaptive traits that they have evolved to survive under local conditions.

'Genetic analysis can tell us about patterns of biodiversity, as well as what evolutionary processes were involved in the formation of current biodiversity patterns. Knowing how biodiversity has evolved could help us know how it will evolve in the future.'

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Genetic changes in our tropical rivers

Working with Griffith University's Professor Jane Hughes, Dr Cook is using genetic tools to assess freshwater biodiversity throughout the rivers of northern Australia. Interesting patterns of genetic diversity have been found in the Kimberley, the Top End and eastern Cape York Peninsula.

'We've found divergent lineages in some species, especially in the Kimberley and the Top End, and distinct populations in other species throughout northern Australia.'

So far, highly divergent genetic lineages have been found in Hyrtl's catfish *(Neosilurus hyrtlii),* Mouth Almighty *(Glossamia aprion)* and the *Caridina* shrimp. 'This possibly means greater species diversity in these animals than we previously appreciated', explains Dr Cook.

Other species, such as spotted blue-eye, pennyfish and MacCulloch's rainbowfish, were also found to have genetic differences among some populations, although the differences are much smaller. 'This is because their populations have not been isolated for as long, perhaps only hundreds of thousands of years, rather than millions of years. Time is the factor here', explains Dr Cook.

Of the five different genetic lineages of Mouth Almighty found by the team, one appears to be restricted to Queensland's Tully River. 'This is an interesting result because two species of crayfish, one shrimp, and genetic lineages in a few other freshwater fish are also restricted to the Tully River. This means that the Tully River is a real hotspot for freshwater biodiversity.'

Mouth Almighty is a mouth brooder—the female lays eggs, the male picks them up and incubates them in his mouth. When the fingerlings can swim and forage, they move away. **So, unlike some other fish whose eggs can get washed downstream, Mouth Almighty does not stray far from its place of birth. As a result, individuals do not interbreed with individuals from other rivers and the chances of local genetic adaptations are higher.**

Working closely with the Uunguu and Dambimangari rangers, Balangarra Traditional Owners and project staff from the Kimberley Land Council Land and Sea Management Unit, Dr Cook and his team carried out extensive sampling in river systems in the North Kimberley. On the basis of this work and the samples provided by the Wungurr rangers, Dr Cook has identified two lineages of Mouth Almighty in the Kimberley, one in the east and one in the west. 'This highlights the extreme isolation of rivers in the Kimberley, many of which have been isolated from one another for very long periods of time.'

Some species, such as the Hyrtl's catfish, were chosen for analysis because they are an important household food source for many Aboriginal people. 'They're not that hard to catch when they're migrating in big numbers at the beginning of the wet', explains Dr Brad Pusey from Griffith University. 'They can get caught up behind waterfalls. And at the end of the wet they are quite fatty.'

Local Uunguu rangers helped researchers collect samples in the Kimberley. Left to right: Dr Ben Cook, ranger Sylvester Mangolamara, Dr James Fawcett (Queensland Government), ranger Raphael Karadada and Griffith University PhD student Kate Masci

The team also selected species with different traits; for example, early breeders and late breeders, mouth brooders, species that lay eggs in nests and those that broadcast their eggs. 'It's interesting to compare genetics of species with different traits when you are trying to link landscape processes with traits, to find out what factors are important in shaping biodiversity', says Dr Cook.

Historically the landscape has shaped biodiversity

Across the north, genetic differences in some freshwater species appear to be lower in rivers that flow into the Gulf of Carpentaria. According to Dr Cook, this is possibly due to fluctuating sea levels over the last 200,000 years. When sea levels dropped, the Gulf became a lake, changing through time from brackish to totally fresh water. The last time this happened was around 10–14,000 years ago when Australia and Papua New Guinea were joined by an exposed land bridge.

Lake Carpentaria, which was smaller than the Gulf today, but still very large, came and went with the glacial cycles. Several rivers from northern Australia and Papua New Guinea flowed across the land bridge into the lake, and many freshwater animals were able to move between rivers via the lake and breed with individuals from other rivers, thereby mixing their genes. This also explains why some freshwater species, such as cherabin (long-armed river prawns) and black catfish, are found in both northern Australia and southern Papua New Guinea.

In contrast, many rivers in the Kimberley and western Northern Territory flowed through deep gorges and, so, did not connect when sea levels dropped during glacial phases. 'This long-term isolation of rivers is probably why there are multiple genetic lineages of Mouth Almighty and other species in different parts of the Kimberley and Northern Territory', says Dr Cook.

What can happen to biodiversity when two rivers meet?

For rivers like those in the Kimberley and other parts of northern Australia, which have been isolated for a long time, what might the consequences be of transferring water between catchments?

Photo: Dave Wilson

Considerable genetic differences have been found among populations of spotted blue-eye.

'When you move water, you're also likely to be moving freshwater animals. Moving water between rivers containing different genetic lineages can have negative consequences for biodiversity, with extinction of the resident lineage being a possibility', says Dr Cook.

He cites an experiment with two glass shrimp lineages in south-east Queensland about 15 years ago. Over the course of seven generations, all males of both lineages bred with the females of only one lineage, the other becoming extinct.

'Hybridisation is the main concern. When you put two lineages together, you start losing local adaptations.'

Informing water resource planning

Dr Jon Marshall is a Queensland Government scientist who advises water planners about how to use this kind of information to inform water resource planning.

'To manage the viability of a population of aquatic organisms, the first thing we need to understand is the genetic structure of the population', says Dr Marshall.

'For example, we might have a species that readily disperses between catchments; so degradation in one catchment might be compensated for in the other. **But if a population is unique to one catchment, we need to make sure that decisions made protect that population—that's the unit we're trying to protect in managing flows.**

'When you're moving water, there's a possibility that animals will be moved with it. Ben's research will be important for working out how big a risk the movement of water is for the population.

'Our water resource planning for the Wet Tropics is in its early stages so this research will feed directly into decisions about the way water is allocated and balanced between human use and the environment.'

Valuing our rivers in dollars and cents

By Amanda Hodgson

Twin Sisters Billabong in the Wildman River region, south-east of Darwin Photo: Ian Lancaster

Defining the monetary value of our river systems in terms of their contribution to agriculture, pastoralism and tourism is easy. But how do you put a dollar value on shady camping areas, great fishing spots, beautiful landscapes or places of cultural significance?

How do you compare the value of river systems in providing irrigation water for crops with that of providing habitat for wildlife or regulating the local climate? This is a challenging question that governments face when they are deciding how to manage our use of river systems.

Our river systems sustain us and our environment. They provide us with opportunities for recreation and they are important for our spiritual wellbeing. We can define all of these contributions to our quality of life as 'ecosystem services'.

For people living in northern Australia's catchments, the rivers are an integral part of their daily lives. Indeed, for all Australians, there is a seemingly endless list of the ways in which rivers contribute to our survival and wellbeing. But because defining the true value of our rivers is difficult, the benefits that have an economic value often get priority by default.

'Often when governments are making decisions about which development pathway to follow, they're looking at costs and benefits of alternatives', says Dr Anna Straton, a TRaCK researcher from CSIRO. 'Those things that can be expressed in dollar values are easy to incorporate in that framework but often the benefits and costs that aren't easily valued are left out of these decisions. For many ecosystem services it's more about the fact that they exist and contribute to human wellbeing than that they have a value within the market system,'

Ian Lancaster, Director of Water Resources in the Northern Territory's Department of Natural Resources, Environment, The Arts and Sport (NRETAS), wants to know the value of ***all*** ecosystem services. 'Putting a dollar value on river systems is of great benefit to planners in our department to guide the development of our water allocation plans. It provides a basis for us to give high priority to protecting ecology and the environment', he says.

How much are we willing to pay?

So how much do Australians value the ecosystem services provided by our tropical rivers? Which services do we value the most? Dr Straton designed a questionnaire that asked a sample of Australians how much they were willing to pay for ecosystem services, focusing on the Fitzroy, Daly and Mitchell River systems as case studies.

'We gave people a hypothetical scenario', she explains. 'If you were in a supermarket and there were different versions of the Fitzroy, Daly and Mitchell river systems on the shelves and each came at a different price, which one would you go for?'.

The hypothetical 'versions' of the river systems provided four ecosystem services:

- floodplain habitat
- an environment for recreational fishing
- species and species habitat important to Indigenous customary activity at waterholes
- production from irrigated agriculture

For each ecosystem service, people were asked whether they would be prepared to pay to have it preserved in the best condition, in fair condition or not at all.

Dr Straton sent almost 3000 questionnaires to randomly chosen households in the Fitzroy, Daly and Mitchell River catchments, and to households in Perth, Darwin, Brisbane, Melbourne, Sydney and Canberra. Indigenous people living in the catchments were interviewed in person.

'We wanted a wide range of opinions because we know the use of Australia's northern rivers is a national issue, particularly with the increasing awareness of water use,' she says. 'These are nationally and internationally significant questions.'

Interestingly, most of the people who responded, including city people, placed the highest monetary value on preserving, in the best possible condition, waterholes important to Indigenous people. The message here, according to Dr Straton, is that whether they were Indigenous or non-Indigenous, whether they lived in the catchment areas or thousands of kilometres away in the city, people were prepared to pay the most amount of money for maintaining waterholes of cultural significance to the highest level.

People were also prepared to pay for preserving high quality floodplain habitat and keeping the rivers in the best condition for recreational fishing. However, if they had to pay for rivers to be in a condition to support irrigated agriculture, they were only prepared to pay for them to be kept in fair condition.

'Overall, people value the three rivers being in the best condition to provide for the environment, recreational use and Indigenous people. While people value some expansion of irrigated agriculture, they prefer a medium expansion rather than a large expansion,' says Dr Staton.

Ian Lancaster did not expect people in the southern cities to place such a high monetary value on the river systems. 'I was surprised given they wouldn't necessarily get the chance to visit and enjoy the rivers. They seem to value just knowing they are there in case they get the opportunity to go there.'

How will this information be used?

Dr Straton has now provided water planners in the north with a report of her findings, which will help them decide how much water may be extracted from the river systems.

'We consult the community about the level of extraction they're comfortable with', says Mr Lancaster, 'and this gives us a basis in the argument for a balance between people making money through development and the value of conserving the environment.'

The report can also help water planners work out the dollar value of efforts to improve the river systems. For example, if an environmental group applied for funding to replant native vegetation to improve the floodplain habitat, water planners can now get a feel for how much that might be worth.

'Dr Straton has done a fantastic job of providing a direct and comprehensive understanding of how we value our northern rivers so we don't have to rely on information from southern Australia or overseas', says Mr Lancaster. He says he would like to see more research on the value of ecosystem services to help him and his staff with developing water allocation plans.

'This report allows us to put a dollar value on things that are not normally a commodity in the way we think of things like fruit and vegetables or the supply of electricity. Money talks and this report gives farmers and people in industry a better idea of how others value all ecosystem services,' he says. 'You could think of the environment as an industry in its own right and the information from the report is a good basis to present that argument.'

Dr Straton has recently travelled to the Mitchell catchment to talk with Traditional Owners about the outcomes of her research. 'Making sure I deliver the results is important because local people and organisations need the knowledge to back up their own arguments for maintaining ecosystem services', she says. 'Local communities can also benefit from knowing that other Australians value their local tropical river ecosystems.'

Waterhole, Darwin River

Photo: NRETAS

Fitzroy River update

The collection of 'river change' stories has begun in the catchment. A local youth organisation, the Yiriman Project, is coordinating the recording of oral histories about changes to river systems and wetlands over people's lifetimes. A group of young local people will record senior people telling their stories on film. The researchers hope to integrate the oral history with the scientific knowledge that they have assembled to establish a more complete picture of the ways that rivers and wetlands work, and the relationships people have with these systems.

Marcus Finn, Pippa Featherston and Emma Woodward continued their intensive field research in the catchment. The economic survey of household catches is progressing; the team has been talking with a number of Traditional Owner groups about their interest in trialling a river-health monitoring program that uses indicators of healthy country of relevance to Aboriginal people. Community members are also working with the team to develop materials for local use and of local interest, such as seasonal calendars.

In June, several teams presented their research at the Fitzroy Catchment Group (FitzCam) and the FitzCam Aboriginal Reference Group meetings in Fitzroy Crossing. At the event, Paul Close and Rebecca Dobbs consulted landholders about their research for the Framework of the Assessment of River and Wetland Health project. As a result, they are now working closely with local cultural advisors, research assistants and pastoralists to collect samples at an extensive range of sites along the Fitzroy River. And in response to Neil Collier's talk about the Power Tools project, the Aboriginal Reference Group has expressed interest in having the project work with its members.


Photo: Paul Close

Researchers sampling at Mugungoor, West Kimberley

After much planning with staff of the Kimberley Land Council Land and Sea Management Unit, Ben Cook and his team spent a fortnight in the north Kimberley working with ranger groups and council project officers. They collected samples of fish, shrimp and snails from the May, Robinson, Mitchell, Carson, Drysdale, King and Pentecost rivers. As part of TRaCK's work to identify aquatic ecosystems of high conservation value, the team is analysing the samples to identify populations that have changed genetically in adapting to local conditions.

Mitchell, Flinders and Norman Rivers update

Fish findings

Field work has been ongoing in the Mitchell and early results relating to fish and what they eat are starting to emerge. Tim Jardine and the team from Griffith University were conducting field work and picking up depth loggers in the middle and lower reaches of the Mitchell in June and July. They are tracing the primary food sources of large and small fish to trace where they are found in the system of river channels, waterholes and floodplains. It seems that an as yet unidentified source of food supply is contributing to fish food webs in the Mitchell.

Ian Halliday from Queensland Primary Industries and Fisheries is continuing his August survey work in the Mitchell in October, mainly at Kowanyama. Ian is developing the same type of datasets as those that he previously incorporated into the Fitzroy River Water Resource Plan, which examine barramundi populations and risks posed from water resource development.

Geomorphologists converge on the Mitchell

Andrew Brooks and Jeff Shellberg travelled the length of the Mitchell River in July with delegates from the 7th International Conference on Geomorphology. Australian and overseas visitors alike were impressed with the rugged isolation of the landscape and the scale of the geomorphological processes at work.

Continued page 15


Photo: Melanie McKenzie

Visiting geomorphologists inspect gully erosion, Dying Pig Gully, Wrotham Park Station, Mitchell River catchment

Daly River update

Highs and lows

The trial of the Framework for the Assessment of River and Wetland Health reached new heights recently as the team were airlifted, with the assistance of the Jawoyn Association's chopper, into hard-to-reach stone country in the Katherine region. Ranid May and Alistair Danger from Charles Darwin University have joined the project and were welcomed by the team for an intense round of dry-season field work.

Fish and flows

In an experiment to examine the effects of fish, shrimp and increased nutrients on the growth of algae, Erica Garcia, Simon Townsend, Peter Novak and Andrew Raith deployed large fish-exclusion cages and nutrient-diffusing substrates in the Edith River.

Danielle Warfe, Peter Kyne, Mark Kennard and Courtenay Mills sampled fish at permanent monitoring sites in the Daly, Katherine and Fergusson Rivers. This sampling is contributing to a long-term dataset on fish assemblages, and will also increase our understanding of the hydraulic and hydrological needs of fish in the Daly River catchment. For this round of sampling, the TRaCK team was joined by Wagiman elders and rangers whose input was invaluable, especially as a Wagiman fish-names poster is currently being created.

Danielle and Peter also conducted sampling on the Edith and Fergusson Rivers with Peter Novak and Neil Pettit. They are investigating how food webs change over the wet and dry season, and if/when there are peaks in the production and movement of food web components such as algae, insects and fish.

Thor Saunders and Ian Halliday have been analysing barra and threadfin salmon otolith (ear bone) data. Initial findings indicate that the impact from flow on fish recruitment is discernable.

Charles Darwin University hosted a workshop and seminar in June where Michael Douglas, Mark Kennard and Brad Pusey presented findings from the Daly River Fish and Flows project.

Andrew Raith sets up a flow tracker in the Edith River. Photo: Peter Novak

The workshop aimed to help water managers and planners understand the implications of where and how much water they allocate to different uses and users. Thirty people from community groups and government agencies attended. Danielle will conduct a similar workshop with northern water management and planning agencies in Perth. A workshop for Queensland representatives was held in April.

Wet and dry artwork at Nauiyu community

Emma Woodward has been working with Nauiyu community members at Daly River on initiating a community art project. Community members hope that their artwork will depict the difference between wet and dry river systems and engage everyone involved in two-way learning and expression.

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Laura Aboriginal Dance Festival

Through the Mitchell River Watershed Management Group, TRaCK was well represented at the Laura Aboriginal Dance Festival in June. The festival is revered as one of the most important cultural events in the region. It was a good opportunity to liaise with members of several language groups and clans, and visitors from all across the north.

Flinders and Norman Rivers

Stephen Faggoter and his team from Griffith University have been doing a series of intensive field sampling in Flinders river waterholes, investigating the drivers of plant growth in this system.

Heavy flooding in the Gulf during the 2008–09 wet season caused major deposits of sediment on grazing lands.

Subsequent algal blooms in the Flinders and Norman Rivers are of concern to graziers in the region. There was major disruption to grazing operations and some loss of stock and property. TRaCK has been liaising with the Northern Gulf Resource Management Group to share knowledge and provide insights into post-flood processes and recovery.

Photo: Jon Marshall

One of the waterholes being studied in the Flinders River catchment

On TRaCK
Tropical Rivers and Coastal Knowledge

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

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

Sustainable enterprises fact sheets
2: Indigenous rights in water

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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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