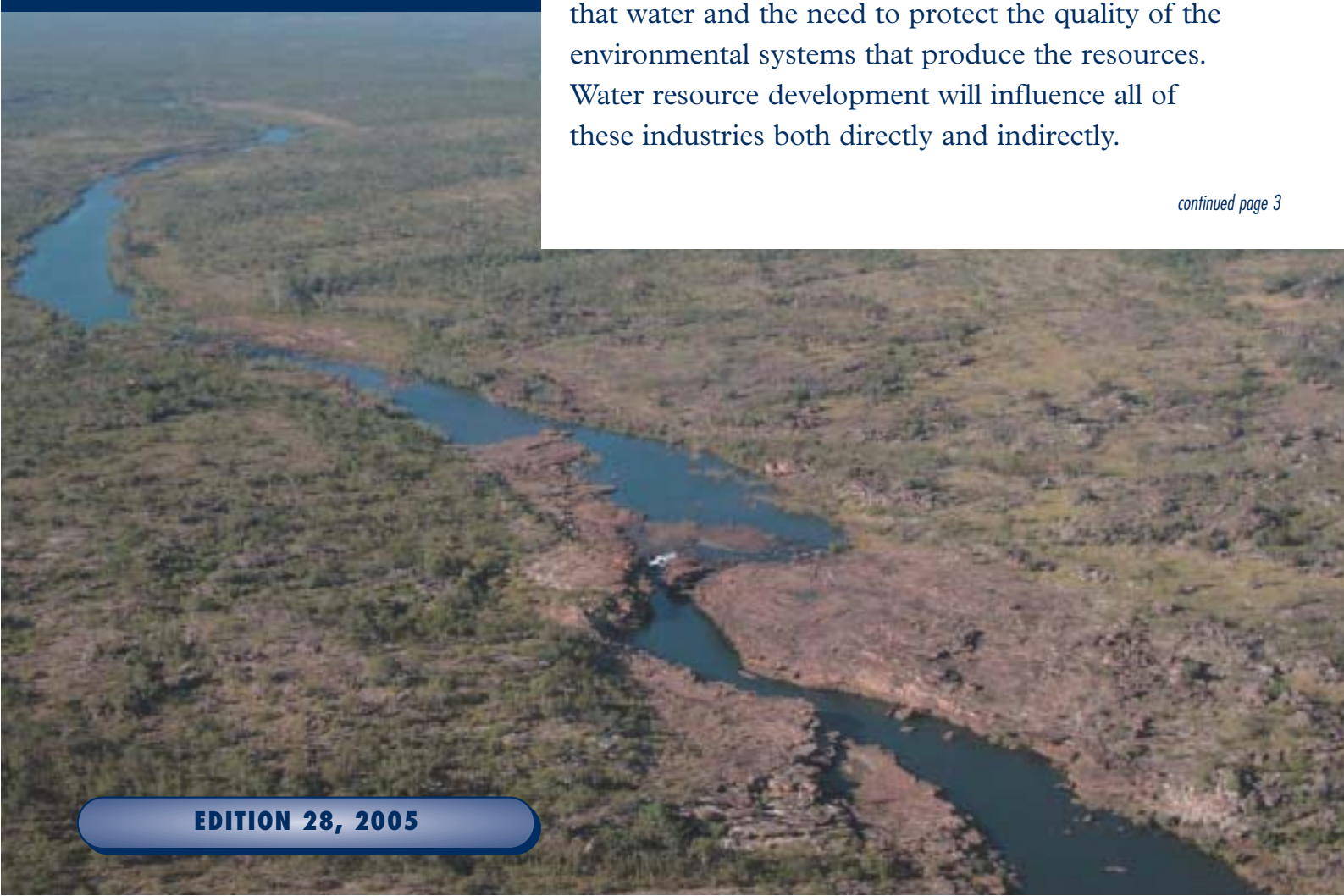
Australian Government
Land & Water Australia

RIPRAP
RIVER AND RIPARIAN LANDS MANAGEMENT NEWSLETTER

TROPICAL RIVERS

The rivers, floodplains, wetlands and estuaries of northern Australia are key resources. They are relatively undisturbed and are highly distinctive compared with other regions of Australia. Fundamental to the vision for sustainable growth in northern Australia will be the development of these water resources, the industries that prosper and the values of rivers to be protected. Industries including pastoralism, mining, aboriginal enterprises, fisheries, cropping and tourism are linked by access to water resources, the consequences of using that water and the need to protect the quality of the environmental systems that produce the resources. Water resource development will influence all of these industries both directly and indirectly.

continued page 3



EDITION 28, 2005

CONtents

Theme: Tropical rivers . . . . . 1 and 3
Classifying the diversity of Gulf rivers 5
Clear water phase tropical rivers and the potential for algal blooms 11
Ecosystem processes in tropical rivers: conceptual models and future R&D 13
Australia's tropical rivers: an integrated data assessment and analysis 15
Freshwater needs of estuaries in the Gulf of Carpentaria 17
Stopping the cane toad invasion of the Kimberley 19
Northern Australian Irrigation Futures 22
Rapt in rivers 24
Participatory research to incorporate indigenous knowledge into NRM 26
Biodiversity and cultural significance of the fishes in the King Edward River 28
Fish passage on the Fitzroy River in the Kimberley Region 30
Addressing indigenous cultural requirements in water allocation planning 32
Looking after freshwater country — Indigenous research priorities for tropical rivers 34
Providing water resource information to the people of the Top End 36

This publication is managed by Land & Water Australia, GPO Box 2182, Canberra ACT 2601

Land & Water Australia's mission is to invest in knowledge, partnerships, innovation and adoption to underpin sustainable natural resource management.

Land & Water Australia's Home Page is: www.lwa.gov.au

Edition 28, June 2005
RipRap is published throughout the year. Contributions and comments are welcomed and should be addressed to the Editor.

Editor: Dr Siwan Lovett

Feedback and comments to:
Dr Siwan Lovett
Program Coordinator
Riparian Lands R&D Program
Land & Water Australia
GPO Box 2182
Canberra ACT 2601
Tel: 02 6263 6000
Fax: 02 6263 6099
E-mail: public@lwa.gov.au
Website: www.rivers.gov.au

Designed by: Angel Ink
Printed by: Goanna Print

ISSN 1324-6941
Product code PN050876

RIPArian lands:

WHERE LAND AND WATER MEET

From the Editor

Australia's Tropical Rivers capture the imagination with their beauty and incredible diversity. This edition of *RipRap* is looking at new projects being funded by Land & Water Australia that are focused on the 'Top End' of Australia, its rivers, people and culture. Through these projects we will learn how to integrate Indigenous and Western knowledge of our rivers so that management strategies can be developed that protect and maintain the social, economic and environmental values of these largely unregulated waterways. I encourage you to think about applying some of the approaches being taken in these projects, as they seek to ensure that people and the knowledge they have about their rivers is incorporated with science, enabling a more complete understanding about these riverine environments to be gained.

As we say 'hello' to the new Tropical Rivers Program, we are saying 'goodbye' to three Land & Water Australia Programs — the National Riparian Lands R&D Program, the National River Contaminants Program and the National Rivers Consortium. These three Programs have been running over the last 5–10 years and are now entering their final communication phase, so watch out for lots of new products over the next 6–12 months. *RipRap* will also be having a 'make-over' as Land & Water Australia moves into a whole new brand and image for the 21st century, so watch this space!

Front cover image: *Mitchell Plateau aerial. Photo Heather Chapman.*

TROPICAL RIVERS

By Brendan Edgar

There is a long history of interest in developing northern Australia and this is currently being influenced by increasing pressure on water supply and river systems in southern Australia. Tropical rivers and groundwater systems are estimated to contain roughly 70% of Australia's fresh water resources, although there is uncertainty surrounding actual water availability because of the quality of information underpinning previous assessments. Environmental changes resulting from water development are also likely to have social and cultural implications for communities. This means that there is a need to establish water requirements for all uses and to assess the benefits gained. This can form the basis for smart land and water management systems that maximise multiple benefits from land and water use.

The Board of Land & Water Australia has identified Australia's unique tropical rivers and associated catchments and estuaries as a priority area for major investment over five years from July 2005. Land & Water Australia is now working with partners and engaging with relevant States, the Northern Territory, indigenous land councils and other stakeholders to build a shared vision for the new Tropical Rivers Program. Land & Water Australia is also inviting expressions of interest from prospective investors interested in partnerships in research and development to improve the knowledge base for managing Australia's tropical rivers and associated catchments and estuaries.

Northern Australia offers a unique opportunity to productively develop land and water resources while protecting downstream users and rivers of high conservation value. The governments of Queensland, Northern Territory and Western Australia are also working to support knowledge generation in tropical Australia, including the joint Tropical Science, Knowledge and Innovation Program, that recognises the wise management of natural resources requires a depth of biophysical, technical and institutional understanding. The Tropical Rivers Program will build capacity and understanding so that the best available knowledge can be used to achieve sustainable natural resource management in tropical Australia.

Land & Water Australia's Tropical Rivers Program will be managed through a program management committee as new partners join the initiative. Start-up funding for 2003/04 and 2004/05 has been secured from the Natural Heritage Trust, National Landcare Program and the National Rivers Consortium, and work

Photo Land & Water Australia.

For further information

Brendan Edgar
Program Coordinator,
Landscapes Arena
Land & Water Australia
Tel: (02) 6263 6000
E-mail: brendan.edgar@lwa.gov.au

Tom Aldred
Program Manager,
Landscapes Arena
Land & Water Australia
Tel: (02) 6263 6000
E-mail: tom.aldred@lwa.gov.au

has commenced on a number of preliminary projects to scope and initiate the larger program. This edition of *RipRap* is featuring a number of these projects, as well as other work Land & Water Australia is supporting in the 'Top End' of Australia.

As is demonstrated in the mix of articles, social, economic and environmental research is being funded, as these three areas are interwoven and cannot be considered in isolation. Land managers have strong interests and experience in environmental management systems and their knowledge and understanding is being included in developing management approaches. Including these inputs in the core research offers a basis for understanding social and economic values, as well as the ecological services provided by tropical rivers.

The combination of a growing interest in water at the national level, regional development aspirations in the tropics, and the condition of tropical rivers provides a unique opportunity for science to be proactive in providing the information needs for sound management of Australia's tropical rivers into the future. It is generally agreed that environmental protection is a more effective long-term management strategy than environmental restoration. At this stage the Tropical Rivers Program is focusing research in four research themes. They are:

1. **Assess river assets and threats**
~ compile information and undertake assessments of rivers, groundwater, floodplains, wetlands and estuaries;
~ undertake threat and risk assessment based on future scenarios;
~ support classification and description of river types to enable transfer of knowledge; and
~ assess land and water resource capability.
2. **Support regional planning frameworks**
~ provide targeted knowledge support for the National Water Initiative; National Action Plan for Salinity and Water Quality, and Natural Heritage Trust regional management initiatives;
~ promote scientifically based resource condition targets and indicators; and
~ develop monitoring and evaluation methodologies.
3. **Assess social, cultural and economic values and opportunities**
~ undertake research to determine what people value in rivers;
~ value ecosystem services;
~ understand indigenous cultural and economic values; and
~ analyse economic and resource development, river protection and management.
4. **Understand river ecosystems**
~ understand ecosystem processes and develop conceptual models of how river ecosystems function;
~ understand river and groundwater flows and hydrology; and,
~ understand the fluxes and balance of nutrients and contaminants in rivers.

This edition of *RipRap* features work being undertaken in each of the themes, much of it forming the basis for further investment as the Tropical Rivers Program matures and works with more partners and stakeholders in the region. If you would like more information about the Tropical Rivers Program contact Brendan Edgar or Tom Aldred (details on previous page).

CLASSIFYING the diversity of Gulf rivers

By Andrew Brooks, Peter Brunner and Pu Lin

Project overview

The catchments of the tropical savannahs in the Gulf of Carpentaria and Cape York region (AWRC Division 9) possess an incredible diversity of river types, and represents what might be regarded as some of the last great frontiers for undertaking basic research on biophysical processes in relatively undisturbed rivers. Land & Water Australia has recently established a major new research initiative that will focus on developing a better understanding of tropical rivers in northern Australia and the ecosystems and communities that are dependent on them. With drought and water shortages now apparently the norm in southern Australia, people are increasingly looking towards the north to satisfy their growing thirst. For this reason alone, there is a strong imperative to begin to understand what drives these tropical river systems so that more informed decisions can be made as to whether water resource exploitation is appropriate in this region. As part of Land & Water Australia's Tropical Rivers Program, this project has been established in conjunction with Queensland Department of State Development and Griffith University to develop a baseline inventory of the diversity of rivers in the Carpentaria Division, as well as a rigorous classification procedure that is appropriate to the scale of the region and resolution of the available data.

Selection of appropriate classification approach

The classification procedure developed in this project will form the basis for understanding the diversity of rivers in tropical Australia, as well as the basis for comparing more detailed insights based on specific case studies. In addition to developing a hierarchical river classification scheme, the project will generate an extensive database of catchment scale drivers of reach scale geomorphic and ecosystem processes. This data will form the basis for testing the reach based classification procedure, as well as a range of bioregional ecological models. One of the major challenges in developing a classification system in this remote region, is that any classification must be able to be applied using remotely sensed data, with limited ground truthing. There is currently a lack of high resolution geospatial data covering the entire region and because of this any broadly applicable classification process must be based on the lowest common denominator data set. To help get around this problem we have employed a multi-resolution hierarchical approach, that allows higher resolution classifications to be overlaid on the coarser broad classification, in those areas where higher resolution data is available. We have also adopted an approach that allows for multiple lines of evidence to be used in deriving the classification depending on the local availability of data. Given the limited availability of high resolution imagery or capacity for ground survey, we also undertook an extensive aerial reconnaissance of the Gulf region in October 2004, in which we collected aerial digital video imagery at a resolution of 1–2 metres along 13,500 kilometres of river channel. This data will form the primary basis for validating the reach scale classification procedure, and with additional development, will form the basis for a rapid condition assessment procedure.

Which approach to use?

A plethora of river classification procedures have been employed in southern Australia by various state government agencies and researchers (see Parson et al., 2004 for a recent review). Unfortunately, schemes such as River Styles (Brierley & Fryirs, 2000), the Geomorphic Assessment of Rivers (GAR) (Brennan & Gardiner, 2004), and other microhabitat classification schemes (e.g. Maddock, 1999), all rely heavily on field assessment to determine the reach or site classification. For example, the modified River Styles approach used by DNRM in Queensland (GAR) discriminates a number of reach classes on the basis of bed and bank material calibre. However, these parameters can only be reliably assessed from a field survey, making this sort of approach unfeasible for application over northern Australia. For the purposes of this exercise, where field survey was not an option, a greatly simplified schema was required that would enable reach classification to be made based on morphological parameters visible on 30 metre resolution Landsat imagery,

coupled with topographic data derived from the 90 metre SRTM DEM data. In addition to this we have used aerial video survey data to validate the classification derived from the satellite imagery over a selected portion of the rivers.

How much of the drainage network should be classified?

In many river classification exercises there seems to be a somewhat arbitrary selection of the stream network to be classified. In this project we will use the channel network defined by the 1:5 M scale topographic drainage network. This network is an appropriate trade off between excessive detail and effort, while still capturing all of the major tributaries. As can be seen in Figure 1, the 1:5 M drainage network is the closest match for the streams already classified by the GAR process in the Southern and Northern Gulf regions. The GAR procedure classified 8532 kilometres of streams in the Gulf, which represents around 33% of the total network in the Gulf at 1:5 M resolution. Table 1 shows how the 1:5 M network compares with drainage networks at a range of resolutions.

A hierarchical multivariate classification

1st order classification

For the purposes of understanding broad regional trends in river characteristics at the whole basin scale, a first order multivariate basin classification was undertaken on the basis of catchment morphometrics, geology, soils, regolith, vegetation and climate. Table 2 shows the categories used for a broad group of catchment scale metrics, and Figure 2 shows an initial basin classification based on the morphometric and geological metrics. Additional parameters can be added to the classification depending on specific comparisons that may be required between catchments, or indeed for different regional scale analyses that might be undertaken. Much of this data can also be used as predictors of processes or species assemblages within different catchments, and as such there is no definitive set of metrics that can be used to perform the basin scale classification.

Definitions

GA: Geosciences Australia
CSIRO: Commonwealth Scientific and Industrial Research Organisations
DNRM: Department of Natural Resources and Mines (QLD)
SRTM DEM: Shuttle Radar Topography Mission Digital Elevation Model
DEM: Digital Elevation Model
BOM: Bureau of Meteorology
AWRC: Australian Water Resources Commission
ERISS: Environmental Research Institute of the Supervising Scientist
Morphometrics: Descriptors of catchment morphology
Regolith: The mantle of weathered rock material that overlies bedrock on the earth surface

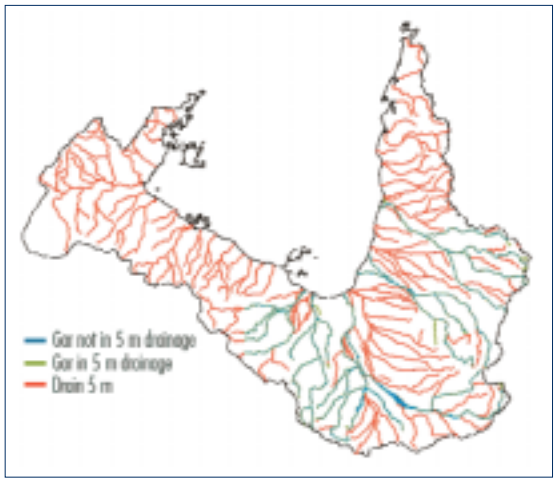


***Figure 1**. The 1:5 M drainage network within the Gulf of Carpentaria catchment. The streams shown in green have been classified under the GAR scheme by DNRM.*

***Note**. Supplied diagrams are an indication of what is described, rather than an accurate reflection.*

***Figure 2**. Basin classification based on geology and morphometrics.*

***Table 1**. Relative length of channel network (km) defined by different resolution drainage networks. M = million, K = thousand.*

Drainage network resolution	1:250 K	1:1 M	1:2.5 M	1:5 M	1:10 M
Total network length (km)	396,964	112,821	37,322	26,056	8665

CLASSIFYING the diversity of Gulf rivers

***Table 2**. Metrics used to classify the 26 AWRC mainland basins.*

	Morphometrics	Geology	Soil classes	Regolith	Vegetation	Climate
Data source	*3 sec SRTM DEM/ 1:250 K drainage network*	*GA 1:25 M surface geology map*	*CSIRO 1:2 M soils map*	*GA 1:5 M regolith map*	*GA 1:5 M 1988 vegetation mapping*	*BOM 0.025 deg grid data*
	Catchment area (km^2)	Jurassic – Cretaceous	Dr	alluvial sediments	Acacia including Racosperma	Mean annual rainfall (mm)
	Total stream length (km)	Mesozoic	Dy	coastal sediments	Astrebla (mitchell grass)	Annual rainfall 50% (mm)
	Drainage density km/km^2	Triassic	Gn	highly weathered bedrock	Dichanthium (bluegrass)	Annual rainfall 90% (mm)
	Hypsometric integral (50^{th} %)	Jurassic	KS–Dy 2.62	moderately weathered bedrock	Eucalyptus	Annual rainfall 10% (mm)
	Max relief (m)	Permian	KS–Gn 2.1	residual clay	Melaleuca Northofagus	Annual rainfall variability index
	% basin < 100 m elevation	Silurian	KS–Uc 4.12	residual sand	mixed or others	Seasonal rainfall variability index
	Basin perimeter (km)	Silurian – Devonian	K–Uc 1.4	soil on bedrock	other grasses	Annual maximum temperature (deg)
	Form factor	Carboniferous	K–Um 1.43	terrestrial sediments	Triodia and/or Plectrachne	Annual minimum temperature (deg)
	Basin length/area ratio	Devonian – Carboniferous	Uc	unweathered bedrock	unvegetated	
	Circularity ratio	Devonian	Uf	very highly weathered bedrock		
	Divide average relief	Cambrian – Ordovician	Ug	(blank)		
		Cambrian	Um			
		Adelaidean (Proterozoic)	(blank)			
		Carpentarian (Proterozoic)				
		Lower Proterozoic				
		Archaean – Lower Proterozoic				
		(blank)				

THE DIVERSITY OF RIVERS IN THE GULF OF CARPENTARIA

From left to right. Top row: Palmer River, Gregory River, Gilbert/Einasleigh Rivers Confluence. Middle row: Flinders River, Watson River, Roper River. Bottom row Limmen Bight River, Upper Flinders River, Mitchell/Palmer Rivers confluence. Photos Andrew Brooks.

2nd order classification

As outlined above, the reach scale procedure used in this classification is a simplified version of the River Styles/GAR approach. In the River Styles classification, scheme valley confinement is assumed to be one of the primary controls on river morphology, along with stream power. To provide a means for both testing these assumed controls and deriving objective measures of confinement, a broad scale index of valley confinement is currently being developed. Given the paucity of discharge data we were unable to derive a reliable estimate of formative discharge (and hence stream power) so we have used a proxy based on channel slope and catchment area. The valley confinement index will be derived from the Multi Resolution Valley Bottom Flatness Index (Gallant & Dowling, 2003) and an empirical channel width catchment area relationship. The product of the confinement and slope/area index will provide a broad scale classification that will sit over the more subjectively defined reach scale classification.

3rd order classification

The most useful scale of river classification for management and ecological applications is that which defines reaches having relatively homogeneous geomorphic characteristics, and it is this scale at which the River Styles and GAR approaches are primarily focused. Given that a GAR assessment had already been completed on

a selection of rivers in the southern and northern Gulf regions, this was used as a starting point for our classification. However, due to the fact that we cannot verify many of the differentiated classes used in the GAR from the remote sensing data we have simplified their 33 classes down to 10 classes as shown in Table 3. These 10 classes can be objectively defined purely on the basis of manual observation of Landsat multi-temporal data. The classification is based on the Australian Greenhouse Office multi-temporal Landsat imagery, which has scenes from 1972, 1980, 1989, 2000 and 2004. Where available we also draw on the aerial videography.

4th order classification

Once the reach classification has been completed, the data is then used to define a set of nested sub-catchments throughout the study area. In the same way as the AWRC basins were used in the 1st order classification as a basis for a basin scale multivariate classification, these sub-catchments will then form the basis for deriving a dataset of explanatory variables at the sub-catchment scale, from which multivariate statistical techniques can be used to assess the dominance of controls on reach scale geomorphic and ecological processes. The advantage of this nested hierarchical approach to classification is that it allows for finer resolution classification to be undertaken within this framework, where the resources and/or data allows. In this case, the existing GAR classification can sit comfortably under the broader scale reach classification.

Table 3. *Simplified 10 point reach classification showing the associated GAR classes that can now be regarded as sub-classes of the coarser resolution 10 point classification*

Simplified reach scale classification for tropical rivers	Corresponding Qld DNRM GAR classification
1. Bedrock rivers*	Upper headwater Headwater Gorge (low sinuosity) Gorge (high sinuosity)
2. Bedrock confined-rivers*	Bedrock controlled, sand Bedrock controlled, sand/gravel Bedrock controlled, gravel Floodplain pockets
3. Low sinuosity rivers	Continuous low sinuosity, fine grained Continuous low sinuosity, sand or gravel Continuous low sinuosity bedrock
4. Meandering rivers	Planfrom controlled meandering Continuous meandering, fine-grained Continuous meandering, sand or gravel
5. Floodouts	Discontinuous floodout Discontinuous reverse floodout
6. Multiple channel rivers	Continuous anabranching Planform controlled anabranching Continuous low sinuosity, multi-channel sand belt Continuous anastomosing
7. Wandering channel rivers	Planfrom controlled anastomosing Planfrom controlled wandering or low sinuosity Continuous wandering sand
8. Non-channelised	Intact valley fill
9. Swamp/waterbody dominated zone	Continuous anabranching swamp belt Confluence wetland Discontinuous channel — chain of ponds Discontinuous channel valley fill
10. Tidal	Continuous channel tidal Discontinuous channel — tidal delta or sand bed

Reconnaissance and validation using GPS located digital video aerial survey

Given that extensive field validation of this analysis was not possible, and that up to date rectified aerial photography or high resolution satellite imagery at a suitable scale is prohibitively expensive, some additional means of collecting relatively high resolution imagery was required that would allow us to validate the classification undertaken with the LandSat imagery. As a means of rapidly gathering relatively high resolution (1–2 metre resolution) data on channel and riparian condition throughout the Gulf, in September/October 2004 we undertook a reconnaissance flight to test the applicability of using aerial videography from a fixed wing aircraft to survey all of the major Gulf rivers.

Previously this technique had been used over confined areas in south-eastern Australia from a helicopter platform using a gyro-stabilised camera. In the Gulf a helicopter platform would have been prohibitively expensive, so we trialled the use of a fixed mount camera on a fast, twin-engine light aircraft. GPS located digital video

***Top**: Beechcraft Barron used for aerial video survey. **Above**: Camera setup through the floor of the plane.*

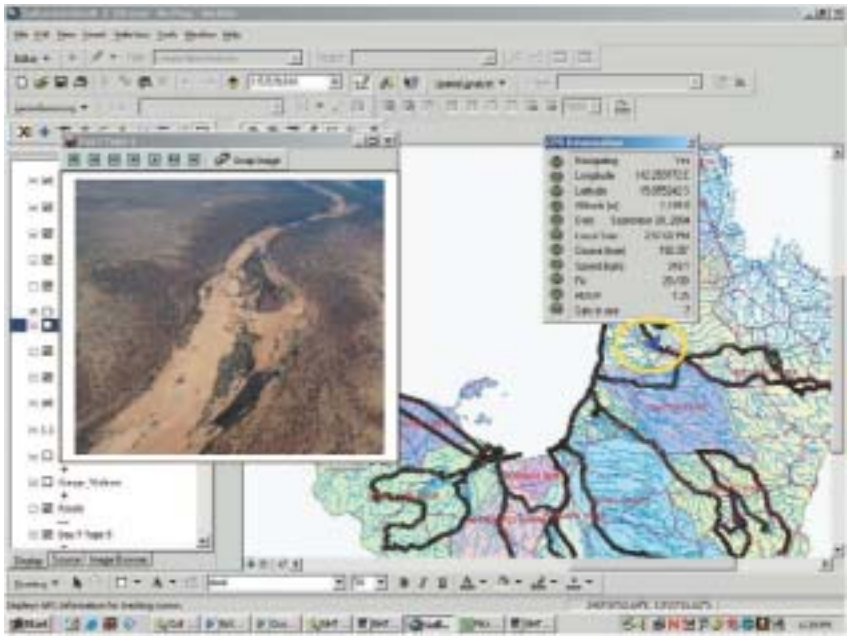


***Figure 3**. Screen shot of the ArcInfo setup showing the video imagery with the GPS location data and the ground location of the imagery (circled arrow on the dark flight path line below GPS box).*

total flying time	43 hours	average field of view width	1008 m
average ground speed	315 km/hr	total area filmed	13,653 km^2
total river length flown	13,500 km	total land area of Gulf	642,000 km^2
% of 1:5 M network surveyed	51.8%	% of total catchment area covered	2.12 %
average altitude above ground	800 m	cost per kilometre of river surveyed	~ $5.50

***Table 4**. Aerial videography statistics*

footage was collected with a professional quality digital video camera mounted through the floor of the aircraft. Using this arrangement imagery of the channel and riparian zone was very efficiently collected over a 10-day period along 13,500 kilometres of river channel with an average field of view of 1 kilometre at a total cost of around $75,000 (or $5.50/km). This dataset alone provides an invaluable baseline inventory of the river channel and riparian condition for the rivers surveyed, but when combined in a GIS platform with a range of additional data layers, forms an extremely valuable basis for NRM planning. Given that the imagery is GPS located (a GPS location was encoded every second onto the videotape), it is possible to convert the video stream into a format that can be viewed within a standard ArcInfo platform. The entire flight path can be overlaid on any relevant GIS coverage or imagery, and the corresponding video imagery extracted at any given point along the route. This provides an extremely efficient means of instantaneously viewing the data at any location without the need to trawl through hours of videotape to locate a site of interest. Furthermore, digital stills taken of the surrounding landscape during the flight can also be spatially located and viewed in a similar manner.

References

Brennan, S. & Gardiner, E. 2004, Geomorphic Assessment of Rivers Series: Gulf Basins and Mitchell Catchment, Brisbane, Queensland Department Natural Resources and Mines: 254.

Brierley, G.J. & Fryirs, K. 2000, "River Styles, a geomorphic approach to catchment characterisation: implications for river rehabilitation in Bega catchment, New South Wales, Australia", *Environmental Management*, vol. 25, no. 6, pp. 661–679.

Gallant, J.C. & Dowling, T.I. 2003, "A multiresolution index of valley bottom flatness for mapping depositional areas", *Water Resources Research*, vol. 39, no. 12, pp. 1347–1361.

Maddock, I. 1999, "The importance of physical habitat assessment for evaluating river health", *Freshwater Biology*, vol. 41, no. 2, pp. 373–391.

Parsons, M., Thoms, M.C. et al. 2004, "Development of a standardised approach to river habitat assessment in Australia", *Environmental Monitoring and Assessment*, vol. 98, no. 1–3, pp. 109–130.

For further information

Dr Andrew Brooks
Centre for Riverine Landscapes
Griffith University
Tel: (07) 3875 6598
E-mail: Andrew.Brooks@griffith.edu.au

CLEAR WATER phase tropical rivers and the potential for algal blooms

By George Ganf
and Naomi Rea

The CRC for Freshwater Ecology once e-mailed its members asking them to nominate a pristine river they were familiar with. Coming from South Australia, I was perplexed and had to reply that the only pristine rivers I knew were those fabulous rivers characteristic of the uplands of the South Island of New Zealand. It was quickly pointed out that many contained vermin (trout) and could not be considered as pristine! At that time I had not experienced the rivers of the Northern Territory's Top End. Several trips north have now left me with a picture of these functionally intact river systems, and my interest in them is that given our understanding of southern rivers, and the relationship between algal blooms and the loss of macrophytes, what is the potential for algal blooms in these clear water phase tropical rivers, and what are the implications of this for future development?

Working from the Environmental Institute of the Supervising Scientist (ERISS) and with colleague Naomi Rea, we have now visited many rivers, including ones that flow into Darwin (Howard, Blackmore, Darwin, Elizabeth) and Bynoe Harbours (Annie, Charlotte) and tributaries of the Daly River (Katherine, King, Edith, Fergusson) that flows west and the Roper River (Elsey Creek of We of the Never-Never fame) that runs east to the Gulf of Carpentaria.

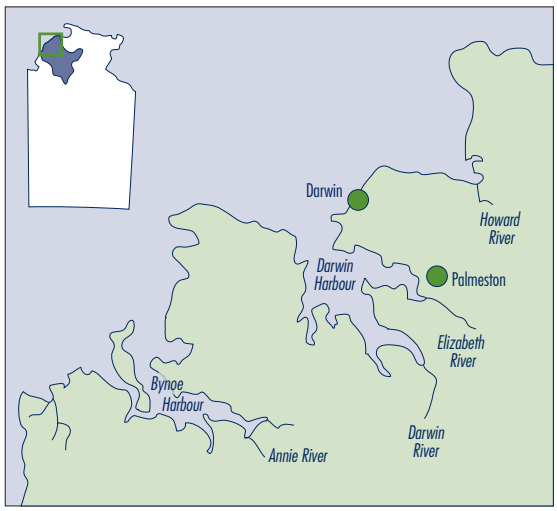
We asked whether these rivers could be considered pristine?, and undertook a series of measurements. I could not believe the first conductivity measurements we took in the rivers close to Darwin, < 20 µS cm^{-1}, surely not (re-calibrate the meter!) I was used to rivers that had conductivities in excess of hundreds of µS cm^{-1}. By way of comparison, distilled water has a conductivity of 1–2 and the River Murray in South Australia can reach 1200 µS cm^{-1}. The Roper River has a much higher conductivity of 900 µS cm^{-1}. The low conductivities in the Darwin region suggest that salt is not a problem, and that the river water is low in ions and maybe nutrients. Unlike the box type cross sections of river channels in parts of Southern Australia that are adjusting to 150 years of land clearance and a new hydrological regime, bed and bank erosion of tropical rivers is minimal which often gives the rivers a relatively shallow profile.

What is the potential for blue-green algal blooms and are there abundant nutrients that could fuel algal blooms? We used an instrument called a Phyto-Pam to determine the abundance of the main groups of phytoplankton as well as to assess the response of the phytoplankton, aquatic plants and benthic algal mats (all called autotrophs) to nutrient enrichment. Measurements of the 'metabolic activity' of these autotrophs indicates how good or poor the environmental conditions are for growth. Metabolically, active autotrophs have maximum yields of 0.6–0.7 for Photosystem II. If the yield is low (<0.2) this would indicate something is inhibiting growth; if it is > 0.6, the plant is 'happy'.

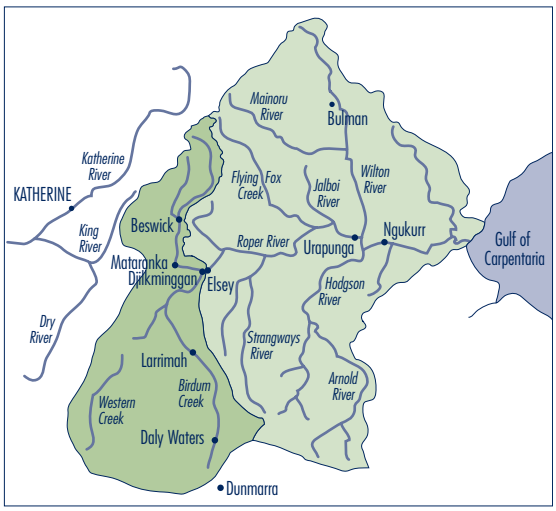
Photosystem I and II

Plants and algae grow via the incorporation of carbon using the sun's energy — a process that is called photosynthesis. Photosynthesis is composed of two photoreactions — Photosystems I and II. Photosystem II is of particular interest as it can tells us if a plant is metabolically active or if its growth is compromised because of a lack of nutrients, or because of something else, for example, a toxicant released from some past mining activity.

Darwin and Bynoe Harbours



Roper River



We also wanted to see whether or not there was a 'seed source' of blue green algae in the rivers. We discovered that this was the case in the Rivers flowing into Bynoe and Darwin Harbour. Although diatoms dominated the initial composition of the plankton, the addition of nutrients resulted in blue green (and green) algae becoming dominant. In contrast, green and brown algae dominated the planktonic communities of the upper Daly and Roper Rivers with little evidence of blue-green algae. The plankton communities of the upper Daly and Roper Rivers have maximum yield of about 0.62, suggesting they are 'happy'. In contrast, plankton from rivers in the Darwin and Bynoe Harbour catchments have maximum yields of <0.2, suggesting inactive populations that may be caused by a nutrient limitation. To test this we enriched samples from these rivers with nitrogen and phosphorus. The response was immediate — yields rose to 0.65 within three days.

The interesting comparison was with some common rooted aquatic plants (*Eriocaulon*, *Limnophila*, *Blyxa* and *Utricularia*) and benthic algal mats that were present at the same sites as the water samples were taken. Without any nutrient enrichment they had maximum yields of >0.6 and did not respond to nutrient enrichment. How can we explain this? One explanation is that the macrophytes and the benthic algae have access to nutrients that are confined to the sediments, whereas phytoplankton do not because they are free-floating. In contrast, in the upper Daly and Roper Rivers, planktonic algae as well as macrophytes and benthic algae do not appear to suffer any nutrient limitation.

What tentative conclusions can we draw, given the pressures that Australian rivers face of development for irrigated agriculture and other extraction based activities? The *current* nutrient status of the Darwin and Bynoe Harbour Rivers suggest they are unlikely to support algal blooms. However, they would be very susceptible to nutrient enrichment as a consequence of changes in land use (urban growth and increased fertiliser use). In contrast, the Daly River headwaters are more susceptible because they have an adequate nutrient supply and, if the right hydrological (reduced base flows) and thermal (stratification) conditions occur, blooms are very likely to develop.

It is apparent that rivers of the Top End are unmodified compared with those in Southern Australia. This project provides insight into the rich variety of processes that occur in these systems. There are many aspects of tropical rivers that require investigation if the conservation, biodiversity and maintenance of the ecological characteristics of these unique Australian rivers is to be sustained. Assistance from Land & Water Australia's Tropical Rivers Program will help answer some of the unsolved questions.

For further information
George Ganf
Environmental Research Institute of the Supervising Scientist, Darwin
(until 30 July)
The University of Adelaide
(after 30 July)
E-mail: george.ganf@adelaide.edu.au

***Top row from left**: Howard River, Howard River macrophyte beds, Edith River.*
***Bottom row from left**: Katherine River Galloping Jacks 5, Katherine River level crossing, King River.*
Photos George Ganf.

ECOSYSTEM processes in tropical rivers: conceptual models and future R&D

By Michael Douglas

Although most river systems in the Australian tropics have largely unmodified flow regimes, there is a growing interest in the development of water resources and river floodplains for irrigated agriculture. At the same time, there is general recognition of the high natural and cultural values of many tropical river systems, culminating in recent proposals for their long-term protection from intensive development (e.g. 'heritage' rivers in Queensland). However, while there is little doubt that many of these river systems are relatively undisturbed by human activity, the long-term protection of environmental and cultural values of rivers in the region is not necessarily guaranteed due to threatening processes (e.g. weed invasions of floodplains, overfishing).

Compared with their more temperate counterparts, rivers in northern Australia have been poorly-studied and, consequently, natural resource managers have a limited capacity to predict how these systems will respond to the combined effects of altered land use and modified flow regimes. Ecological studies of rivers in the wet-dry tropics, to date, have been primarily limited to survey and inventory of biodiversity. Although these have consistently highlighted the national and international significance of the region's biota, little information has been gathered about the important ecosystem processes and services that sustain this biodiversity. Ecosystem models developed and tested in river-floodplain systems in other biomes (e.g. Murray-Darling and Lake Eyre basins) have not been rigorously tested in the Australian tropics. Furthermore, although there are acknowledged links between river flows and commercially important northern coastal fisheries (e.g. northern prawn fishery), the causal nature of such relationships is, at best, poorly understood.

The broad objective of this project is to lay the foundation for the development of an integrated, multidisciplinary program of research on ecosystem processes in tropical rivers and their floodplains. This will have a particular focus on the influence of flow as a primary driver of biophysical processes, and aims to quantify the links not just between rivers and their floodplains, but also with estuarine and coastal ecosystems. Importantly, the proposed larger program of research will highlight opportunities for incorporation of indigenous knowledge in the identification of ecosystem components of high conservation and cultural value, and in the framing of priority research hypotheses.

Katherine River. Photo Ian Dixon.

For further information

Dr Michael Douglas
Charles Darwin University
Darwin NT 0909
Tel: (08) 8946 7261
E-mail:
michael.douglas@cdu.edu.au

ECOSYSTEM processes in tropical rivers

The project brings together a multidisciplinary consortium of over 20 freshwater and marine researchers, many with considerable experience working in northern Australia. Consortium partners come from Charles Darwin University, Griffith University, University of Western Australia, CSIRO Sustainable Ecosystems, CSIRO Marine Research, CSIRO Land and Water, Australian Institute of Marine Science, Environmental Research Institute of the Supervising Scientist, Geoscience Australia, Department of Environment (Western Australia), NT Department of Infrastructure Planning, NT Department of Business, Industry and Resource Development, the Northern Land Council, Queensland Environment Protection Agency, and Queensland Department of Primary Industries and Fisheries.

These consortium partners met at Charles Darwin University in November 2004. At this first meeting, the group identified critical ecosystem processes in tropical rivers and identified major knowledge gaps related to these processes. This was used to determine priority areas for biophysical research on tropical river ecosystem processes. The group also identified opportunities for integration of social and cultural research with biophysical research.

The group will meet again in June 2005 to develop conceptual models of tropical river ecosystems that identify important biophysical processes and linkages between floodplains, rivers and coastal ecosystems and include predictions of the likely responses to water resource development and land-use change. At this meeting the group will also be developing a framework for a larger R&D program on ecosystem processes that identifies potential funding partners, key stakeholder groups and research providers. We have continued consultation with NT, Qld and WA governments and regional NRM groups; all have indicated strong interest in future research on tropical river ecosystem processes.

As "eyes turn north" for water resource development, it is important we have adequate scientific knowledge and management tools so problems manifest in the south are not repeated.

Tropical Rapid Appraisal of Riparian Condition

DEVELOPING A TOOL TO ASSESS AND MONITOR TROPICAL RIVERBANK CONDITION

By Ian Dixon

Tropical rivers are an important and dynamic feature of northern Australia's vast savanna landscape, providing valuable cultural, economical and ecological contributions to the region. Their riverbank habitats are, however, particularly vulnerable to disturbances such as weed invasion, feral animals, fire, overgrazing and erosion. It is recognised that a user-friendly tool to assess and monitor riverbank condition would support land managers in directing management programs and to monitor their effectiveness over time.

The Tropical Savannas Cooperative Research Centre in collaboration with Land and Water Australia is developing a user-friendly rapid assessment tool. Researchers from Charles Darwin University and James Cook University have successful trialled a draft protocol — the Tropical Rapid Assessment of Riverbank Condition (TRARC) — in the greater Darwin region and Burdekin River catchment. Trials to validate the TRARC have included training workshops with Greening Australia, the NT Government Water Monitoring Branch, Kakadu National Park rangers and other interested volunteers.

Over the next 12 months, further trialling and development of the TRARC will continue in more regions across northern Australia, such as the Kimberley, Roper River and Gulf of Carpentaria regions. The TRARC will soon be available as a user-friendly manual with guidelines aiming towards the conservation and improvement of northern Australia's tropical riverbanks.

For further information

Ian Dixon, Tropical Savannas CRC, Darwin NT 0909
Tel: (08) 8946 6761. E-mail: ian.dixon@cdu.edu.au

Edition 26 of RipRap also featured an article on the TRARC and is available on the www.rivers.gov.au website

AUSTRALIA'S tropical rivers: an integrated data assessment and analysis

By Rick VanDam and Renee Bartolo

Australia's tropical river systems are unique and form one of the last great river networks in less-impacted condition in the world today; together, they are an internationally significant asset (Australian Tropical Rivers Group, 2004). In achieving sustainable development and growth in northern Australia, utilisation of the water resources of our tropical rivers will need to be balanced with maintaining their ecological character — for example, protection of the aquatic ecosystems and the many benefits they provide to society. The rivers and wetlands of northern Australia are considered public resources and yet are increasingly subject to degradation, restrictions on access, and claims for development (Storrs & Finlayson, 1997). Decisions made about access to, and development of water resources, will affect various industries including cropping, pastoralism, mining, fisheries, Aboriginal enterprises, tourism and conservation.

For the vision of sustainable development to be effectively realised, a better understanding of the aquatic ecosystems is required. These ecosystems have yet to be studied in a systematic manner (Gehrke et al., 2004). Across the Australian tropics, generally only those catchments with mining, industrial, or intensive agricultural development have information available on the ecology, biology, geomorphology, hydrology and management opportunities. This information is fragmented and insufficient for addressing the management needs of the future. The key knowledge gaps include: ecological character; assets and threats; and management structures.

In order to address some of these knowledge gaps, the Australian Government (Land & Water Australia and the Natural Heritage Trust II) has funded a project titled *Australia's tropical rivers — an integrated data assessment and analysis*. This project is being conducted by the National Centre for Tropical Wetland Research and will: establish an information base for assessing status and change; undertake ecological risk assessments of major pressures; and trial a framework for the evaluation of goods and services provided by wetlands, as perceived by multiple stakeholders, including local and indigenous people, private sectors and governmental agents.

Forested sand bed creek, Ngarradj (Swift Creek), Northern Territory. Photo courtesy Mike Saynor.

Objectives

Specific objectives of the project are to:

- compile a multiple-scale inventory of the habitats and biota of the rivers and wetlands of tropical Australia through the use of an integrated GIS, and where necessary develop and/or ensure consistency with other suitable typologies based on hydrological and landform features.
- develop a risk assessment framework and undertake risk analyses for key catchments/significant locations and pressures, which meet stakeholder needs.
- provide a framework for analysis of the ecosystem services provided by the habitats and biota of the rivers and wetlands of northern Australia.

Approach

The approach encompasses a desk-top analysis and a targeted field-based component spanning northern Australia and extending across jurisdictional bounds. Consultation processes are embedded throughout the project.

Multiple-scale inventory

The specific tasks in conducting the multiple-scale inventory involve collation and interpretation of existing biophysical data for the region, and targeted field sampling. The basis of the model being used has been developed within Australia and is subject to international critique through the Ramsar Wetlands Convention and associated international mechanisms. The model has previously been applied to the Asian Wetland Inventory. The approach uses an integrated GIS, which enables analyses at several scales through the use of remotely sensed imagery, core and interlinked datasets and suitable habitat typologies.

Risk assessment framework

There are a number of key elements in developing the risk assessment framework that will be addressed. Firstly, identification of assets and threats within the focus catchments will be

undertaken through a combination of consultations with stakeholders and a review of existing reports and management plans. Both spatial and aspatial data related to assets and threats will also be collated. The spatial data will then be compiled in a GIS, linked to the inventory. Secondly, conceptual models for each of the focus catchments will be developed, focussing on the interactions between key assets and threats. Finally, both semi-quantitative and quantitative risk analysis will be conducted on selected threats.

Framework for analysis of ecosystem services

The work related to this sub-project has been carried out by six postgraduate students from the University of Wageningen, The Netherlands. The catchments selected for developing the ecosystem services framework were the Mary River and Douglas-Daly catchments, Northern Territory. The students collated existing information and consulted with the many stakeholders within these catchments. Some of the framework has been populated with specific information and is currently being drawn together in a synthesis report.

Communication and consultation

Consultation to date has involved establishing contacts with agencies, boards and representatives panels in WA, QLD and the NT to introduce the project and seek collaboration and support, and access to information. A project Steering Committee composed of key stakeholders, regularly reviews and discusses the project's directions and progress. A stakeholder workshop was held in Darwin in November 2004. The workshop was well attended by stakeholders representing government, non-government, indigenous, industry and research interests. Another stakeholder workshop is planned for later this year. All consultation is based on a communications plan and includes the ongoing exchange of information, collaboration, reporting and demonstrating initial outcomes.

Outcomes

The key outcome of this project will be increased knowledge of the status of aquatic ecosystems and the pressures that they face in an era of increased expectations of resource development. The knowledge base will be made available to resource managers and researchers. Adoption of the integrated and multiple-scale model for inventory and assessment will enhance our national capability to influence national and international decisions that affect natural resource management. This will further build the expertise and leadership capability of scientists from northern Australia.

References

Australian Tropical Rivers Group, 2004, *Securing the North: Australia's Tropical Rivers*. A Statement by the Australian Tropical Rivers Group. Published by WWF Australia, Sydney.

Gehrke, P., Bristow, K., Bunn, S., Douglas, M., Edgar, B., Finlayson, M., Hamilton, S., Loneragan, N., Lund, M., Pearson, R., Prosser, I. & Robson, C. 2004, *Sustainable Futures for Australia's Tropical Rivers — A strategy for developing research directions for Australia's tropical river systems*, Outcomes from a forum at Charles Darwin University, 1–3 February 2004, CSIRO Land and Water Technical Report No. 17/04.

Storrs, M.J. & Finlayson, C.M. 1997, *Overview of the conservation status of wetlands of the Northern Territory*, Supervising Scientist Report, 116, Supervising Scientist, Canberra.

For further information

Dr Rick VanDam
Environmental Research Institute of the Supervising Scientist
Tel: (08) 8920 1175
E-mail: Rick.VanDam@deh.gov.au

***Left**: Norman River, Queensland. Photo courtesy George Lukacs.*
***Right**: Bed-rock confined upper reaches of the Mitchell River, Western Australia. Photo courtesy Mike Saynor.*

FRESHWATER NEEDS of estuaries in the Gulf of Carpentaria:

FIGURING OUT WHAT WE NEED TO KNOW

By Julie Robins and Ian Halliday

Water is a limited resource in Australia and there is a growing need to use our water resources in the most efficient way to support agriculture, industry, our cities and towns, as well as our natural ecosystems. Most research into the freshwater needs of aquatic ecosystems has focused on freshwater areas in southern Australia, with this information being used to develop policies and methods of allocating environmental flows for temperate and sub-tropical rivers. Currently, State and Federal Governments are assessing the potential to develop the water resources of northern Australia, however, there is a need to understand what freshwater does in tropical rivers and their estuaries before any development proceeds. Conceptual models of the role of freshwater in tropical estuaries could be used to estimate the likely impacts of flow modification on fisheries and the industries that these resources support, such as commercial and recreational fishing and fishing-related tourism in northern Australia.

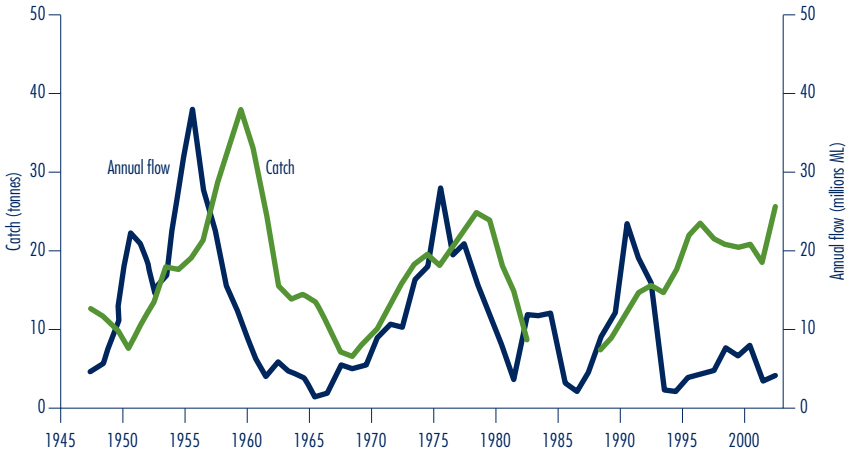
This project is designed to review the available data and to prioritise the critical knowledge required to enable informed sustainable development of tropical water resources, particularly those of the Gulf of Carpentaria, to take place. It has three objectives to:

1. Develop conceptual models of the links between water flow and estuarine-dependent fisheries for catchment types in the Gulf of Carpentaria.
2. Identify and review the value of current datasets relevant to these conceptual models.
3. Identify gaps in knowledge and research needs that would contribute to determining the freshwater requirements of estuarine-dependent fisheries in the Gulf.

By their definition, estuaries are the places where freshwater meets saltwater, and there are numerous species that depend on this interaction for the completion of their life cycle. To date, preliminary conceptual models have been developed for the role of freshwater on the life history of banana prawns, barramundi, mud crabs, king threadfin, grey mackerel, mullet and inshore shark species. For example, we now know that in the Fitzroy River on the east coast of Queensland, catches of barramundi are strongly correlated with freshwater flows (Figure 1). Our work shows that this is a result of freshwater flows enhancing the number of young-of-the-year (i.e. baby) barramundi that survive and then grow to enter the fishery (Staunton Smith et al., 2004). In the case of banana prawns (Figure 2), we now have a large amount of evidence that freshwater flows influence their movement downstream, and the subsequent catch in commercial fisheries (Vance et al., 1985; Robins et al., 2005).

Further input into these conceptual models is now being sought from scientific experts, fishers, and other key stakeholders with knowledge of estuarine systems in the Gulf of Carpentaria.

***Figure 1 (below)**. Barramundi catch and freshwater flow for the Fitzroy 1945 to 1980.*
***Figure 2 (right)**. Banana prawn catch in the Gulf of Carpentaria.*



FRESHWATER NEEDS of estuaries in the Gulf of Carpentaria

We have also collated metadata on 59 existing datasets held by CSIRO, State government agencies, universities and private individuals that are potentially relevant to the freshwater flow-fishery relationship in the Gulf of Carpentaria. Areas covered include species abundance and distribution surveys, fisheries catch, habitat distributions (i.e. mangroves, seagrass, saltpans); and flow and rainfall statistics. The metadata about these datasets will be reviewed to determine their relevance to the flow-fishery relationship. An assessment will also be made as to whether further analysis (e.g. in reports or published papers) will assist us to increase our knowledge about the role of freshwater flow in estuaries. We hope to have the collated metadata available on the web by July 2005.

The conceptual models we have developed for the Gulf of Carpentaria, in conjunction with the assessment of existing datasets, will be used to identify any significant knowledge gaps about how estuaries function in our Tropical Rivers. We will then use this information to identify the research that needs to be undertaken to enable us to determine the freshwater flow requirements of estuarine-dependent fisheries. Feedback on the relevance of these research needs will be sought from stakeholders in the Gulf of Carpentaria. It is hoped that this project will be a key input into any water allocation discussions concerning the future development of these important tropical rivers and estuaries.

Figure 3. *Recreationally caught barramundi.*

For further information

Ian Halliday or Julie Robins
Queensland Department of Primary Industries and Fisheries
Deception Bay Qld 4508
Tel: (07) 3817 9530
E-mail: ian.halliday@dpi.qld.gov.au

Selected references

Robins, J.B., Halliday, I.A., Staunton-Smith, J., Mayer, D.G. & Sellin, M.J. 2005, Freshwater flow requirements of estuarine fisheries in tropical Australia: a review of the state of knowledge and application of a suggested approach, *Marine and Freshwater Research*, vol. 56, pp. 1–18.

Staunton-Smith, J., Robins, J.B., Mayer, D.G., Sellin, M.J. and Halliday, I.A. 2004, Does the quantity and timing of freshwater flowing into a dry tropical estuary affect year-class strength of barramundi (*Lates calcarifer*)? *Marine and Freshwater Research*, vol. 55, pp. 787–797.

Vance, D.J., Staples, D.J. & Kerr, J.D. 1985, Factors affecting year-to-year variation in the catch of banana prawns (*Penaeus merguiensis*) in the Gulf of Carpentaria, Australia. *J. Cons. int. Explor. Mer*, vol. 42, pp. 83–97.

STOPPING the cane toad invasion of the Kimberley

By Lee Scott-Virtue, Dean Goodgame and Andrew Storey

The invasion of the cane toad into Kakadu National Park in the Northern Territory is negatively impacting on aquatic and terrestrial biodiversity. The localised extinction of the Northern Quoll and potential localised extinction of the freshwater crocodile, water monitor and other animal species, as well as the threat to fragile eco-systems may eventually impact on the World Heritage Listing of this Australian icon. Scientists have only barely scratched the surface of what may also be happening at the invertebrate level as a result of competition with cane toads, with this level being the building blocks for sustainable biodiversity. Small reptiles are also under threat as the cane toads compete for their staple diet of ants, beetles and other small arthropods. There is growing concern that the cane toad is having a much greater impact at this level than first thought.

Currently, cane toads are at the Victoria River and at estimated rates of advance, the Kimberley are only six months to two years away from an invasion. If the cane toad is allowed to cross the WA border it will immediately have a devastating negative impact on the fauna and the ecosystems of the Kimberley region. It will also impact on Aboriginal culture and everyday life, and on the social and economic well being of the Kimberley community as a whole. Aboriginal communities living in Kakudu and other parts of the Northern Territory have watched the gradual extinction of bush foods such as Little Mertons Monitor and other reptile species. Concern over water quality (cane toads poisoning the water) and a gradual loss of animal

Cane toad (Bufo marinus)

'bush tucker' has had a major impact on traditional spiritual and cultural activities. Many communities have stopped taking the young people into the bush to 'learn' about hunting and fishing (quote from Ju Ju Wilson, Mirriuwong elder, talking about family members living in Katherine). This same concern about the future is being expressed by Kimberley Aboriginal people.

A Community and Scientific Forum on Cane Toads was held in Kununurra on 19 and 20 March 2005. Sponsorship for this forum came from community members, local business people and government agencies (see the website www.canetoads.com.au). Sixteen scientists and specialists were invited to speak at this Forum. Community groups and individuals were also asked to mount educational displays for the

"It is important to realise that the pristine aquatic and terrestrial habitat systems of the Kimberley are already under threat. Kimberley flora and fauna and many of our aquatic systems are in a fragile state due to consistent poor government management decisions such as aerial burning. The impact of the cane toad in the Kimberley, if allowed to happen, will literally destroy one of the last biodiversity wilderness frontiers in Australia".

Community Day of the event. Aboriginal elders from various regional Language Groups opened the 'community' and 'scientific' days, addressing their concerns about what the cane toad will do to their food resources if allowed into WA.

The Forum was split into a 'community' and a 'scientific' day. The aims of the community day were to raise community awareness, and involved displays of cane toads for people to see what they look like (to avoid mis-identifications and accidental culling of native species), information pamphlets, posters and cane toad t-shirts, movies on cane toads, informative presentations, and examples of traps for controlling cane toads. The scientific day brought together researchers to discuss latest findings on cane toad biology, impacts on native fauna, means of control, monitoring approaches, likely pathways from the NT into the Kimberley, and an action plan of appropriate and most effective strategies and management decisions that might stop, or at best delay and minimise the cane toad invasion in the Kimberley. The listing of the cane toad as a Key Threatening Process under the *Environmental Protection and Biodiversity Act 7.07(b) 1999* was also raised.

Kimberley identity Malcolm Douglas and author Tim Winton flew to Kununurra to lend their support to the Kimberley communities commitment to stop the cane toad from crossing the WA border. At the Forum it was agreed that cane toads would invade WA unless immediate action was taken to halt their progress. Some of the key resolutions that came from the meeting were that:

~ the communities of the Kimberley do not want cane toads in the region.
~ every possible means of preventing the invasion by cane toads should be immediately implemented.
~ control should commence from the Victoria River (NT) and not at the WA border.
~ the ecological, economic (including tourism, ecosystem services), cultural (including lifestyle and community) and social (including health and family) values of the Kimberley Region, and subsequently the rest of WA will be diminished by cane toads.
~ loss of biodiversity would occur if cane toads invade the Kimberley Region.

It was also agreed that there is insufficient information on the potential impacts of cane toads to ensure proper protection of the ecological values of wetlands listed as of International Importance under the Ramsar Convention; namely Lakes Argyle and Kununurra, and the Lower Ord River.

***Above and opposite**: Colourful displays were used to raise awareness about cane toads. Cage full of cane toads for second caption, all photos Lee Scott-Virtue.*

Those at the forum unanimously endorsed these resolutions, and recommendations based on them were developed. As a direct result of the recommendations that came out of the Kununurra Cane Toad Forum, and interest by the public in the significance of the impact of the cane toad on the Kimberley and WA in general, a number of strategies have been implemented.

1. Primarily, it has been agreed by community and local government agencies to draw on the expertise and research currently being undertaken by Northern Frogwatch and other researchers in the Northern Territory. Kimberley Specialists, Conservation WA and other private agencies have affiliated with the Northern Frogwatch objective to 'stop the Toad' at the Victoria River. Conservation WA have initiated a 'STOP THE TOAD' forum in Perth on 4 June, and Graeme Sawyer from Northern Frogwatch will outline how we can use both trapping and other methods to 'block-off' the main corridors of entry into WA.
2. The pending publication (by Kimberley Specialists) of the scientific papers presented at the Kununurra Forum will be available

shortly and will provide a solid baseline information data for WA scientists.

3. The listing of the cane toad as a Key Threatening Process under the *EPBC Act* (and one of the projected outcomes from the Kununurra Forum) has now been pushed through.
4. The release of a promotional DVD produced from the filming and recording we had done over the weekend of the Kununurra Cane Toad Forum will feature key outcomes from the meeting. It will feature interviews from influential people in the public eye and scientists, will emphasise community support and explain what the local community is doing to prevent the cane toad from devastating this region. The DVD focuses on the need to change the defeatist attitude that the cane toad cannot be stopped.
5. Dr Sarah Brett from Kimberley Vet Clinic and Kimberley Wildlife Rescue has volunteered her services for cane toad identification and euthanasia. Kimberley Specialists is looking at purchasing both a mobile and stationary freezer unit for temporary storage of cane toads at the vet clinic.
6. Kimberley Specialists will continue to update the website www.canetoads.com.au to provide the Kimberley and WA community of what is happening in the fight against the cane toad.
7. Private businesses such as Triple J Tours (run by Jeff Hayley) will continue to financially sponsor the Kimberley Communities fight against the cane toad. Without Jeff's commitment, Kimberley Specialists would not have been able to financially get the Cane Toad Forum 'off the ground' in the first place, and
8. A petition has been raised and tabled to the Legislative Council of the State Parliament of Western Australian asking the government to commit to assist the community in preventing the spread of cane toads into Western Australia.

For further information

Lee Scott-Virtue and Dean Goodgame
Kimberley Specialists in Research
Tel: (08) 9168 2576
E-mail: kimberleyspecialists@westnet.com.au
www.canetoads.com.au **or** www.kimberleyspecialists.com.au

Dr Andrew Storey
The University of Western Australia
Crawley WA 6009
Tel: (08) 6488 1482
E-mail: awstorey@cyllene.uwa.edu.au

Northern Australian IRRIGATION Futures

By Liz Chapman

The history of irrigation settlement in southern Australia has been a story of social and economic drivers, and engineering feats. Environmental considerations did not enter into the equation. It is not too late to ensure that *environmental sustainability* is the key driver for policy decisions about the expansion or contraction of irrigation in northern Australia.

At the instigation of the National Program for Sustainable Irrigation (NPSI) a major research project has commenced across northern Australia. Its aim is to understand the biophysical features of the northern tropical systems and describe a sustainability framework so that knowledge is available to guide debate and decision making. From this provision of information, the many different interest groups — all of whom have strong views about the future of northern Australia — can debate their positions.

Partners in the Northern Australia Irrigation Futures (NAIF) research project include the Commonwealth, Queensland, Western Australia and Northern Territory Governments, the CRC for Irrigation Futures (CRCIF) and NPSI. The project is also linked with Land & Water Australia's Tropical Rivers Program, NRM regional bodies, local governments and communities across northern Australia. CSIRO Land & Water and the CRCIF are project partners, and have responsibility for undertaking the design and development of the research, headed by Dr Keith Bristow and informed by a Steering Committee and Stakeholder Reference Group.

"The task is multi-faceted and difficult, but it has to be done if the environment is to receive proper consideration in debate and decision making regarding the future of irrigation in northern Australia" said Principal Investigator, Dr Keith Bristow. "The first year has been largely devoted to engaging with a wide range of stakeholders to confirm research directions and priorities. The value of the research, in the end, will be the transparency it brings to the debate and decision making as everyone will be able to access the same, rigorous information."

Biophysical issues that need to be addressed when considering irrigation within a whole-of-systems and catchment context include the source and availability of water, variability in supply, the types of soils and landscapes, surface-groundwater systems and interactions, environmental flow requirements, and likely on- and off-site impacts of implementing a particular irrigation system and management structure.

One of the first steps has been to research and initiate development of a sustainability framework that can be applied to any given area. Given the variations between catchments and

Drysdale River. Photos with this article Heather Chapman.

Boab tree.

regions across the top-end, the framework will involve a set of tools and processes which recognise the different kinds of knowledge required to address visioning, planning and assessment, and monitoring and reporting. Its function will be to help frame the questions, considerations and indicators when thinking about irrigation in a given area. A background paper on Indicator Frameworks (Kellett, B., Bristow, K.L. & Charlesworth, P.B. 2005) can be accessed via the NPSI Knowledge Base www.npsi.gov.au or via the project's website www.clw.csiro.au/naif

"There are many interests and there is no doubt that this is a hot topic" said Program Coordinator for NPSI, Murray Chapman. "We have to steer a path so that science can play its part in informing decision making."

For further information

Liz and Murray Chapman
Program Coordinators
National Program for Sustainable Irrigation
Tel: 03 5763 3214
E-mail: rplan@mcmedia.com.au

NATIONAL PROGRAM FOR
Sustainable Irrigation

Bell Gorge with water monitor on rock.

The state of rivers will continue to be of paramount importance in a future of climate change, increasing populations and uncertain water supplies.

River*symposium* 2005 will focus on some of the pressing issues important to water and food security such as transboundary catchment conflicts and resolutions, water scarcity and urban and rural tensions over sharing water resources. Institutional and legal arrangements for river management will be featured along with work on rivers as corridors. We will continue discussions on living with floodplain rivers, maintaining and restoring native fish populations, polluted rivers and predicting and planning for climate change. Regular features of River*symposium* sessions on community involvement, dams, and the Thiess River*prize* finalists will return.

Keynote speakers

- Brian Richter, Director, Sustainable Waters Program, Freshwater Initiative, Nature Conservancy, USA
- Chief Roy Mussell, Fraser Basin Council and Chief of the Sto:lo First Nation in Canada
- Wolfgang Junk, Max Planck Institute for Limnology, Germany
- Dr Sally Driml, Climate Change and Economics, Environment Protection Agency, Australia
- Stefano Burchi, The Food and Agriculture Organisation of the United Nations, (FAO UN), Italy

Special sessions

- Water Partnerships: Australia, Asia and the Pacific
- The Great Debate: Scarce water in a growing world – can we make room for environmental objectives?
- Young Water Scientist of the Year
- The contribution of indigenous peoples to river and fisheries management
- Legal frameworks workshop
- The Yangtze River: challenges and experiences
- CPR for Rivers: the Victorian River Health Program: caring, protecting and restoring
- Healthy Catchments/Healthy Waterways: making the connections in South East Queensland

The 8th International River*symposium* will be held at Brisbane's Convention Centre from 6–9 September. For further information, booking and registration details visit:

www.riverfestival.com.au/symposium

Riverfestival

RAPt in rivers

COMING TO AN END…

National Riparian Lands R&D Program, National River Contaminants Program and National Rivers Consortium coming to an end…

These three Land & Water Programs are officially concluding in June 2005 this year, however, investment will continue to be made over the next eight to twelve months in a busy communications phase. A range of new products will be developed that synthesise key research findings, and ensures the legacy of these three Programs is maintained. To keep up to date with these new products check the website www.rivers.gov.au and of course, *RipRap*!

For further information

Dr Siwan Lovett
Program Coordinator
Tel: 02 6247 7997
E-mail: siwan.lovett@lwa.gov.au

WELCOME TO…

Tom Aldred has joined Land & Water Australia to take on the role of Landscapes Manager. He is on secondment from the Australian Government Department of Agriculture, Fisheries and Forestry where he has worked for the past ten years and has been inolved in the NRM policy taskforce that designed the National Action Plan for Salinity and Water Quality, and then almost two years establishing the joint departmental team responsible for implementing the National Action Plan. He has also worked in rural support and adjustment (including the Agriculture – Advancing Australia package), Regional Forest Agreements and in Ministerial Offices. His early career was spent as a field forester with NSW State Forests.

Oh the times, they are a changing……

Well, I think we all feel the need for a make-over or a 'renovation rescue' at some time or other, and Land & Water Australia is no exception. Over the next few months a new 'look' for Land & Water Australia will be phased in, with the new Programs in our Landscapes Arena — Tropical Rivers and Environmental Water Allocation — rolling out the change. So that we can keep the body of work together that the National Riparian Lands R&D Program, National River Contaminants Program and National Rivers Consortium have invested in, we are going to continue the 'River Landscapes' look and feel through to the end of the year. This will mean that all the new products being developed from the research in these Programs will be easy to identify, so watch out for a whole range of Fact Sheets, Manuals, CDs and more that will be available over the next twelve months.

new River and riparian fact sheet

Fact Sheet 13 – Managing riparian widths to achieve multiple objectives

The question that landholders and other river managers ask most frequently when discussing riparian areas is "How wide does it need to be?" In this Fact Sheet, we have tried to respond to this question by bringing together information from a variety of sources about the different widths of riparian vegetation required to achieve different purposes or management objectives. Although there is a broad consistency about the general widths recommended for riparian areas, there are differences depending on the aims being sought, location and the regulatory framework that governs the area. This Fact Sheet provides approximate guides for achieving different management objectives in riparian areas, as well as highlighting where to go for further information and technical expertise.

It is available from CanPrint Communications 1800 776 616 and on the website www.rivers.gov.au

PROJECTS IN THE ENVIRONMENTAL WATER ALLOCATION PROGRAM

Contracts have recently been signed for the first two projects within the Environmental Water Allocation Program. Six more projects are currently being assessed.

Natural resource buy-backs and their use to secure environmental flows

(BDA Group and Ms M. Scoccimarro)

Water management authorities are currently investigating methods for securing increased water for environmental purposes in the Murray Darling Basin in response to COAG agreements to increase environmental water allocations. There are a number of options being considered, including the possible buying back of water allocations on a short-term or long-term basis.

This project will investigate potential buy-back schemes by reviewing experiences with buy-backs in other sectors and then developing alternative designs that will be discussed at a workshop. Management authorities will be closely involved in the implementation of the project. Stakeholder views will also be obtained through a questionnaire. The buy-back designs that emerge from this analysis will be passed onto water management authorities for their consideration. Any buy-back designs will be designed to:

- account for temporal differences when water is of greatest value to the environment,
- be consistent with prevailing institutional arrangements but adaptive to future reforms,
- share uncertainty and risk between environmental managers and other water users, and
- ensure that other issues, such as salinity, can be factored into purchasing strategies.

The project will commence in May 2005 and will be completed by May 2006.

Water regime dependence of fish in the wet-dry tropics

(Dr M. Douglas, Charles Darwin University, Darwin)

While there has been considerable research conducted into the environmental flow needs of the more heavily stressed rivers of south-eastern Australia, there has been comparatively little research into the flow needs of the environment of rivers in tropical Australia. Some of these rivers are coming under increasing pressure for development.

This project will provide information on the flow needs of freshwater fish in the Daly River of the Northern Territory and will complement earlier Land & Water Australia supported research into the flow needs of invertebrates in this river. Information will be obtained from both sampling studies and collaboration with Aboriginal traditional owners. The project outputs will include:

- a record of indigenous knowledge about fish distribution and ecology,
- information on the identity, distribution and ecology of fish in the Daly River Region,
- a conceptual model describing the role of the dry season flow regime in driving spatial and temporal variation in fish community structure and function drawing on over the range of historical rivers flows,
- recommendations to the NT Government on the minimum flow requirements to protect fish species and critical freshwater habitats,
- a program to monitor the ecological outcomes of altered flow regimes, and
- a predictive model which can be used determine the likelihood of particular outcomes of water allocation scenarios on freshwater fish.

While the project will draw on indigenous knowledge, this information will not be publicly available without the approval of traditional owners.

The project will commence in early June 2005 and will be completed in April 2009.

For further information
Richard Davis
Program Coordinator
Tel: 02 6273 1484
E-mail:
richard.davis@lwa.gov.au

PARTICIPATORY research to incorporate

By Susie Williams

There is growing recognition and understanding of the differences between Western and indigenous knowledge frameworks. Investigation of indigenous knowledge has highlighted the complexity of values held by Aboriginal people associated with land and water. This has led to greater recognition of different knowledge systems and the more non-utilitarian values associated with environment.

Aboriginal people are in control of a growing amount of land across Australia and are currently trying to maintain (or re-establish) their traditional responsibilities to country. Land & Water Australia currently funds several indigenous-focused natural resource management research projects within Tropical Australia to enable Aboriginal people to be more meaningfully involved in driving national resources management (NRM) priorities. Indigenous knowledge is highly integrative and 'place' specific and '*depends on Country for its context and significance*' (Robin pers. comm., 2004). In contrast, Western knowledge often seeks abstract concepts that can be more universally applied across time and space. Aboriginal people have a living relationship with country that informs their view of landscape and land management. The strong link between place and knowledge makes extrapolating research outcomes a challenging process, especially taking into consideration sensitive knowledge, intellectual property and the context within which they exist.

Last December, Land & Water Australia convened a Research and Development Forum in Darwin bringing together lead researchers to integrate learnings from across their suite of indigenous-focused projects. Among the forum presentations were projects focused on tropical rivers — David Morgan, *Biodiversity and cultural significance of fishes in the King Edward River* (page 28); Jean Fenton, *Fish passage along the Fitzroy River* (page 30); Sue Jackson, *Addressing indigenous cultural requirements in water allocation planning* (pages 32); Patrick O'Leary, *Indigenous research priorities for tropical rivers* (page 34); and Naomi Rea, *Recognising indigenous cultural values and rights to water* (*RipRap* Edition 27).

The objective of the forum was to focus discussion on new knowledge and approaches currently emerging in this research field. The themes highlighted were complex and the following is a brief overview of the discussions about how to incorporate indigenous knowledge into NRM.

Catching fish with a throw net and learning indigenous names and understanding of the river and the fish that swim in it. Photo David Morgan.

indigenous knowledge into NRM

Participation research

A participatory research approach has been developed for NRM projects with an aim to more directly target audiences and participants through their involvement in activities and decision-making. It is well-known that peoples' capacity to embrace change or new practices is directly linked to how much control they have over that change. Participation is an effective means to engage with stakeholders and project participants in such a way that knowledge adoption (research uptake) is embedded within projects. By participating in the research process, people are in control of their contribution and they can see tangible, local benefits for their involvement while building skills and interest on the ground. This ensures that knowledge outcomes from projects are taken up by the people living on and managing Country. Knowledge can also be better managed by the custodians of intellectual property via a participatory approach.

Knowledge management

Indigenous people see an intrinsic link between knowledge (information) and 'place' and therefore reapplying (or removing) traditional knowledge from its context is considered largely inappropriate. Western knowledge systems often seek universal information, which aims to be applied across landscapes and are not specific to 'place'. This raises fundamental issues for the collection, storage and use of data and knowledge acquired through dual knowledge projects. The protection of indigenous knowledge is a critical issue in research, and protocols and approaches are being developed to address this.

Multidisciplinary approach

The strongly integrated nature of traditional Aboriginal land management acknowledges the interdependence of culture, society, health, economy, environment, and people, all with equal importance. Western science has traditionally partitioned knowledge and separated out research strands, but in more recent times an attempt at understanding systems more holistically has pushed 'systems thinking' back into the popular domain. Multidisciplinary projects are thus evolving to suit this need, and are particularly relevant in indigenous-related research to interpret hypotheses from different perspectives.

Building relationships

In indigenous culture, building relationships is seen as vitally important for developing meaningful lines of communication. Participation and capacity for involvement at a local level relies on strong and ongoing relationships between researchers and project participants. This means that projects need to be long term and conducted over years rather than months, and require strong commitment from funding bodies and research organisations.

Language

Language is a barrier in cross-cultural research and often complex ideas cannot be easily translated across languages. Often English is a second, third or fourth language for Aboriginal people involved in projects. Indigenous language relates strongly to context and can further explain why extracting data and knowledge from a specific place is often inappropriate. Western language within the NRM field can be esoteric and laden with acronyms so careful consideration of 'industry' language is needed for effective communication between researchers, participants and across disciplines.

In summary

NRM projects aim to build the capacity of (or empower) the local community to manage change to the environment within their sphere of influence. Research within a cross-cultural context must therefore incorporate dual knowledge systems for effective engagement of participants and successful communication to both cultures. Researchers recognise traditional ecological knowledge as distinctive, valuable and applicable to current land and water management. A more widespread recognition of this is needed at all levels of management (from ground-based activity, through to government or research organisations, and funding bodies) to build institutional and public community value, and strengthen mainstream understanding, of indigenous knowledge.

For further information

Alice Roughley
Program Coordinator
Tel: 02 6263 6000
E-mail: alice.roughley@lwa.gov.au

BIODIVERSITY and cultural significance of the fishes

By David Morgan and Margaret Sefton

This project involves Murdoch University's Centre for Fish & Fisheries Research, the Kimberley Language Resource Centre and traditional owners of the north-western Kimberley, the Belaa, Ngarinyin and Wunambal-Gaambera people. This project aims to not only further our knowledge on the fishes found in the Kimberley, but is recording information regarding traditional knowledge (i.e. names and cultural significance) of the fishes.

During October and November 2004, 30 sites on the King Edward and Carson Rivers, in the northern Kimberley region of Western Australia, were sampled for fish. A total of 24 fish species were recorded in the catchment (this includes a species of rainbowfish captured in the adjacent Dominic Creek but not recorded in the King Edward or Carson Rivers). Species captured were photographed and the Ngarinyin and Belaa names were recorded for most of the fish species captured. Pansy Nulgit, Morton Moore, Dolores Cheinmora and Agnes Charles provided the location of sites in Ngarinyin and Kwini (Belaa) country, and recorded Ngarinyin and Belaa names of fish.

The next sampling trip is scheduled from mid-June to mid-July and will involve the Wunambal-Gaambera people.

There appeared to be a substantial difference between the fish fauna associated with the upper King Edward when compared to the Carson and Morgan Rivers. For example, the sites sampled in the King Edward were dominated by spangled perch, western rainbowfish, black bream (Jenkin's grunter), long-nose grunter, Hyrtl's tandan, false-spotted gudgeon, an unidentified species of glassfish and also possibly Rendahl's catfish (requires verification). In contrast, the Carson and Morgan rivers were far more diverse with not only the above species captured, but also barramundi, silver cobbler, lesser-salmon catfish, black catfish, Macleay's glassfish, Prince Regent hardyhead, oxeye herring, seven-spot archer fish, flathead goby, bony bream, Butler's grunter, barred grunter, mouth almighty, longtom and a restricted species of gudgeon (slender gudgeon).

The posters of fish species found in the Fitzroy River (west Kimberley) and a poster of the likely freshwater fish species in the Carson and King Edward Rivers were distributed to community members in Mount Barnett and Kalumburu. This generated interest in developing fish posters for these regions, and documenting scientific and language names for fish.

Belaa is a Non-Pama-Nyungan language spoken by about 30 adults in Kalumburu. It is likely that there are less than 20 fluent speakers of Belaa, and Kwini Elders have been documenting their language and stories in the hope that this work may help future generations. The production of fish posters documenting the names of fish in Belaa and English is seen as a useful way of helping to ensure that children will know and remember these names.

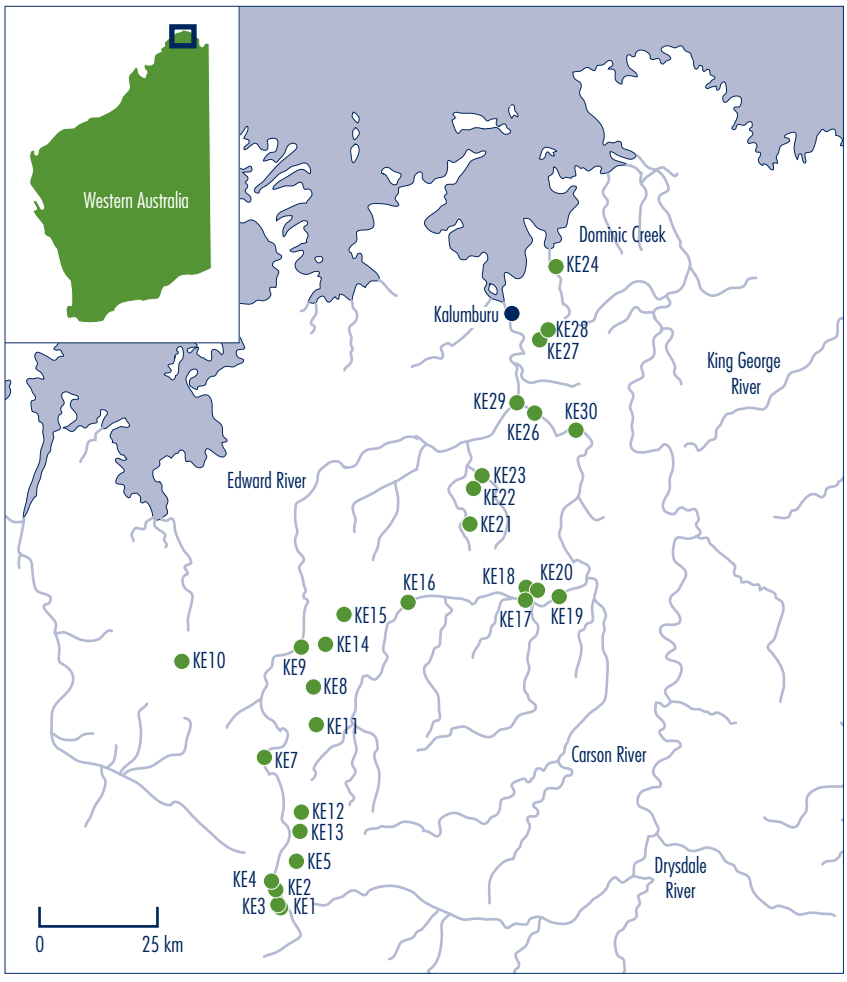


***Figure 1**. Sites sampled for fish on the King Edward and Carson Rivers.*

in the King Edward River, Kimberley

Milyengki, Carson Pool, Dolores Cheinmora and Agnes Charles

Dolores Cheinmora: Nyarrinjali, kaawi-lawu yarn' nyerreingkana, Milyengki-ngûndalu. Waj' nyerreingkana, kaawi-ku, kawii amûrike omûrung, yilarra a-mûrike omûrung.
Agnes Charles: We are here at Milyengki looking for fish. He got one barramundi, a small one. Yilarra is the barramundi's name.

Dolores Cheinmora and David Morgan at the Carson River. Photo David Morgan.

Dolores Cheinmora: Wardi-di kala' angbûnkû naa?
Agnes Charles: Can you see the fish, what sort of fish is that?
Dolores Cheinmora: Anja kûkûridingei, Kalamburru-ngûndalu.
Agnes Charles: This fish, the barred grunter, lives in Kalumburu areas.

*Barred grunter (*Amniataba percoides*). Photo David Morgan.*

Belaa has also been referred to as Kwini/Kunin/Kuniyen by speakers of the language and is regularly referred to as "My Mother's language" or "My Grandmother's language" rather than being described using a specific term. Kwini is a directional term meaning "from the sunrise side" and Kwini Elder Dolores Cheinmora distinguishes her language, Belaa, from her tribe, the Kwini. Gaambera and Winambal/Wunambal are neighbouring languages that are closely related to Belaa. There are also close connections with the language spoken in the Oombulgurri area.

Murdoch University, the KLRC, together with the Kimberley Land Council have been collaborating on a number of projects since 2001 that relate to fish diversity and their cultural significance in Kimberley rivers. The KLRC works closely with communities to support projects which help to maintain indigenous languages throughout the Kimberley. This project would not have been possible without the financial support of Land & Water Australia and special thanks go to the traditional owners that made it possible to work on their country.

For further information

David Morgan
Centre for Fish & Fisheries Research
Murdoch University WA 6150
Tel: (08) 9360 2813
E-mail: d.morgan@murdoch.edu.au

Margaret Sefton
Kimberley Language Resource Centre
Halls Creek WA 9770
Tel: (08) 9168 6005
E-mail: info@klrc.org.au

FISH PASSAGE on the Fitzroy River in the

By David Morgan, Dean Thorburn, Jean Fenton and Leith Bowyer

The Fitzroy River is home to a unique assemblage of fishes, a number of which are endangered. Recent studies by the Centre for Fish and Fisheries Research at Murdoch University, the Kimberley Land Council and the Kimberley Language Resource Centre have demonstrated not only the importance of the Fitzroy River as a critical habitat to a number of these species but also that at least one, the Freshwater Sawfish (*Pristis microdon*), is an icon to the river and is culturally significant. The Freshwater Sawfish (which grow to almost 3 metres in the river) is listed as **Endangered** on the International Union for Conservation of Nature and Natural Resources (IUCN) Red List and as **Vulnerable** under the *Environment Protection and Biodiversity Conservation (EPBC) Act*. Elsewhere they have undergone massive population declines and the Fitzroy River has been identified as holding one of the last known viable populations. Other species in the river that are listed by the IUCN include the Northern river shark (*Glyphis* sp. C), the Freshwater whipray (*Himantura chaophraya*), the Dwarf sawfish (*Pristis clavata*), the Barnett River gudgeon (*Hypseleotris kimberleyensis*) and Greenway's grunter (*Hannia greenwayi*).

Covering almost 90,000 km^2, the Fitzroy River catchment is relatively uncleared, non-saline and is largely unregulated. The barrage, approximately 100 kilometres upstream of the limit of tidal influence, is the only major artificial obstruction to fish migration in the river. While recent studies have demonstrated that Freshwater sawfish use the river as a nursery, with all of those in the river being immature, the presence of the barrage is thought to severely affect the upstream migration of not only this species, but also other important food fishes such as Barramundi (*Lates calcarifer*).

Depending on flood levels resulting from the wet season, the barrage may be impassable for fish for up to 10 months of the year, indeed, during the wet of 2005 it may have only been negotiable for a few weeks. As part of the assessment of the impact of the barrage, the Department of Environment is comparing the different magnitude of flow events, based on current and historical data and the efficacy of constructing a fishway is being discussed with the wider community. Monitoring of the fish fauna has demonstrated that there is a substantial difference between the species found above and below the barrage. For example, species that we caught immediately below the barrage but not above include Freshwater sawfish, Bull sharks (*Carcharinus leucas*), Oxeye herring (*Megalops cyprinoides*), Diamond mullet (*Liza alata*) and Giant herring (*Elops hawaiiensis*). Each of these species is essentially of marine origin and they use the river as a nursery.

One Freshwater sawfish that we tagged in July 2004 at the barrage was recently (May 2005)

Kimberley Region of WA

caught below the barrage and has thus been trapped for almost a year. It will be another wet season before this species can move over the obstruction. It is worth noting that we also caught this same fish in November 2004 at the barrage, as well as two others that were tagged in July 2004.

We have caught numerous Bull sharks below the barrage and at times we observed them 'leaping' out of the water. Up to a maximum of 1.4 metres long, Bull sharks not only pose a threat to people swimming at the barrage, but one was found to consume a small sawfish and another a pig. Isotope analysis of the fishes below the barrage has also demonstrated that Bull sharks are a major predator of sawfish. Furthermore, this impediment to fish migrations has the potential to decimate year classes of Barramundi that move upstream after each wet, only to become trapped and predated on. Recreational fishing is also popular at the barrage, and the majority of sawfish captured there had line around their rostrum. In order to aid in the maintenance of not only the sawfish population in the river, but also other migratory species, such as Barramundi, which are important to upstream communities as a food source, a fishway should be constructed on the barrage.

More information on the fish of the Fitzroy River and Freshwater sawfish is available at http://wwwscieng.murdoch.edu.au/centres/fish/

For further information

David Morgan and
Dean Thorburn
Murdoch University
South Street, Murdoch, WA
E-mail: d.morgan@murdoch.edu.au, d.thorburn@murdoch.edu.au

Jean Fenton
Kimberley Land Council
Derby WA
E-mail: jean.fenton@klc.org.au

Leith Bowyer
Department of Environment
Kununurra, WA
E-mail: leith.bowyer@environment.wa.gov.au

Images from left: The barrage, a Bull shark and (above) a Freshwater sawfish. Photos David Morgan.

ADDRESSING indigenous cultural requirements in water allocation

By Sue Jackson

A key question arising from the multifaceted re-evaluation of water resources brought about by the Council of Australian Government water reforms is: how are indigenous people's cultural values and requirements to be addressed and protected? Whilst rivers and wetlands are being recognised as legitimate 'users' of water, indigenous people's interests in environmental flows, including their traditional ecological knowledge, have tended to be neglected. This lag is being slowly addressed in a number of jurisdictions where resource management mechanisms have been adapted to recognise cultural values, most notably the concept of an environmental value or beneficial use under the National Water Quality Management Strategy. Other examples include the notion of a 'cultural flow' emerging from contributions to the Living Murray Initiative from the Murray-Darling Basin's Indigenous Nations (Morgan et al., 2003).

In a small number of north Australian catchments, water allocation processes are now endeavouring to acknowledge and protect indigenous cultural values of water and water-dependent ecosystems. However, where indigenous values have been considered, there has been a tendency to assume that a surrogate environmental flow will address cultural requirements. We do not know if this assumption can be relied upon, nor is it clear whether volumetric measures can address the less tangible values like the association between water and identity, heritage, spiritual well-being and belonging. How can resource managers be sure that water allocation decisions capture the full range of social values and not just those that are easy to measure or price?

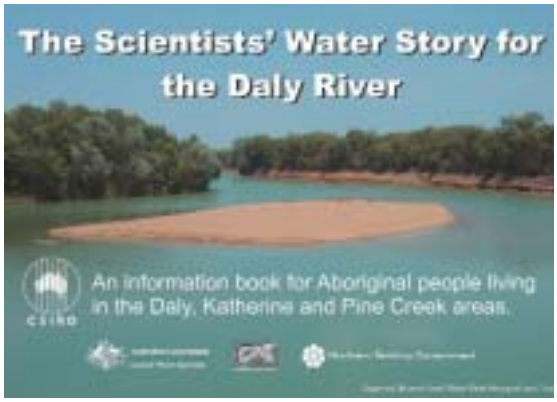
How can resource managers be sure that water allocation decisions capture the full range of social values and not just those that are easy to measure or price?

Preliminary research conducted in the Daly region, found the symbolic and intrinsic values of water were of great significance to the many resident Aboriginal language groups (Jackson, 2004). In this region, environmental planning exercises have triggered the production of a reasonable ecological knowledge base, while little effort has been devoted to understanding the nature of the cultural values and how they might be affected by potential changes to the flow regime brought about by increased water use.

This project, funded by Land & Water Australia, seeks to address issues arising from the application of a Western scientific approach to resource allocation in a cross-cultural situation. The objectives are to:

1. ensure Aboriginal people in a significant section of the Daly River catchment understand the contemporary water resource management regime, especially water allocation planning;
2. demonstrate how Aboriginal environmental knowledge can contribute to the determination of environmental water requirements;
3. define the indigenous cultural values of water and investigate the means for incorporating and protecting cultural values in the Daly River water allocation plan; and.
4. develop and communicate a generic framework and methods from the Daly experience for use in other tropical catchments, and elsewhere where indigenous interests are similar.

To date, we have been working towards satisfying the first goal of improving Aboriginal people's understanding of catchment management science and water planning. This has involved the production of the 'Scientists Water Story of the Daly River' — a plain English booklet with numerous diagrams and photos to explain hydrological concepts, a body of knowledge about water, how it is acquired, and its social and



cultural context. A cross-cultural approach to story-telling is appealing for two reasons. Firstly, it is understood as a communication process that leaves room for other culture's versions of reality, rather than assuming that the scientific account or explanation is the only one. Secondly, story-telling plays a powerful role in Aboriginal cultures, with much knowledge encoded in mythology, narratives, and song.

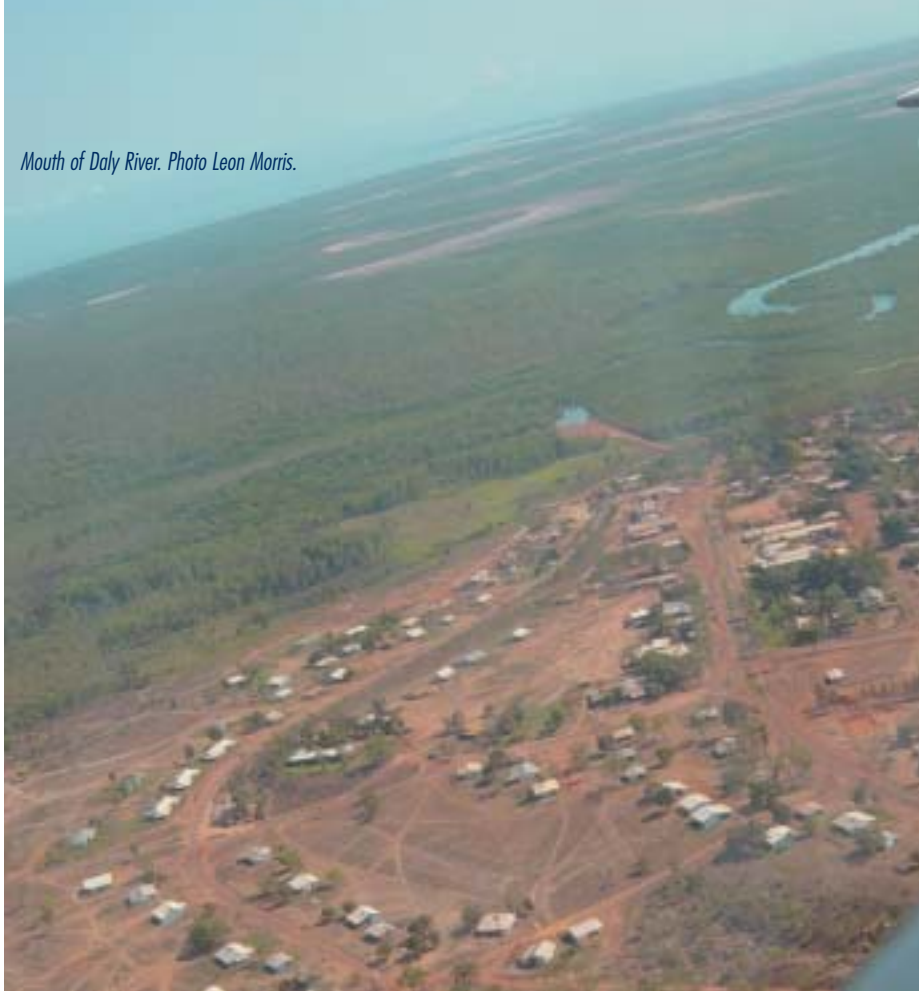
As traditional hydrological knowledge is revealed through the course of this project, further water stories will be developed, and the validity and worth of Aboriginal systems of knowledge enhanced. Individual language groups, of which there are ten in the catchment, may wish to tell their own story about the formation of the Daly river, the surface water-groundwater interactions, and the ways in which the river and its associated environments have changed over time.

The next stage of the project will require that we develop an inventory of riverine resources and values of significance to Aboriginal groups. It will be crucial to establish a link between the resources, values and flow regime, so that we can, for example, describe the seasonality-of-use and discharges that are important for resource maintenance. An Aboriginal research assistant will assist in the collection of this information and we will discuss with communities the best way of representing their knowledge to mutual benefit.

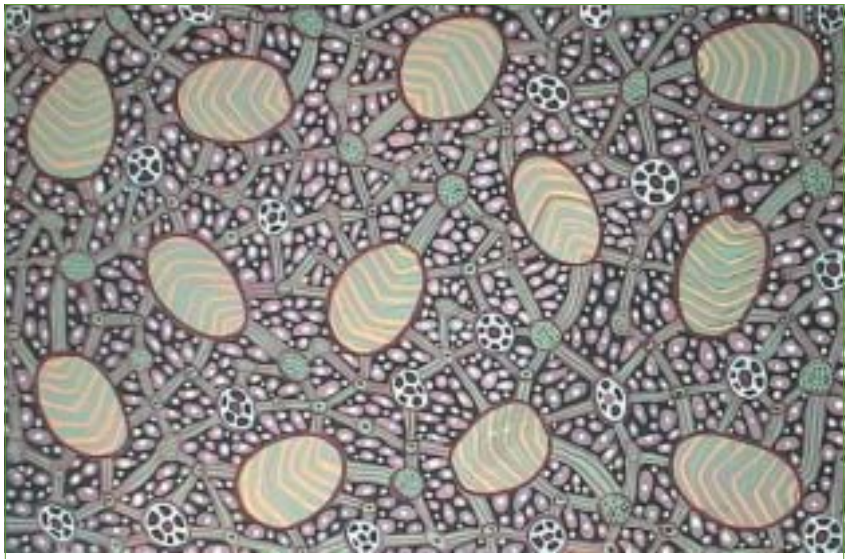
CSIRO is working closely with the peak Aboriginal organisation, the Northern Land Council, and the Northern Territory Department of Infrastructure, Planning and Environment, which has catchment planning responsibilities in the region. With a water allocation plan and integrated land-use plan currently under development, the research aims to assist an important sector of the community to better participate in catchment management decisions and to conserve their traditional knowledge for the benefit of future generations.

For further information

Sue Jackson, CSIRO Sustainable Ecosystems, Winnellie NT 0822
Tel: (08) 8944 8415. E-mail: sue.jackson@csiro.au



Mouth of Daly River. Photo Leon Morris.



***Patricia Marrfurra, Merrepen Arts, 'Marlarrggu (Long Neck Turtles)'**, acrylic on canvas, 60 x 40 cm. Young and old looked forward to the end of the dry season when the water in the billabong has receded and it is ready to go out and hunt for long neck turtles. A long pole is used to poke into the mud, when it hit a hollow sound, the foot is then used to trace the outline of the turtle. The hand then reaches down to pull the turtle out of the sticky mud. In the painting, Patricia Marrfurra shows the turtles camouflage among the stones and mud.*

References

Jackson, S. 2004, *Preliminary report on Aboriginal perspectives on land-use and water management in the Daly River region, Northern Territory*, Report to the Northern Land Council and Daly River Community Reference Group, Northern Territory Department of Infrastructure, Planning and Environment, Darwin, www.ipe.nt.gov.au

Morgan, M., Strelein, L. & Weir, J. 2003, Indigenous rights discussion paper: Living Murray Initiative, Report written in support of the Indigenous final report to the Living Murray Initiative, Murray-Darling Basin Commission, Canberra.

LOOKING AFTER freshwater country — Indigenous research priorities

By Patrick O'Leary

Indigenous people in Northern Australia have an intimate knowledge of tropical rivers and freshwater systems. Right across the North people depend on healthy rivers, wetlands and estuaries for food for subsistence including fish, freshwater turtles, waterbirds like magpie geese, and to provide fresh clean water for daily use. Water in all its forms is also culturally important. Groundwater, creeks and rivers, billabongs and estuaries, and the plants and animals that depend on them are not only vital for survival but an integral part of songs, ceremonies, hunting and collecting, and other activities that bind people to their country. Mythological accounts involving neglect of water management may operate as ecological warnings pointing to the need to manage and share water carefully (Jackson et al., 2005 in press).

Because people have these strong responsibilities and ties to their country arising from traditional law and everyday life, their interest in the health and management of freshwater country is intense. Historically, however, indigenous people have struggled to gain a seat at the negotiating table as important owners, users, and managers of Northern Australia's river and freshwater systems. While this is slowly changing, there are still many barriers to overcome. River research is an area where there needs to be greater acknowledgement of indigenous interests. Land & Water Australia has supported the North Australian Indigenous Land and Sea Management Alliance (NAILSMA) to produce a report on indigenous research interests and priorities for tropical rivers.

NAILSMA is the body formed by a coalition of Land Councils and other Aboriginal and Torres Strait Islander organisations with an interest in land and sea management in Northern Australia. NAILSMA's focus is to support indigenous people on country through their representative and other bodies to assist indigenous land and sea management right across the North. Currently hosted by the Cooperative Research Centre for Tropical Savannas, NAILSMA is building its profile with indigenous land and sea managers and other stakeholders in Australia's North.

NAILSMA has contracted the CSIRO Sustainable Ecosystems group in Darwin to undertake the research to inform Land & Water Australia's Tropical Rivers Program. CSIRO will produce a report aimed at assisting Land & Water Australia to shape the Tropical Rivers research program so that it will effectively engage with the North Australian indigenous community and their research interests.

Meeting of Aboriginal people from the Daly River, 2004. Photo Northern Land Council.

for tropical rivers

While the project is still at early stages, it will have a number of components including:

- an information brochure to be circulated to interested indigenous organisations and individuals in the Tropical Rivers program area explaining the project, introducing the Tropical Rivers program, and posing a number of questions about river research and use to think about;
- a series of interviews with Aboriginal organisations across WA, NT and Qld discussing river usage, regional issues and priorities for research;
- a combination of meetings, workshops and case studies focussing on particular river catchments to see what the local on-ground issues are and how research might help. The emphasis will be on research that can provide useful information across Northern Australia, even though it may be concentrated in particular regions; and
- a review of the management arrangements across Northern Australia including legislation, government policy, natural resource programs and other arrangements to see how well they serve indigenous people.

Some of the questions that will be used to assist people in thinking about their input include:

- How do you tell whether the rivers in your area are healthy?
- Have the rivers changed in your lifetime/ experience-if so how? What has caused this?
- How does this affect indigenous people in the area?
- Is there any information you would like to help you in keeping your rivers healthy?
- How do you think rivers could be used in the future? How would you like to see rivers in your area used?
- Have people in your area been involved in research? What kind of research?
- Has the experience of research in your area been a good or a not-so-good experience? Why? What could make research practices better?
- What kind of research would you/your organisation like to see done on rivers, groundwater, wetlands, estuaries?
- How would you/your organisation like to be involved?

The project team will be talking to relevant organisations and their stakeholders throughout the North from May and June, and aim to deliver a final report later this year.

If you would like further information about this project

Patrick O'Leary
CSIRO Sustainable Ecosystems
Winnellie NT 0822
Tel: (08) 8944 8447
E-mail: patrick.o'leary@csiro.au

Joe Morrison
NAILSMA (North Australian Indigenous Land and Sea Management Alliance)
Tel: (08) 8946 6702
E-mail: joe.morrison@cdu.edu.au

Reference: Jackson S., Storrs M., & Morrison J. 2005, in press. 'Recognition of Aboriginal Rights, interests and values in river research and management perspectives from Northern Australia', *Ecological Management and Restoration.*

PROVIDING water resource information

By Ursula Zaar

In 1996, the first of a series of mapping projects was started by the Water Resources Branch of the Department of Infrastructure, Planning and Environment NT (DIPE) with the aim of providing water resource information to the people of the Top End in a form which is readily understood by all and which would encourage participation in natural resource management decision making.

The first such project was the East Arnhem Land Water Study. It was the brainchild of Mr Peter Jolly who recognised the need for water resource information to be made readily available to land managers, in particular the people of Arnhem Land and their representative organisations, as they were becoming more actively involved in formal land and water management. It was acknowledged that Aboriginal people face a difficult challenge, in that they must be able to make land use decisions which not only provide material and economic benefits, but also ensure that their society and culture, and the environment in which it operates, remains healthy and strong. At the time, water resource information produced by the NT Government for the region was highly technical and very site specific, targeted at obtaining supplies for a community or town. Reports were written for an audience of engineers, scientists and planners. The reality was that the majority of the audience for this project would not have completed year 10 [1] and English may not be their first language.

1 Boughton, B. 2001, Popular education, capacity-building and action research: Increasing Aboriginal community control of education and health research, CRC for Aboriginal and Tropical Health Occasional Paper, Issue No. 5, Darwin.

Swimming hole at Mandillbareng, West Arnhem Land.

Funding for the study and others that ensued was primarily obtained through the Natural Heritage Trust, the NT Government and ATSIC with the Northern Land Council (NLC) assisting with liaison. With a focus on user friendly products, a field program was initiated to not only ascertain the water resources of the region but also to liaise closely with the people in determining the structure of the maps. The approach adopted was one of cross cultural education. Scientific understandings and indigenous people's view on water were to be presented. The indigenous perspective was of primary importance if products were to be presented in a relevant way. The approach made a start to addressing what are common issues faced by indigenous people the world over, namely that 'their cultural and spiritual understandings about water are misunderstood or simply ignored by dominant Western societies and that indigenous communities are not included meaningfully in water policy and planning processes' (website: www.indigenouswater.org).

Products — scientific data

The major products of the water studies were the water resource maps. These were produced at 1:250 000 scale. They depict the groundwater and surface water resources of the region. To produce the maps, aerial photographs and satellite images were studied in combination with geological maps and the DIPE water resource databases. Field programs including drilling, test pumping, water sampling and stream gauging were undertaken in areas where there had been no previous investigations. An excerpt of one of the maps is shown in Figure 1.

River flow was plotted according to its minimum flow. A graduated system was developed with rivers with the most flow depicted with the thickest, darkest lines (Figure 1). Because DIPE had operated a number of stream gauging stations throughout the region since the 1960s, the long term variations in flow could be taken into account when working out the minimum flow.

In the Top End, all dry season river flows are attributable to groundwater discharge. The maps could therefore be viewed as purely groundwater

to the people of the Top End

Figure 1. *Excerpt of map 'Water Resources of North Eastern Arnhem Land'.*

Groundwater features: Djinawawuy gapuwuy
Lots of water / large supply (yield): dhanan gapu
Widespread aquifer comprising poorly consolidated sandstone. Large quantities of groundwater are available, sufficient for irrigation and industrial purposes. Bore yields typically more than 10 L/s (maximum 50 L/s). High success rate expected. This aquifer provides the base flow for many of the major rivers. Due to possible coastal saline intrusion effects, caution should be taken when using this map for those areas within 10 kilometres of the coast.

Homeland supply: gapu märr dhanan homelandgu
Local aquifers in fractured sandstone, siltstone, dolomite and volcanic rocks. Stock and domestic quantities of groundwater are available at selected sites. Bore yields typically range from 0.5 to 5.0 L/s. Moderate success rate expected.

Small homeland supply: gapu märr lurrkun' homelandgu
Narrow zones of high yielding sand aquifers (as above) occurring as valley infill between shallow granite locally containing small supplies of groundwater (e.g. up to 1.0 L/s). Moderate to low success rate expected.

Little chance of water: märr ranhdhak wäna
Local aquifers in weathered granite and sand layers within clay. Small supplies (up to 1.0 L/s) sufficient for small domestic use are available at selected sites. Low success rate expected.

gapu dhäkay-murrkthunara
Indicates saline groundwater, generally underlying saline coastal flats.

maps. Mapping aquifer extent with perennial river flows allowed regional relationships to be quickly ascertained. All large groundwater discharges (large rivers) were found to come from extensive regional sandstone or limestone aquifers.

In the East Arnhem Study, when recorded minimum flows were related to groundwater levels and moving average annual rainfall, a high degree of correlation was observed. This correlation was used to extend the minimum flow record over the historical rainfall record. The 1970–72 period showed on all accounts to be the clear low point in river flows. The large natural variation in minimum flow has implications on future studies on environmental flows as well as water supplies.

Further to this, the correlations developed can be used to predict the impact of future climate change scenarios. The information gathered provides a start to understanding the connective water environment better, which in turn can be further related to other ecological processes.

Working with a cross-cultural framework and at a grass roots level fostered involvement from the local people and ensured that final products were appropriate. For the East Arnhem Land Water Study the final products consisted of:

1. water resource maps: showing groundwater potential and surface water features, legends translated into five languages, Aboriginal place names written in Yolngu orthography.
2. diptych posters showing scientific and Aboriginal knowledge on water
3. reports: general explanatory report, Aboriginal knowledge report and technical report
4. satellite image posters covering the region
5. CD-ROM with all the above, as well as a GIS and interactive photographic and video spatial dataset.

Liaison

For each water study we liaised with all the homeland resource centres and councils, introducing the project and gaining their support. This was vital to the success of the project as they represented the people on the land in the region. For the East Arnhem Study alone, 10 such organisations collaborated with the project team.

Laurena and Lana playing with cherubin, Gamajbuk billabong, West Arnhem Land.

Images left to right. Students from Maningrida CEC undertaking a spring flow gauging at Gudjerama creek. Helicopter and quads were used to access sites with the Manwurrk Rangers, central Arnhem Land. David Gulpilil explaining water level changes at a wetland, East Arnhem Land.

Numerous council meetings were attended and field trips to homelands scheduled. Communication was either by phone or radio. On arrival at each homeland the field crew, which would usually consist of one male and one female, would meet with the key people and discuss the project under the shade of a tree. Draft maps, satellite images and aerial photos were used in the discussions on water resources. Much information was documented at these small meetings. A couple of people, or at times a family would then accompany us to river sites, wetlands, waterholes or wells, explaining characteristics of the resource along the way. Sometimes we camped with the traditional owners whilst travelling through the land. During these trips it was noticed that some elders held a great deal of detailed information about their country even though they may not have visited there for many years. They remembered names and events, sometimes singing their traditional songs relating to the area in which they were in. Photos and video footage were taken with traditional owners talking about the land and water, not only in English but also their native language. These were later burnt onto CD-ROM.

As well as liaison with traditional owners on their homelands we also worked with a number of aboriginal ranger groups. The Northern Land Council invited us to workshops and meetings they were undertaking with the rangers and other scientists, and we also ran workshops with specific ranger groups. These provided good avenues for information exchange.

Cultural values

Early on in the field program it became apparent that the topographic maps being used were failing to give a sense of place to the local people because of the lack of place names of which they were familiar. Aboriginal place names have significant meaning, relating to their people, their ancestors, and their country. They play a key role in story oration as often stories relate the journeys of creative beings and the natural features created. Documenting place names acknowledges aboriginal cultural heritage, recognising its important value. As it was paramount that the products from the project were to be as user friendly as possible, and span two cultures, we set about recording aboriginal place names. In doing so they were able to relate more easily to the maps and all people could then locate areas of discussion. Names were recorded by directly marking them on the maps during discussions or by site visitation and location recording by use of GPS. Spelling was a problem as the traditional owners either left it up to the team or came to a general consensus amongst the group. To improve this, discussions were recorded on audio tape for later correct transcription by a suitable person. A further improvement was to video tape the discussions. In the East Arnhem Study the Yolngu (East Arnhem Land) orthography was utilised with letters explained on each map. By the end of this study several hundred place names had been collected.

In working with the traditional owners we began to gain an insight into Aboriginal culture

2 Raymattja Marika-Mununggiritj

recognising that it is inextricably connected with the land. In our discussions invariably 'Dhuwa or yirritcha' would be mentioned. These are the two moieties to which all nature; land, animals and people belong. Often we recorded the moiety of a place name. Further to this, the moieties relate as mother and child, with one always the mother of the other; a Yothu-yindi relationship[2]. There was undoubtedly a web of relationships throughout the region between land and people which was highly significant to them. Each area of land had a traditional owner or spokesperson — there were no areas unbeknown to them. At times access to areas was denied because of sacred sites, and at other times access was far too difficult due to the rough terrain. In these areas we were heavily dependent on the local knowledge, coupled with maps, to gain a perspective on the water resources.

Outside of place names, cultural knowledge was documented on posters and in a report highlighting creation stories of water sites, how water is represented in aboriginal art and what role water plays in their day to day life including how they sourced survival supplies. Video clips were made with traditional owners discussing water sites on their land in their own language with an English translation. The traditional knowledge documentation provided by no means a complete account of traditional values of water, but it aimed to achieve an insight into their perspectives and management of water, encouraging respect and understanding. This in turn leads to better management practices.

Benefits

Studies that followed on from the East Arnhem Land Water Study were the West Arnhem Land Water Study, the Katherine and South West Arnhem Land Water Study, the Tiwi Islands Water Study and the Wadeye/Nauiyu Water Study. All were completed with similar products to the East Arnhem study. The studies have been well received by the people of the region. The East Arnhem Land Water Study gained finalist placing for the National Landcare awards representing the Territory in the research category.

These projects have provided improved knowledge on regional groundwater and surface water systems. The maps have not only been used by Aboriginal resource centres in their outstation planning but also by numerous other agencies. Aboriginal land managers and business enterprises such as buffalo mustering, sustainable forestry and tourism ventures have used the maps and GIS to assist their management and optimise their operations. The products have assisted with feasibility studies for developments such as oyster and prawn farming and have been used by land managers for studies from exotic ants to feral pigs. Results have contributed to the National Land & Water Resources Audit, to the development of the Plan of Management for the Dhimurru Indigenous Protected Area and were recently used to provide baseline information for the community so that they could understand the probable impact on water resources of the proposed mine expansion at Gove. The maps have also been used for their clear and up to date documentation of Aboriginal communities, roads and Aboriginal place names by the Police, Customs and schools.

The study products make a start to effective water management by providing tools which incorporate the local way of thinking. Further studies are planned for regions not currently mapped pending funding.

For further information

Ursula Zaar
Department of Infrastructure, Planning and Environment (NT)
Tel: (08) 8999 3616
E-mail: ursula.zaar@nt.gov.au

***Left**: Place names being documented by Aya from Traditional Owners Jimmy, Agnes, Molly and Patricia at Nauiyu Community.*
***Right**: Bede, James, Bernadine and Rex discussing water sites at Wudipuli, Wadeye Region.*

RIPRAP

RIVER AND RIPARIAN LANDS MANAGEMENT NEWSLETTER

All editions of RipRap are available at www.rivers.gov.au

Edition 10, 1998: Streambank stability ★. **Edition 11**, 1998: Riparian zones: what are they? **Edition 12**, 1999: Managing the riparian zone within a total farm system ★. **Edition 13**, 1999: Benefiting from overseas knowledge and experience ★. **Edition 14**, 1999: Managing and rehabilitating riparian vegetation. **Edition 15**, 1999: Seeing is believing: the value of demonstration sites. **Edition 16**, 2000: Managing snags and Large Woody Debris. **Edition 17**, 2000: Monitoring and evaluation ★. **Edition 18**, 2001: Inland rivers and riparian zones ★. **Edition 19**, 2001: River and riparian habitat for fish ★. **Edition 20**, 2001: River contaminants ★. **Edition 21**, 2002: What are ecosystem services? ★. **Edition 22**, 2002: Riparian research ★. **Edition 23**, 2003: Managing riparian land to achieve multiple objectives ★. **Edition 24**, 2003: Building capacity for river and riparian restoration. **Edition 25**, 2003: Catching up on contaminants. **Edition 26**, 2004: Tools and techniques for river management. **Edition 27**, 2004: Connecting communities ★.

★ Hard copies of these editions are available.

Clip or copy this coupon ☛ and return to

Jennifer Bruce
Publications Officer
Land & Water Australia
GPO Box 2182
Canberra ACT 2601
Tel: 02 6263 6000
Fax: 02 6263 6099
E-mail: subscribe@lwa.gov.au

☐ Would you or a colleague like to be on our mailing list for RipRap or other Land & Water Australia newsletters?

Title: Mr, Mrs, Ms, Dr (please circle) First name: .....

Surname: .....

Position: .....

Organisation: .....

Postal address: .....

..... State: ..... Postcode: .....

Tel: ..... Fax: .....

E-mail: .....

Suggest a theme for future issues: .....

.....

☐ Riparian Management Fact Sheets ☛

Available in hard copy and pdf format at www.rivers.gov.au

☐ Yes! Please put me on the mailing list for the following Land & Water Australia R&D newsletters:

☐ *RipRap* — River and Riparian Lands Management

☐ *Thinking Bush* — Native Vegetation

☐ *People make a difference* — Social & Institutional Issues

Disclaimer

Print Post Approved Number
PP 299436/00235