LWA/NHT Project DET18

Australia's tropical rivers – an integrated data assessment and analysis

Milestone Report 5

Progress report for sub-projects 1 (Inventory & mapping) and 2 (Assessment of the major pressures on aquatic ecosystems)

June 2006

Contents

Project summary

Sustainable management of Australia's tropical rivers and wetlands requires an integrated information base for assessment of their ecological character (including benchmarking their status) and the development of policy, especially for environmental flows and potential uses of water. This project is establishing an information base for assessing status and change of Land and Water Australia's tropical rivers study area, and, using the information base, is undertaking several case studies of ecological risk assessments of major pressures for various focus catchments.

The information base is being built on consultation, analysis of existing information, and, in the future, will include specific investigations to provide further data. It is anticipated that the final integrated information base will be used as a reference for assessing change to the river/wetland habitats and their species, and the ecosystem services they provide. As reference conditions for assessing change and environmental flows cannot be provided for all localities or species, it is expected that surrogates will be determined and responses to key pressures assessed through structured and quantitative frameworks and linked with the provision of ecosystem services. These analyses will extend analyses being done through other initiatives in tropical Australia.

Project details

Project Reference Number: DET18

Project Title: Australia's tropical rivers – an integrated data assessment and analysis.

Contracted Research Organisation: Environmental Research Institute of the Supervising Scientist (ERISS) on behalf of the National Centre for Tropical Wetland Research (NCTWR).

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Project duration: July 2004 – September 2006.

Milestone number: 5

Due date: 12 June 2006

Project objectives

The project will provide an information base for determining and applying management priorities and land use practices of relevance to stakeholders, including local and indigenous people, private sectors and governmental agents. Specific objectives are to:

1. undertake a multiple-scale inventory of the habitats and biota of the rivers and wetlands of tropical Australia, where necessary developing and/or ensuring consistency with other suitable typologies based on hydrological and landform features;
2. undertake risk assessments of the major pressures on the habitats and biota of the rivers and wetlands of selected focus catchments in tropical Australia; and
3. provide a framework for analysis of the ecosystem services (e.g. provision of water for multiple uses), provided by the habitats and biota of the rivers and wetlands of northern Australia.

These objectives each relate to one of the three sub-projects that make up the Tropical Rivers Project:

Sub-project 1 – Inventory of the biological, chemical and physical features of aquatic ecosystems;

Sub-project 2 – Assessment of the major pressures on aquatic ecosystems; and

Sub-project 3 – Development of a framework for the analysis of ecosystem services provided by aquatic ecosystems.

Milestone 5 and Achievement Criteria

This Report (Milestone Report 5) reports against the following milestones:

Sub-project 1 – Report on progress towards multiple-scale maps of aquatic ecosystems; typology of aquatic habitats; and a description and database of information on biological, chemical and physical features of aquatic habitats; and

– A DVD of the biophysical data and associated mapping products

Sub-project 2 – Report on progress towards specific analyses of major pressures (eg. weeds, feral animals, infrastructure, water pollution) for selected major catchments.

Below we have summarised our progress to date for Sub-projects 1 and 2 as well the key consultation and communication activities since the Milestone 4 report. Additionally, any administrative, human resource and technical issues are identified, and their consequences on the project and milestone schedules discussed. More detailed information for Sub-projects 1 and 2 is provided in Attachment 1. The CD of the biophysical data and associated mapping products for Sub-project 1 has been provided separately.

The Achievement Criterion for Milestone 5 is the receipt and acceptance of this report by Land &Water Australia.

Variations to Milestones

An extension to the original deadline for Milestone 5, from 31 March to 12 June 2006, was approved by LWA on 29 November 2005. This request was made following a project team meeting on 21 November 2005, where the status of the project and the work required for successful completion was reviewed. The key basis for the requested extension was that the integration of the multiple datasets and associated data analyses for the biophysical analyses, and the associated development of an ecological typology, was going to extend beyond the original completion date of 31 March 2006.

Following this, a further request for an amendment to the Milestone schedule was made on 11 April 2006, and approved on 9 May 2006. The requested amendment was again made largely on the basis of the time required to complete the necessary data integration and analysis required to develop the ecological typology for the tropical rivers. Consequently, the revised deliverables for this Milestone (No. 5), were amended to those detailed in the preceding section. The revised deliverables for the final technical Milestone (No. 6), due on 1 October 2006, are now as follows:

- Sub-project 1 – submission of final report and GIS; and
- Sub-project 2 – submission of final report.

Progress for Sub-project 1

Inventory of the biological, chemical and physical features of aquatic ecosystems

Description

The major purpose of this Sub-project is to undertake a multiple-scale inventory of the habitats and biota of the rivers, floodplains and estuaries within Land & Water Australia's program area for the Tropical Rivers funding program. The project will integrate information from the previous Land & Water Australia data collation project and additional published sources to make an initial assessment of the diversity, status and ecological value of aquatic ecosystems across the region. This will be undertaken using the multiple-scale model for inventory supported by the Ramsar Wetlands Convention and being applied in the Alligators Rivers Region. The core data will cover information necessary for describing the biological, chemical and physical character of an aquatic ecosystem.

Status

A summary is provided in table 1 of progress against the key activities that occurred, and/or were scheduled to occur, between August 2005 and June 2006. The major activities during the reporting period involved (i) ongoing data gathering and analysis for the biophysical attributes, and (ii) construction of the GIS and associated standardisation of the datasets and metadata records.

Progress for Sub-project 2

Assessment of the major pressures on aquatic ecosystems

Description

The objective of this Sub-project is to develop a risk assessment framework applicable to the key focus catchments and significant locations that meet stakeholder needs, within the region of the TRIAP. In developing the risk assessment framework, semi-quantitative and quantitative risk analysis will be undertaken where possible, for selected threats. The focus will be on three catchments: the Daly River (Northern Territory), Flinders River (Queensland) and Fitzroy River (Western Australia). In addition, there will be a broad overview of the major pressures on tropical Australia's aquatic ecosystems, based on data gathered during this Sub-project and Sub-project 1. Throughout this Sub-project stakeholders will provide input and feedback.

Table 1 Summary of progress for key activities for Sub-project 1 (Inventory and mapping).

Data and metadata standards	A hierarchical directory structure has been applied for the storage and management of spatial datasets. All spatial datasets are maintained in a geographic projection, using the Geocentric Datum of Australia 1994. Following a review of procedures for the creation and management of metadata within the Department of Environment and Heritage, metadata for databases / datasets has been progressively created / updated to the ISO19115 standard. Significantly,all datasets now have a metadata record attached to them. It should be noted that the level and availability of metadata varies considerably.
Compile existing GIS datasets at 2.5M, 250K and other scales	Collation and compilation of data for the inventory component of the project has been completed, with data compiled at two broad scales (continental – 1:2,500,000; and catchment scale – 1:250,000). In addition, data has been collated for the 'focus' catchments at the catchment scale, or better. Data collation is continuing at a reduced level to support risk assessment activities within the three focus catchment, focussing on the collation of datasets representing the distribution of feral animals, weeds, rare and threatened species, and temporal variations in land use and landcover. A license for cadastral /land tenure data for the Kimberley region in Western Australia is currently being sought, and will complete the coverage of this type of data across the project area. In the intervening period since the last milestone, existing collated datasets have been reviewed and updated to ensure that the latest versions of key datasets (geology, topography, hydrology) are held by the project database.
Identify, collate and analyse additional data for reach attributes	Additional national (eg AUSRIVAS, OZCAM, BirdsAtlas) and State/Territory faunal and floral databases were accessed and data extracted to identify the distribution of specific species at catchment and focus catchment scale. Additionally, new spatial datasets were created for hydrological, geomorphological and water quality attributes. Analyses have been undertaken to look for patterns/relationships of biophysical attributes across the tropical rivers.
Develop geomorphic classification/typology	Both the continental scale and focus catchment scale geomorphic classifications were completed. These classifications are being used by other Theme Leaders in the analyses of their data.
Trial and apply skeletal typology	Given the dependency of this activity on the finalisation of the data analyses for the key biophysical attributes, there was little progress. However, the project timeline has been extended to reflect this delay (see *Variations to Milestones*). A brief description of the intended approach for developing the typology is provided in Attachment 1.
Estuary classification review	Data collection has included information on tidal character and non-tidal processes, cyclone paths and land crossing, climate change and variability projections and estuarine classification systems. Classification systems have been reviewed. This component is approaching completion.
Field sampling	Following discussions with and agreement from LWA, there will no longer be a field component to the project. It was agreed that the project budget would not allow for useful field surveys and associated data analysis to be undertaken.
Ongoing consultation and awareness	See *Communications achievements*.

Status

A summary is provided in table 2 of progress against the key activities that occurred, and/or were scheduled to occur, between August 2005 and June 2006. Through discussions with LWA, the scope of this sub-project was formally broadened to include a northern Australian overview of threats to aquatic ecosystems. The main aim of this component is to identify and describe the the key threats, and their relative risks, to the aquatic ecosystems of the tropical rivers. This will be done using a relatively coarse level, catchment scale relative risk model, and is described in more detail in the risk assessment framework and methodology paper (see below and Attachment 1). Progress has been sound, but slower than anticipated, mostly due to staff resourcing constraints. Nevertheless, numerous key activities were undertaken, including stakeholder workshops in two of the focus catchments (Fitzroy and Flinders), the completion and distribution of a risk assessment framework and methodology paper, and the development of several conceptual models for the focus catchments, depicting the inter-relationships between the ecological assets and threats. In addition, a large amount of information on ecological assets and threats for the tropical rivers study area and the three focus catchments was collated.

Table 2 Summary of progress for key activities for Sub-project 2 (Assessment of pressures).

Activity	Progress/status
Risk assessment framework and methodology	A paper describing the risk assessment framework and methodology has recently been completed and distributed to stakeholders.
Identify key stakeholders &	Stakeholder identification has been an ongoing task. Since the last milestone Report, the key stakeholders for the Flinders river were identified.
	Stakeholder liaison/consultation has been active and ongoing, and will continue. This process has helped refine and improve the information on assets and threats
Liaise with stakeholders on assets and threats	A stakeholder workshop has been conducted in Derby, WA for the Fitzroy catchment, and in Richmond, Qld for the Flinders catchment. The Daly River, NT stakeholders will be consulted in the coming weeks.
Identify, acquire data for, and describe key assets & threats	Data acquisition has been occurring for several months, for all three focus catchments and the tropical rivers study area as a whole. Information from spatial datasets and key synthesis documents is still being extracted and synthesised.
Compile new GIS layers/ datasets & maintain metadata	Where possible, spatial data for key assets and threats have been acquired or are currently being acquired through the relevant State, Territory or Commonwealth agencies. This activity is advanced for the Daly River and in ongoing discussions with CALM and WWF for the Fitzroy River. To date, little attention has been paid to the Flinders River.
Develop conceptual models	Draft conceptual models have been developed for the Fitzroy catchment and a conceptual model for land clearing has been drafted for the Daly River. Over the coming weeks the conceptual models will be completed.
Semi-quantitative risk analyses	A model for conducting semi-quantitative risk analysis at the catchment and regional scale has been selected: the Relative Risk Model. Application of the model will commence upon completion of the conceptual model and effects/consequence analysis.
Quantitative risk analyses	Data is currently being sourced for the specific requirements of quantitative risk assessments. In addition, software (Netica) has been purchased to undertake Bayesian newtork development.

Human resource issues

The key human resource issues during the reporting period are summarised below:

- We secured the services of Dr Don Franklin from Charles Darwin University to complete the birds component of Sub-project 1. He has completed the analysis and associated report.
- To overcome the resource issues associated with a lack of availability of staff to allocate time to activities associated with Sub-project 2, ***eriss*** appointed Renee Bartolo in November 2005 to manage and undertake the sub-project, with assistance from other relevant staff where necessary. Good progress on this Sub-project has been made within this reporting period (see Attachment 1).

Communications achievements

Communication and consultation activities have continued to take place since the last reporting period. Two significant stakeholder communication activities were the workshops held in Derby, WA for the Fitzroy catchment, and Richmond, Qld for the Flinders ctachment. These workshops were designed as a forum to elicit stakeholder views on ecological assets and threats in their focus catchment. Another important communication activity is the commencement of cross-project collaboration meetings in December 2005. Meeting participants include represnetatives from the TRIAP, CDU, NRETA and NAIF. The regular meetings are designed to share knowledge, ensure relevant linkages between projects are built through regular communication and minimise duplication. One key aspect that the meetings address, is the coordinated approach by the various projects in engaging stakeholders.

Following the second edition of the project newsletter a third edition was distributed to all stakeholders in November 2005 and a fourth edition in April 2006 (Attachment 5). Distribution of the newsletter to stakeholders is an important tool to identify stakeholders who have not been engaged previously.

Communication activities in the last quarter have continued to raise awareness of the TRIAP amongst relevant groups. Numerous TRIAP presentations will be delivered in various forums such as Riversymposium in the coming months. Further details of communication activities are presented in Attachment 2.

Summary

Sub-project 1, *Inventory of the biological, chemical and physical features of aquatic ecosystems*, continued during the reporting period, with a large amount of existing data for catchment/river biophysical attributes being updated. The most significant activities were (i) the completion of the geomorphic classifications, (ii) various analyses of data for some of the other biophysical attributes being studied (eg. hydrology, riparian vegetation, waterbirds) and (iii) the updating and completion of much of the metadata record for the datasets currently held. Delays in obtaining and analysing final datasets resulted in an extension of the sub-project timeline being approved, with completion now expected in early October.

Sub-project 2, *Assessment of the major pressures on aquatic ecosystems*, has progressed during the reporting period. An extension to the scope of the sub-project was formalised, with a risk overview of the tropical rivers study area being included in addition to the focus catchment risk analyses. Reasonable progress has been made, with the completion of a document outlining the approach the project will undertake for the ERA for stakeholder distribution, the drafting of conceptual models and the collection of information on ecological assets and threats across the tropical rivers region. Specific spatial data relating to threats are currently being sourced.

Communications activities continued during the reporting period according to the communications strategy. Key activities during the period included stakeholder workshops in Derby, WA and Richmond, Qld and the regular cross-project collaboration meetings with NAIF, CDU and NRETA. Consultations and formal communications activities (eg. project newsletter, conference attendance, web page updates) will continue to occur and be recorded.

Listing of Attachments

Attachment 1	*Detailed progress report for Sub-projects 1 and 2.*
Attachment 2	*Detailed progress report for communication and consultation*
Attachment 3	*ERA overview and proposed framework and methodologies document*
Attachment 4	*Fitzroy River stakeholder workshop report*
Attachment 5	*Tropical Rivers Project Newsletter November 2005 and April 2006*

Attachment 1 Detailed progress report for Sub-projects 1 & 2

Detailed Progress Report for Sub-project 1

Inventory of the biological, chemical and physical features of aquatic ecosystems

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Project description and objectives

The major purpose of this project is to undertake a multiple-scale inventory of the habitats and biota of the rivers, floodplains and estuaries of northern Australia within Land & Water Australia's (LWA) geographic scope for the Tropical Rivers funding program. The project will integrate information from the previous data collation project and additional published sources to make an initial assessment of the diversity, status and ecological value of aquatic ecosystems across the region. This will be undertaken using the multiple-scale model for inventory supported by the Ramsar Wetlands Convention and being applied in the Alligators Rivers Region. The core data will cover information necessary for describing the biological, chemical and physical character of an aquatic ecosystem.

The inventory data will be used to illustrate known areas of biodiversity importance and gaps in information. The data will be linked to a river/wetland typology, which will provide a framework for predicting the possible occurrence of specific biota and habitats within previously unsurveyed areas. The inventory will provide information for policy and management implementation at multiple-scales (eg. regional, catchment, or individual habitat). This will be possible through the use of GIS data layers and presentation of information at appropriate scales.

Data collection/collation

Collation and compilation of data for the inventory component of the project has been completed, with data compiled at two broad scales (continental – 1:2,500,000; and catchment scale – 1:250,000). In addition, data has been collated for the 'focus' catchments at the catchment scale, or better. Table 1 summarises the datasets that have been collated to date. Data collation is continuing at a reduced level to support risk assessment activities within the three focus catchment, focussing on the collation of datasets representing the distribution of feral animals, weeds, rare and threatened species, and temporal variations in land use and landcover. A license for cadastral/land tenure data for the Kimberley region in Western Australia is currently being sought, and will complete the coverage of this type of data across the project area. In the intervening period since the last milestone, existing collated datasets have been reviewed and updated to ensure that the latest versions of key datasets (geology, topography, hydrology) are held by the project database.

A significant component of the data collation activity which has occurred since the last milestone report has been the collation and integration of datasets which have been generated and produced by theme leaders of the inventory component. These include products representing geomorphic, hydrologic, and vegetation classifications of the rivers, and are described elsewhere in this report. Each of these datasets have been checked to ensure that the datasets are in a consistent format and datum.

Table 1 Datasets collated for the inventory component.

Theme	Continental scale (>1:2,000,000)	Catchment scale + focus catchment scale (<=1:250,000)
Administration	ATSIC boundaries	
	Local Government Area boundaries	
	State boundaries	
Climate	Annual rainfall, and mean monthly rainfall	
Elevation	3” SRTM DEM	
Fauna	OzCam reptile and amphibia data	Amphibia and reptiles from NT Govt
	Atlas of Australian birds	Reptiles from Qld Govt
	AusRivas macroinvertebrate	Birds from NTGovt
Fire	NAFI Fire frequency 1997-2005	
	Firescars 2005	
Geology	1:5,000,000 regolith	
	Geology	
Geomorphology	Geomorphic classification of rivers	
	Landforms from Atlas of Australian soils	
Groundwater	Hydrogeology	Groundwater of the Katherine region
Hydrology	Drainage features	Catchment/basin boundaries
	Waterbodies	Drainage features
	Waterbody points	Drainage points
	Hydrological classification	Water points
	Gauging station distribution	Sub-catchment boundaries
	Monthly median flow	Named / major rivers
		Reach and basin assessments
Imagery	Landsat scene of Australia	
Infrastructure	Localities	Airfields
	Populated places	Localities
	Roads	Rail
	Railway lines	Roads
		Place
		Roads from cadastre
Landuse		Land use mapping for NT and Qld
Land systems		Landsystems of the Daly
Tenure		Cadastral data for WA, NT, Qld
		Tenure data
Soils	Atlas of Australian soils	
Vegetation	Vegetation classification	Mangrove maps for NT and Qld
	Savanna vegetation	Rainforests in the NT
	Pre- and post- European vegetation	Threatened flora in the NT
	Rare plants	Forests of the NT
	Vulnerable flora	Landscape health / vegetation clearing
	Vegetation changes	
	Riparian indicator species	
Wetlands		Ramsar sites
		Directory of Important wetlands

Geomorphology

The geomorphic classifications at both the continental scale and focus catchment scale were completed during the reporting period. An initial break down of geomorphic classes at the continental scale was done in a GIS environment, using the 1:2,000,000 Digital Atlas of Australian Soils. When the distributions were mapped, it became apparent, through initial feedback, that further differentiation within the alluvial class was required. The number of relevant datasets that have been compiled to a similar scale limited the number of datasets that could be used to differentiate these data. Further differentiation was completed using the dataset representing the dominant geomorphic landform characteristics of the region (at a scale of 1:2,000,000) to differentiate and identify additional alluvial sub-classes. As a result, a final 7-class typology was generated for application at the broad (continental) scale. A comparison of the initial, and the final broad-scale classes (table 2) has been be applied to illustrate the geomorphic characteristics of rivers across northern Australia.

The three focus catchments have had the geomorphic classes mapped using the named and major rivers at a scale of 1:250,000. River reaches were mapped using 1:50,000 (where they existed) and 1:250,000 topographic maps, some geology maps and Google Earth images available on the internet. No ground truthing has been undertaken.

From initial observations and a workshop held in Darwin in July 2005, 10 river reach classifications were identified as possibly present within the focus catchments. As the mapping was being undertaken several new classes were identified, increasing the number of reach classes to 12. Table 3 shows the total river lengths of the various reaches for the three focus catchments. As an example, the mapped geomorphic classes for the Daly River are shown in figure 1.

Water quality

The review of available water quality data has confirmed the preliminary findings discussed in previous milestone reports: basically the data are of little or no use as an aid for ecological condition assessment. The data have been collected by numerous *ad hoc* programs and therefore lack strategic consistency; nevertheless it is apparent that the vast majority of monitoring has been aimed at resource assessment and was never intended to address ecological health issues. The resulting dataset may have served its intended purpose but it is of very limited use to ecologists. In fact many key ecological parameters have either been entirely omitted (e.g. water transparency, chlorophyll) or have seldom been measured (e.g. nutrient concentrations). There are large numbers of records relating to conductivity, alkalinity, turbidity and hardness. However, even for these parameters overall spatial coverage is limited and erratic, and temporal replication is inadequate to provide many useful insights into water quality dynamics.

Table 2 Continental-scale geomorphic typology of rivers.

Initial broad-scale classification	Final broad-scale classification
(1) Bedrock Channel	(1) Bedrock Channel
(2) Bedrock confined	(2) Bedrock-confined
(3) Alluvial	(3) Level alluvial plain
	(4) Undulating alluvial plain
	(5) Rolling alluvial plain
(4) Lake/Swamp	(6) Lake / Swamp
(5) Estuarine	(7) Estuarine

Table 3 Focus catchment-scale geomorphic typology of rivers.

Reach Classification	**Flinders River Length (km)**	**Fitzroy River Length (km)**	**Daly River Length (km)**
Bedrock channel	579.75	609.24	372.10
Bedrock confined	3956.87	3137.84	2355.03
Estuary	274.25	111.49	80.09
Billabong/lake/swamp	Not Present	5.64	46.46
Anabranching	23273.88	3639.18	846.70
Non-channelised	238.15	61.78	72.89
Chain of ponds	97.05	40.03	453.52
Meandering	785.86	301.60	431.49
Low sinuosity	449.86	174.69	202.91
Floodout	Not Present	39.77	Not Present
Gully	Not Present	24.14	Not Present
Wandering	270.82	Not Present	Not Present

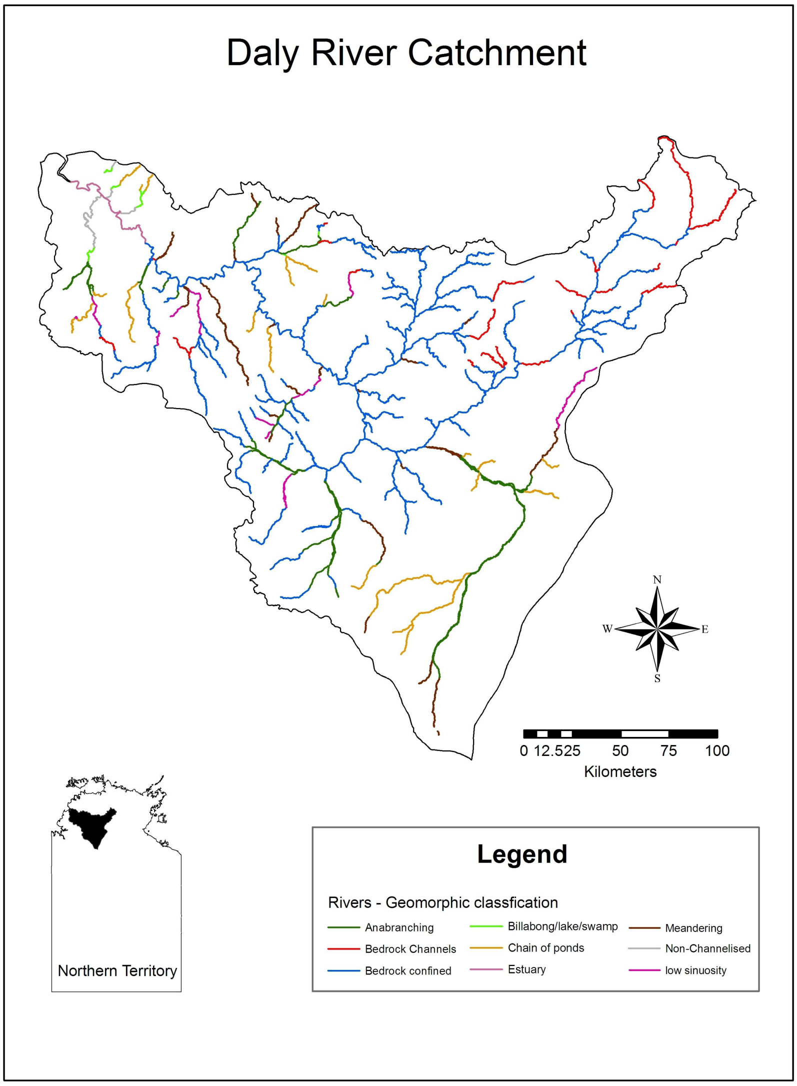

Figure 1 Geomorphic mapping for the focus catchment of the Daly River.

It is our assessment that the existing datasets are far too patchy and unbalanced to adequately describe the condition of tropical river systems, as they are notoriously dynamic and highly variable. Simple summary statistics such as measures of central tendency and variance are very likely to yield meaningless, even misleading values and are not presented in our report. Maps showing the locations of existing and pre-existing monitoring sites and the numbers of samples collected for various parameters are being prepared so that readers can assess the extent of the data coverage. However, the report warns potential users that the data are unsuitable for most ecological applications, and focuses on explaining the existing deficiencies and recommending methods that could be used to obtain improved monitoring outcomes in the future.

The available data provide no basis for the development of an ecologically-relevant classification scheme. This study has attempted to redress this deficiency by assessing the status of some of the key biophysical variables that drive water quality in tropical rivers, rather than relying on the water quality data itself. This was done by drawing on the findings of detailed case studies conducted in other parts of tropical Australia and professional experience gained through years of research on tropical ecosystems, to propose conceptual models of the processes that drive water quality and ecosystem condition. It was then necessary to determine if any of the key biophysical drivers identified in the models could be employed as surrogate indicators for water quality classification purposes. It has proven possible to prepare some maps that identify parts of the river systems that are considered likely to exhibit different water quality characteristics and/or dynamics due to differing catchment characteristics (eg. number of runoff days and relative sub-catchment contributions) and/or the presence of certain riparian features (eg. floodplain wetlands, stormwater detention areas and instream waterholes).

Despite this limited success, the data available for many of the most important drivers are inadequate so it is not feasible to propose a sensible water quality-based classification scheme at this time. However, the conceptual models described in the report encapsulate much of our current understanding of water quality processes in tropical Australian river systems and this makes them a valuable resource in their own right.

Hydrology

Flow statistics, mean annual runoff and coefficient of variability, derived for 107 gauging stations within the tropical rivers region with long-term flow data were used to determine the spatial variation in annual runoff and variability across the region (figures 2 and 3, respectively). Monthly runoff data for each of these stations highlighted the strong seasonal nature of streams throughout the wet-dry tropics and also showed regions where perennial flow is likely to occur.

In a previous Milestone report, streamflow data and basic flow characteristics for stations within the Daly river catchment were presented. Streamflow characteristics have now been derived in more detail for all three focus catchments within the region – Daly, Fitzroy and Flinders River catchments. A total of 28 gauging stations were identified within these three catchments to have at least 20 years of complete annual flow data. Several hydrology variables were derived for each of these stations, based on flow variability, flood regime pattern and intermittency.

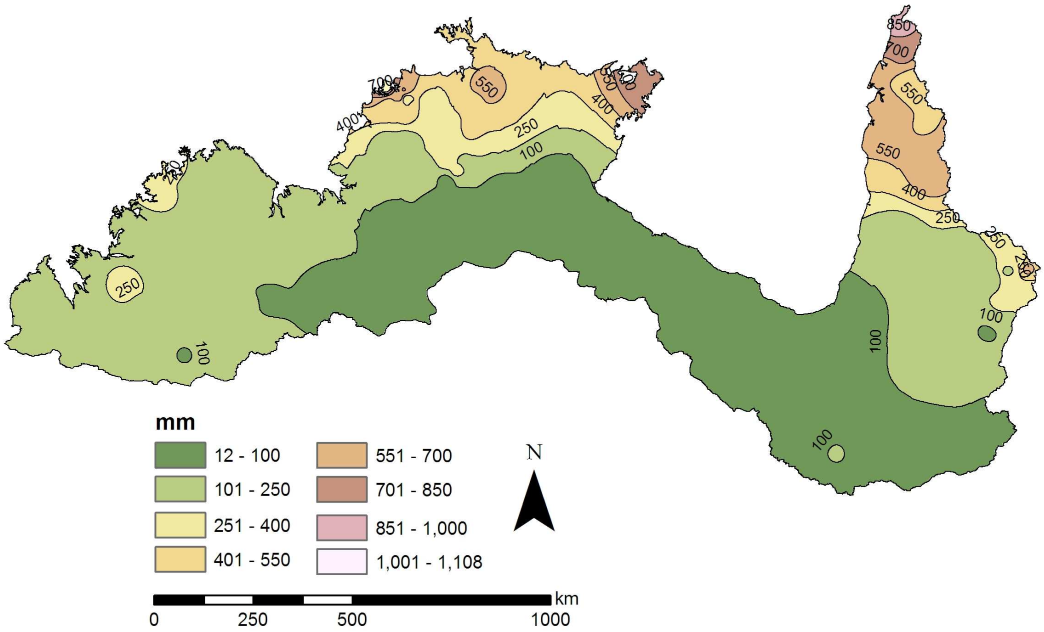

Figure 2 Contour map showing mean annual runoff across the tropical rivers region

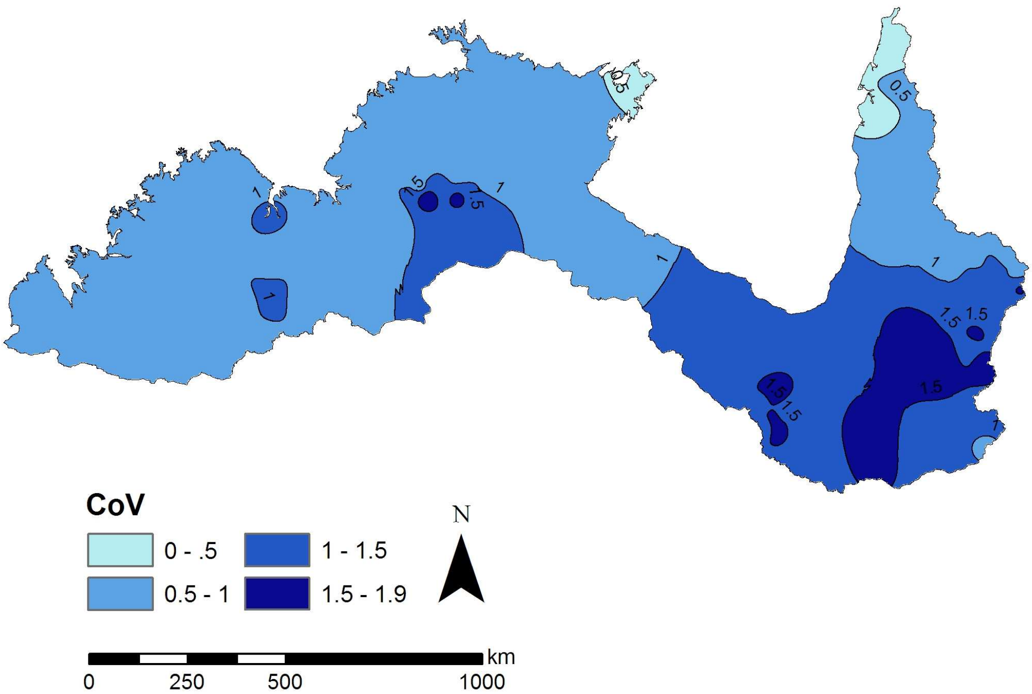

Figure 3 Contour map showing coefficient of variation (CoV) of annual flow across the tropical rivers region

One of the primary aims of this component of the project is to classify the flow regime of streams within the tropical rivers region. A multi-variate analysis of the hydrology variables derived for the 28 stations within the focus catchments were used to classify streams into four flow regime groups: (1) perennial, (2) seasonal, (3) dry seasonal, and (4) seasonal-intermittent streams. The coefficient of variability and the number of zero flow days were the two most significant variables for classifying streams into flow units. The perennial streams were characterised by low annual variability and had no more than occasional zero flow days. Seasonal streams have a similar annual variability to the perennial streams but are characterised by zero flow during most of the Dry season. Dry seasonal streams are characterised by high annual variability and are dry for more than half of the year. Only three streams were classified as seasonal-intermittent, and these streams are dry for almost the entire year, have very high annual variability and flow generally only occurs as a result of a large storm event during the wet season. Figure 4a-c shows the classification of streams within the three focus catchments.

It is recommended that hydrological variables are derived for some or all of the long-term gauging stations outside the three focus catchments within the tropical rivers region for a more comprehensive classification of streamflow regimes for the region.

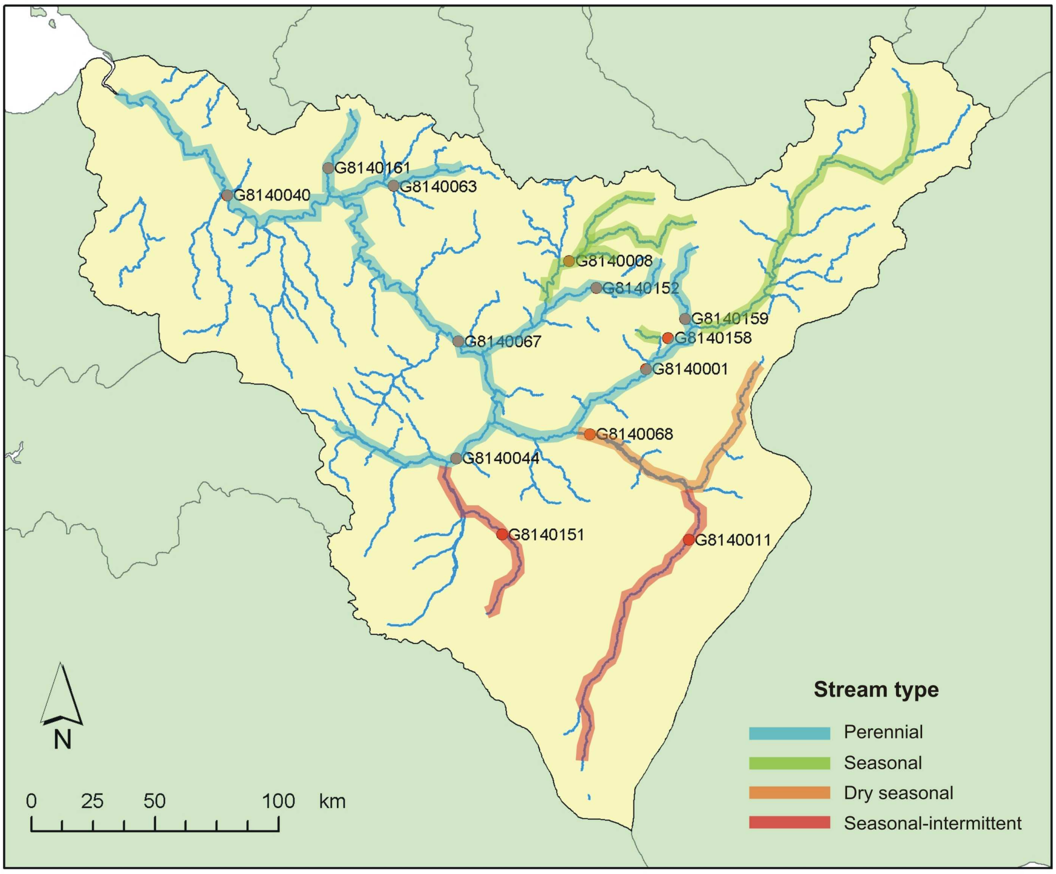

Figure 4a Classification of streams within the Daly River catchment based on the cluster analysis.

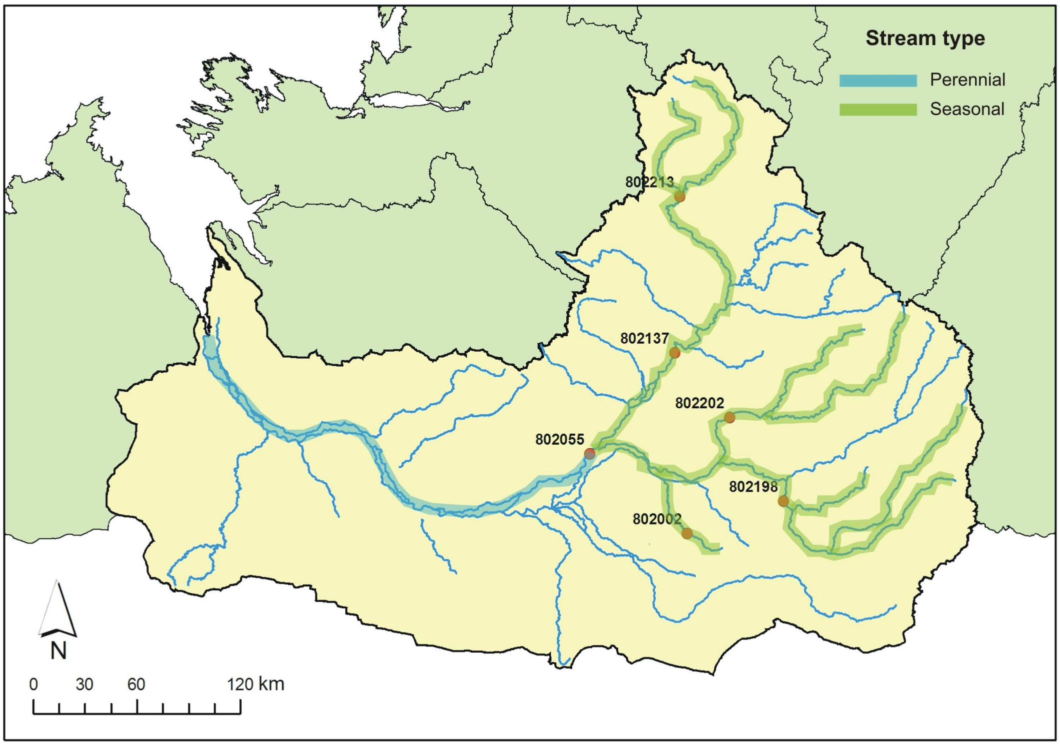

Figure 4b Classification of streams within the Fitzroy River catchment based on the cluster analysis.

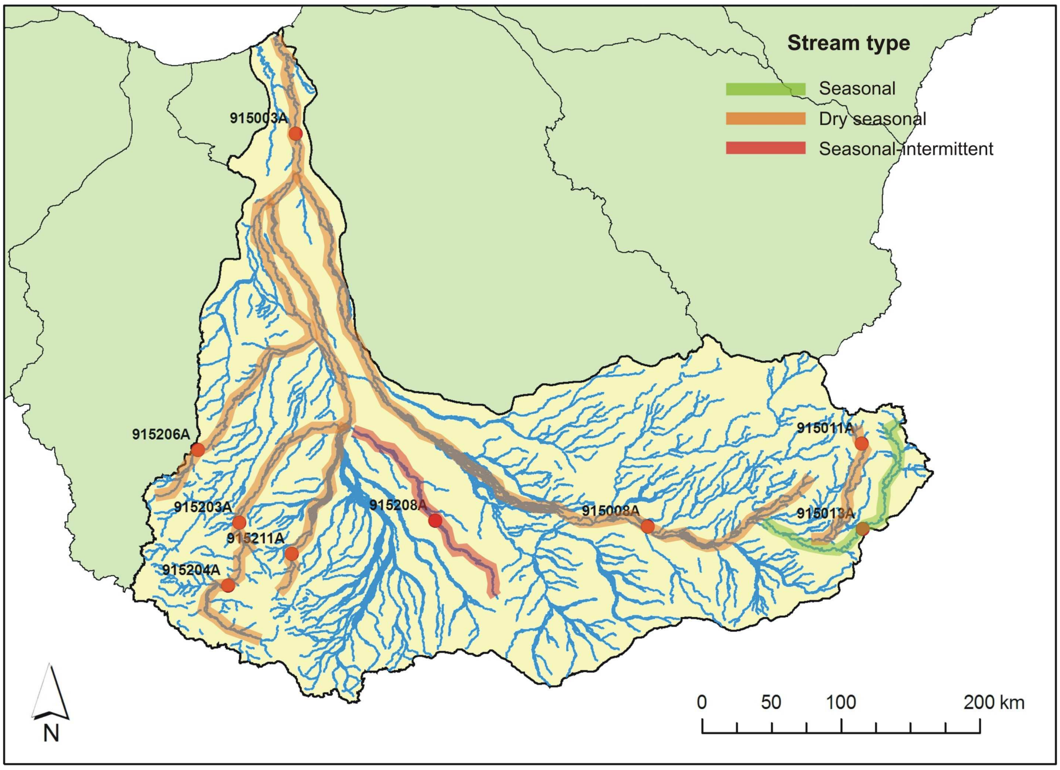

Figure 4c Classification of streams within the Flinders River catchment based on the cluster analysis.

Vegetation (Riparian associations)

An assessment of the riparian vegetation in the three focus catchments, Fitzroy River (WA), Daly River (NT) and Flinders River (QLD), and the 48 non-focus catchments, was based on herbarium accession data and field-record data as cited in the Milestone 4 report. For each catchment, the most commonly recorded species in each were used to determine Riparian Vegetation Associations. The Associations in the three focus catchments were developed in greater detail than the non-focus catchments, in that the focus catchments were further subdivided into 3-5 Associations within each, whilst a single Association was provided for each of the non-focus catchments.

With regards to species identification and reliability: As it was beyond the scope of this research to positively identify the > 5000 herbarium records used as the basis for plotting distribution of riparian species, it became apparent that the use of two functional groups of *Melaleuca* species was preferable, rather than using individual species. Identification of the large-leafed *Melaleuca* species (*M. argentea*, *M. fluviatilis*, *M. leucadendra*) was unreliable in some cases based on herbarium accession data. For example, many were identified to species by their various collectors or subsequently in the herbarium by individual researchers, and identification of these species in the dried state (ie. a preserved herbarium specimen) is difficult. In addition, recent new taxonomy, such as in the case of *M. fluviatilis* which was first described in 1997, may indeed jeopardize correct identification of those specimens collected prior to the description of that species. For example, specimens of *M. fluviatilis* may have previously been identified as either *M. argentea* or *M. leucadendra*. To alleviate this potential inaccuracy, *Melaleuca* species are divided into two functional groups, namely the '*Melaleuca* large-leaf species', which includes the taxa noted above, and the '*Melaleuca* small-leafed species', which includes *M. bracteata* and *M. trichostachya*.

Riparian Vegetation Associations in the focus catchments

Five Riparian Vegetation Associations were recognized in both the Flinders and Fitzroy River catchments (figures 5 and 6), whilst three Riparian Vegetation Associations were recognized in the Daly River catchment (figure 7), based on the available data. For convenience, the Riparian Vegetation Associations are based on elevation as a broad indicator, and in which it is reasonably expected that a particular association will occur where predicted. Distribution of most species is predicted rather than confirmed by herbarium records. Ground-truthing was undertaken in the Flinders River catchment at 29 sites and the level of prediction accuracy was about 70%.

Riparian Vegetation Associations in the non-focus cachments

Eleven Riparian Vegetation Associations are recognized in Tropical Rivers catchments (i.e. the three focus catchments and the 48 no-focus catchments) (table 4; figure 8). The catchments and the Riparian Vegetation Associations in each are included in fFigure 9.

The 'Eucalyptus camaldulensis/Melaleuca large-leafed species/Lophostemon grandiflorus' Association was the most commonly occurring association, whilst three associations were unique to single catchments.

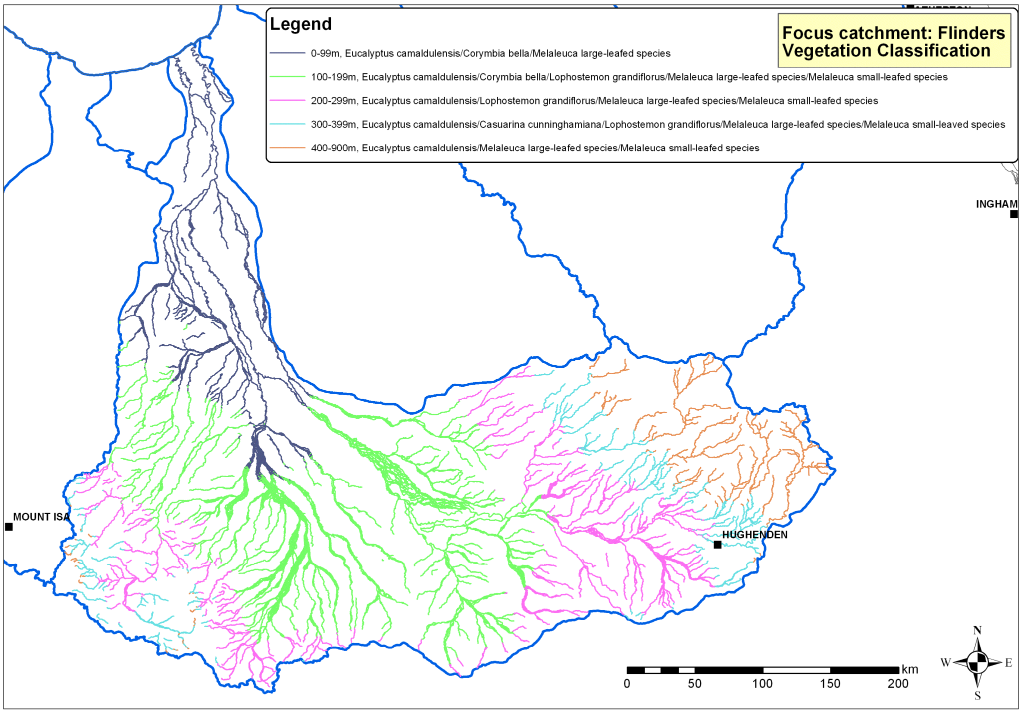

Figure 5 Riparian Vegetation Associations in the Flinders River catchment.

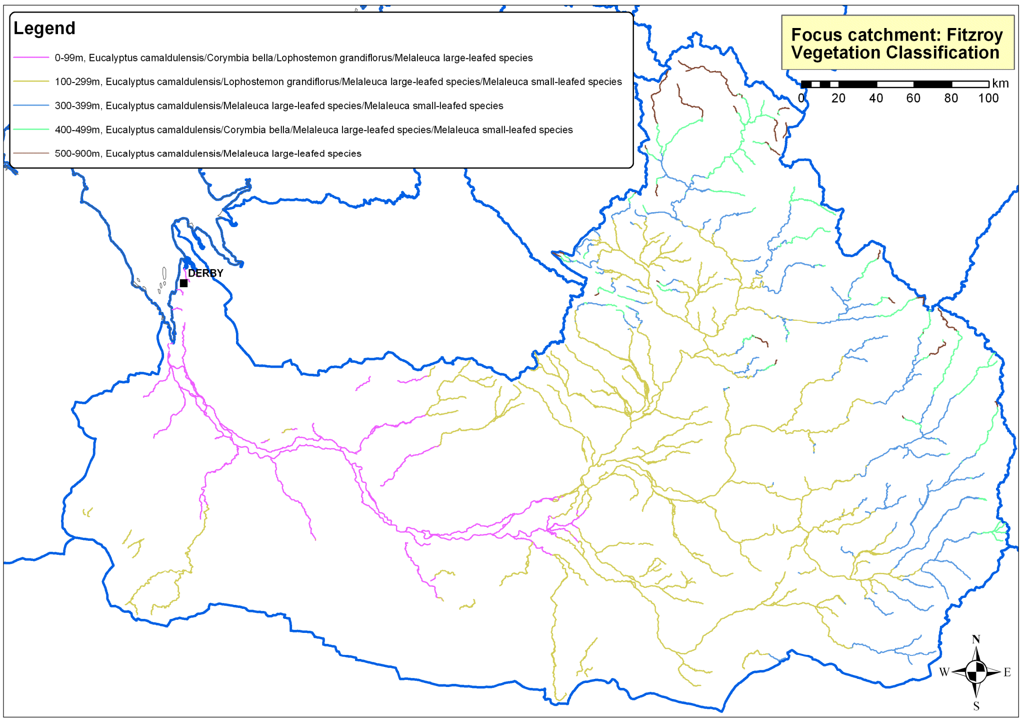

Figure 6 Riparian Vegetation Associations in the Fitzroy River catchment.

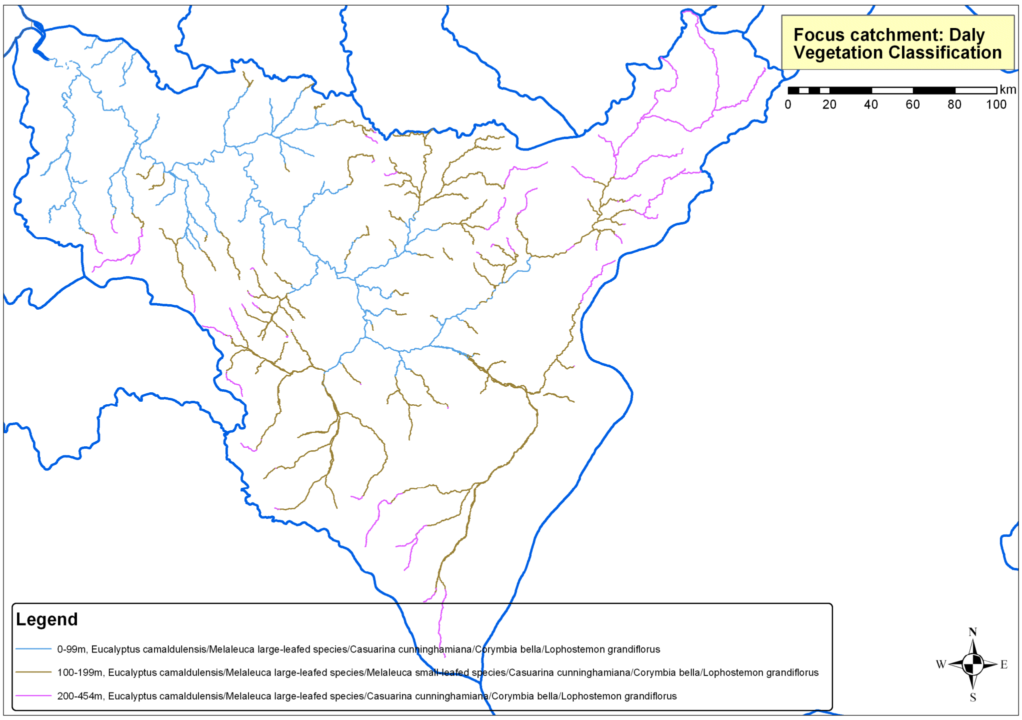

Figure 7 Riparian Vegetation Associations in the Daly River catchment.

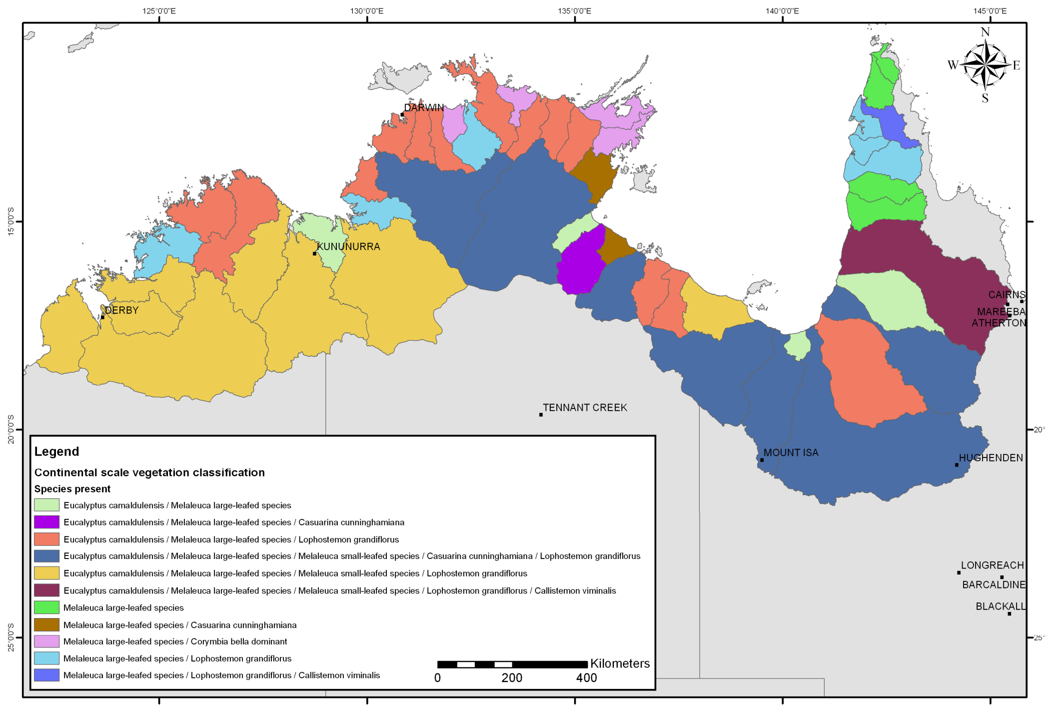

Figure 8 Riparian Vegetation Associations in all catchments.

Table 4 Riparian Vegetation Associations and the catchments in which they occur.

Riparian vegetation association	Catchment
1. Eucalyptus camaldulensis/ Melaleuca large-leafed species	20, Keep River; 30, Morning Inlet; 42, Staaten River; 43, Towns River.
2. Eucalyptus camaldulensis/ Melaleuca large-leafed species/ Casuarina cunninghamiana	25, Limmen Bight River.
3. Eucalyptus camaldulensis/ Melaleuca large-leafed species/ Lophostemon grandiflorus	1, Adelaide River; 3, Blythe River; 5, Calvert River; 8, Drysdale River; 10, East Alligator River; 12, Finniss River; 16, Goyder River; 21, King Edward River; 26, Liverpool River; 27, Mary River; 31, Moyle River; 33, Norman River; 37, Robinson River.
4. Eucalyptus camaldulensis/ Melaleuca large-leafed species/ Melaleuca small-leafed species/ Lophostemon grandiflorus	6, Cape Leveque Coast; 18, Isdell River; 24, Lennard River; 34, Ord River; 35, Pentecost River; 40, Settlement Creek; 44, Victoria River; 50, Fitzroy River.
5. Eucalyptus camaldulensis/ Melaleuca large-leafed species/ Melaleuca small-leafed species/ Lophostemon grandiflorus/ Callistemon viminalis	29, Mitchell River.
6. Eucalyptus camaldulensis/ Melaleuca large-leafed species/ Melaleuca small-leafed species/ Casuarina cunninghamiana/ Lophostemon grandiflorus	14, Gilbert River; 23, Leichhardt River; 28, McArthur River; 32. Nicholson River; 38, Roper River. 49, Flinders River; 51, Daly River.
7. Melaleuca large-leafed species	7, Coleman River; 9, Ducie River; 17, Holroyd River; 19, Jardine River.
8. Melaleuca large-leafed species/Corymbia bella dominant	4, Buckingham River; 15, Goomadeer River; 22, Koolatong River; 48, Wildman River.
9. Melaleuca large-leafed species/Lophostemon grandiflorus	2, Archer River; 11, Embley River; 13, Fitzmaurice River; 36, Prince Regent River; 41, South Alligator River; 46, Watson River.
10. Melaleuca large-leafed species/Lophostemon grandiflorus/Callistemon viminalis	47, Wenlock River.
11. Melaleuca large-leafed species/Casuarina cunninghamiana	39, Rosie River; 45, Walker River.

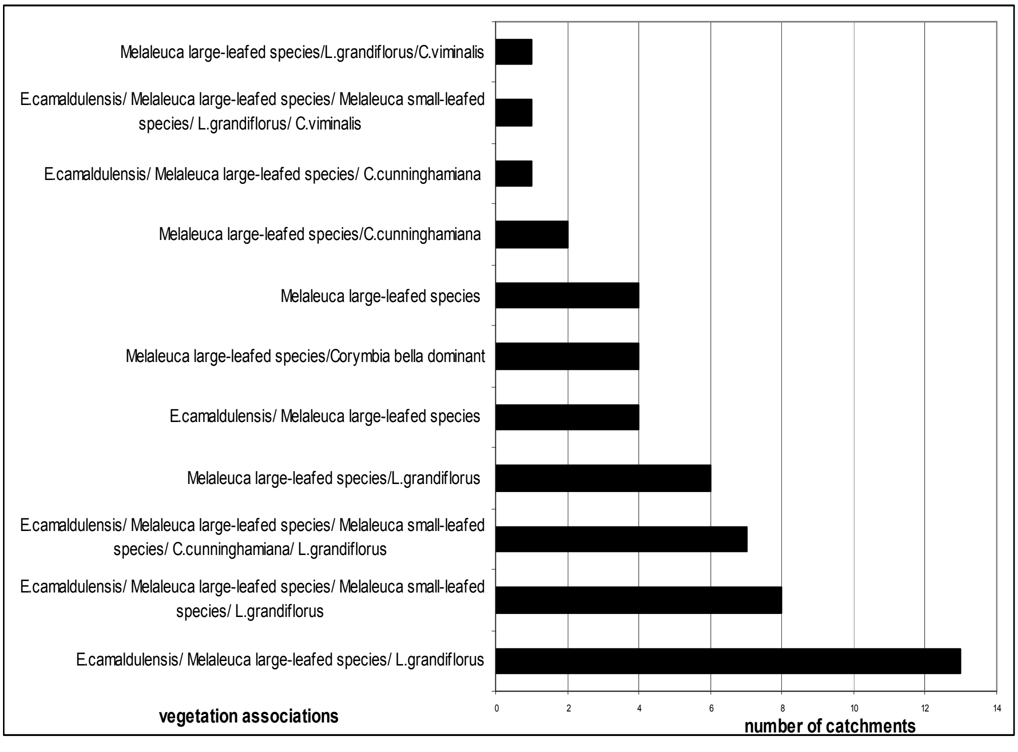

Figure 9 The Riparian Vegetation Associations in the Tropical Rivers catchments and the number of catchments in which each association occurs.

Invertebrates

Previous TRP Milestone reports have described consultations and a framework for employing aquatic macroinvertebrates in a multi-scalar, inventory and assessment tropical rivers study. The framework considers (i) broad-scale, rapid assessment using AUSRIVAS, and (ii) assessments at specific sites and/or for conservation & biodiversity importance. The rationale for this dual approach was provided in the TRP Milestone 2 report.

(i) AUSRIVAS data for broad-scale, rapid assessment

AUSRIVAS bioassessment data may be potentially used in one of two ways: (i) evaluating the potential to derive wet-dry tropical AUSRIVAS models, with possible improved precision and resolution with the artifices of jurisdictional boundaries removed (– currently models have been developed for separate states and territory); and (ii) seeking links between macroinvertebrate data and the corresponding hydrology, geomorphic classification and water quality datasets of the respective streams (rationale provided in other TRP reports).

Family-level (and for NT, some genus-level) data were acquired from WA, NT and QLD agencies, as well as from ERIN, for wet-dry tropical streams. For the wet-dry tropics, agencies have collected in two seasons, early and late dry seasons. For the purposes of examining a reasonably standardised dataset from across northern Australia, AUSRIVAS data mostly from the period 1998-2000 were selected and combined for early dry season, edge (QLD, NT) or channel (WA) habitat. ('Channel' habitat was the most similar of the WA habitats sampled to the NT and QLD's 'edge' habitat.) The resulting dataset comprised 73 WA sites, 155 NT sites and 95 QLD sites.

Analyses conducted on combined agency AUSRIVAS data

The combined agency dataset was analysed using PRIMER multivariate software. Ordination (multi-dimensional scaling) and classification plots were derived from presence-absence data. In a preliminary two-dimensional ordination (but with high stress), NT sites generally grouped separately from QLD and WA sites which tended to group together (figure 10). This observation was generally supported by the classification (figure 11) where the great majority of sites were contained in two large clusters separated at a similarity of ~55%: one cluster (115 sites) containing, almost exclusively, NT sites while the other (159 sites) contained a mix of QLD (71), WA (56) and remaining NT (32) sites. The former large NT group was further divided into two discrete groups (indicated). On closer examination, the two NT groups were generally associated with 'high' (Group 1) and 'low' (Group 2) alkalinity waters.

The separation of NT macroinvertebrate samples from QLD and WA may be related to subtle differences in habitat sampled, artefacts of sample sorting methods, real zoogeographical differences across northern Australia, or a mix of any of these factors. PRIMER's SIMPER routine may be used to examine which taxa are contributing to the differences amongst state/territory agencies in the cluster and ordination analyses. The results of this analysis showed that the NT separation from WA and QLD was due primarily to greater proportions in the NT samples of the taxa Orthocladiinae (Chironomidae), Elmidae, Hydroptilidae, Ecnomidae and Oligochaeta, and lower proportions in the NT samples of Hydrophilidae, Coenagrionidae, Libellulidae, Notonectidae, Corixidae, Gerridae, Pleidae and Gomphidae. This separation coincides closely with those taxa known to be better represented in laboratory processed (NT) and live-sorted (WA and QLD) macroinvertebrate samples respectively (Humphrey & Thurtell 1997). The former taxa are small and cryptic while the latter are more often large and uncommon in samples with a small probability of being included in laboratory subsamples (unless a dedicated 'large-pick' method is employed in the laboratory to recover these taxa).

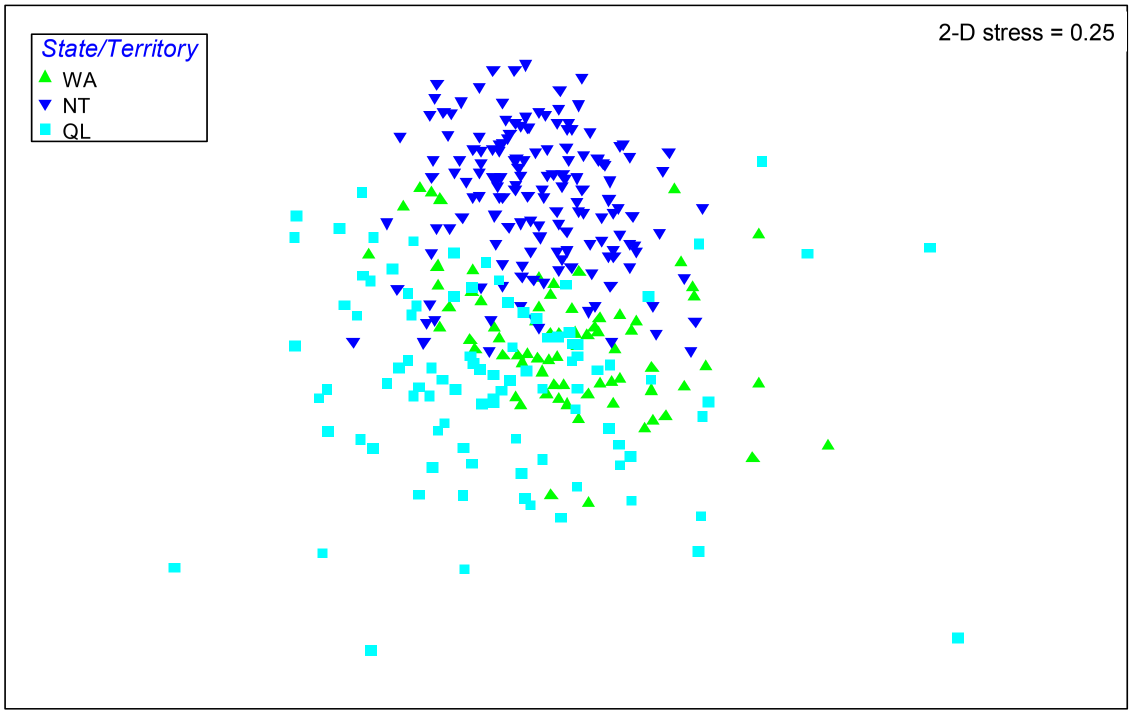

Figure 10 MDS ordination analysis of AUSRIVAS presence/absence data from wet-dry tropical stream, early dry season, edge/channel habitat

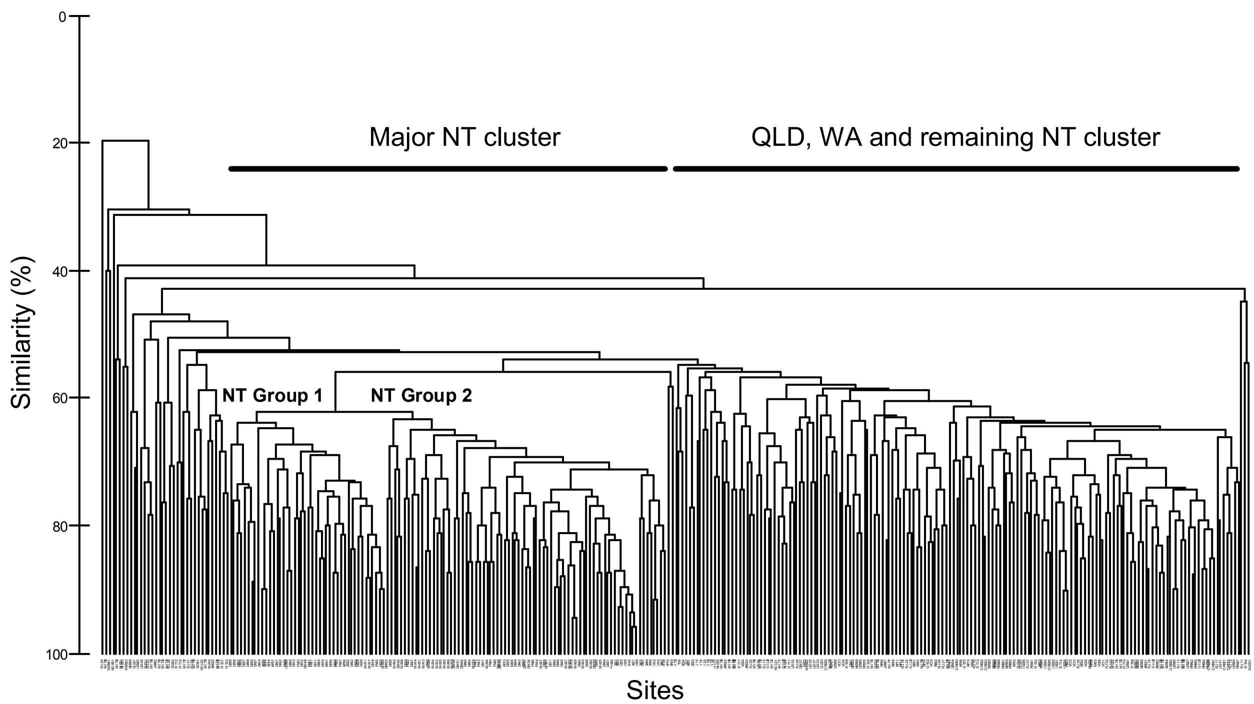

Figure 11 Cluster analysis of AUSRIVAS presence/absence data from wet-dry tropical stream, early dry season, edge/channel habitat

Thus, an early conclusion arising from the analysis of combined agency AUSRIVAS data is that the resulting group separation is very much influenced by differences in sample processing methods adopted by the different agencies. Because QLD and WA agencies both ‘live-sort’ samples in the field, there may be merit in separately analysing these combined agency data to seek zoogeographic patterns and environmental relationships in the ensuing multivariate analysis.

Analyses conducted on NT Daly River (AUSRIVAS) data

Because of the likely artefacts inherent in combined agency AUSRIVAS analyses (from above), separate analysis of genus-level NT data was conducted with a particular focus on determining whether patterns in macroinvertebrate communities were reflected in corresponding hydrology, water quality data and geomorphic classifications. Data from 50 Daly River catchment sites were examined for this analysis. Analysis at this lower taxonomic level has the advantage of providing, potentially, better resolution and sensitivity to environmental gradients that may be present in the data.

Multivariate ordination and cluster analyses were conducted, as previously described (above). The classification plot is shown in figure 12. Two major groups were defined at a similarity of ~43%: one cluster containing mostly sites of permanent stream flow, the other containing mostly sites of seasonal flow (figure 3). Within the cluster of sites of permanent flow, a further division was evident of sites of generally low (upland) and high (lowland) alkalinity (figure 3). These results are generally consistent with the findings of Dostine (2000)[1] who analysed a similar – but not identical – dataset and configuration of Daly River sites using species-level data. Dostine (2000) identified four major classification types based upon macroinvertebrate composition: (i) perennial-flow, lowland sites of high alkalinity, (ii) perennial-flow, upland sites of low alkalinity, (iii) seasonal-flow, upland sites of low alkalinity, and (iv) sites from small streams of seasonal flow or pools of larger streams.

From the above description, the main environmental factors defining macroinvertebrate groupings in the Daly River catchment are seen to be hydrologically and chemically based. There was little correspondence between 6 over-lapping geomorphic classification groups derived for the Daly catchment from another TRP sub-project (M Saynor, W Erskine and colleagues) and the macroinvertebrate groups identified in this and Dostine’s (2000) earlier study. For example, while one of the two major macroinvertebrate clusters from Figure 3 assigned as ‘permanent flow’ was further divided into low and high alkalinity groups, in geomorphological terms there was little distinction in this collective of sites with 78% of the sites being defined as “bedrock confined channel”. Thus, in this example the geomorphic classification subsumes real biological separation and pattern. It is likely that this poor correspondence is exemplary of what would result if similar relationships were sought more broadly between geomorphic and macroinvertebrate datasets amongst wet-dry tropical streams.

[1] Dostine P 2000. *Patterns in macroinvertebrate community composition and recommendations for monitoring in the Daly River system*. Report NR2000/14. Department of Lands, Planning and Environment, Darwin.

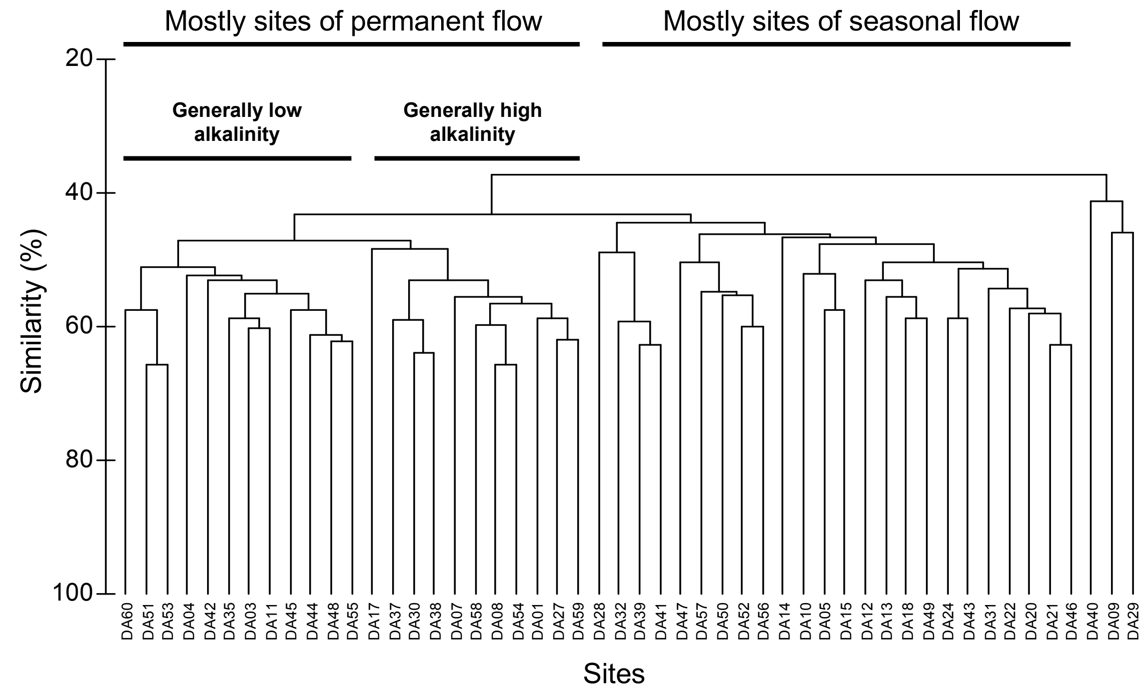

Figure 12 Cluster analysis of AUSRIVAS presence/absence data from the Daly River catchment, early-mid dry season, edge habitat

While a separate TRP project has examined hydrological patterns and features of focus catchments for the TRP study region (project by D Moliere), the use of these results in better accounting for observed macroinvertebrate patterns is limited. Thus while pattern of stream flow (perennial vs seasonal) has been shown to be important in characterising macroinvertebrate communities in the Daly River catchment (from above), the hydrology typology derived in the study by Moliere is derived from data from a relatively small number of gauging stations and hence has very limited capacity for interpolating or extrapolating stream flow and associated patterns elsewhere in the catchment. Records of stream flow collected at the time of macroinvertebrate sampling are most useful for this purpose.

(ii) Macroinvertebrate inventory data for assessments at specific sites and/or for conservation & biodiversity importance

An earlier TRP objective for this (macroinvertebrate) sub-project stated (from Milestone 4 report):

- For assessments at specific sites and/or for conservation & biodiversity importance, species-level data will be acquired from the several wet-dry tropical streams for which such information is available, while other taxonomic information will be acquired from specialists and national databases.

Since this last Milestone report, a decision was made at ***eriss*** that it would be impractical to extract and compile macroinvertebrate species-level data from northern Australian streams because of (i) the enormity of the task (involving thousands of species), and (ii) issues associated with data custodianship and ownership that would take excessive time and resources to resolve. Instead, the approach has been to carry out extensive consultations to compile meta-data descriptions of macroinvertebrate species-level data available for Australia's wet-dry tropical streams. A summary of this component of the study is provided below. This meta-data description will assist others, in future, source and compile species-level data should this need be identified, prioritised and adequately resourced.

As described in the last Milestone report, similar data inventory and assessment projects are also being conducted in the (mainly) Wet tropics. A project being coordinated by Niall Connolly of the Australian Centre for Tropical Freshwater Research (James Cook University) was described. This project aims to develop a species-level interactive atlas of macroinvertebrates in the Wet Tropics that is proposed to be expanded into other bioregions. Niall Connolly has offered to extend this atlas to include wet-dry tropical exemplary data, most likely focusing on Ephemeroptera. The work would draw upon the results of an NHT-funded project recently completed by Dr Phil Suter (Latrobe University) which describes habitat profiles of species from some prominent aquatic insect groups.

Meta-data summary of macroinvertebrate species-level data available for Australia's wet-dry tropical streams

Available species-level meta-data associated with the freshwater macroinvertebrates of northern Australia's wet-dry tropics is being compiled from various sources including State and Territory Museum database collections, relevant online databases, as well as research, inventory and taxonomic literature produced by government agencies, conservation services and other expert researchers.

The following account provides a summary of the type of data found through such consultations. Where available, associated contacts are also provided.

Museum collections

Australian Museum

The Australian Museum (AM) has an extensive collection of mollusc specimens relevant to the current project area, distributed in all three states/territory. These species-level data have been data-based and include the relevant geo-references (latitude and longitude site co-ordinates) and locality names. The museum's collection has been data-based with funding from DEH for its new database, "The Australian Heritage Assessment Tool" (AHAS).

Contact: Alison Miller (Technical Malacology).

The aquatic insect inventory held at the Australian Museum, relevant to the project area, is not as extensive and shows an overall bias towards the east coast, including Queensland's wet tropics. Taxonomic groups included here are the hemipteran families, Nepidae and Hydrometridae, and coleopterans belonging to the families Hydrophilidae and Dytiscidae. The data have been geo-referenced.

NB: "MS name field" must not be used in publication.

Contact: Dr Dave Brittion (Entomology Collection Manager).

The AM's mollusc and aquatic insect data have been been provided to ***eriss*** for the TRP inventory and can be categorised into drainage areas if required.

Museum of WA

The museum mollusc collection includes samples from the Kimberley region of WA and some records from the extreme west of the NT. The molluscs and other freshwater groups in the museum's collection from northern Australia are largely not data-based or identified beyond genus or even family level. Material on loan to other non-WA Museum researchers has been data-based; for example, their mollusc collection has been worked on by Dr Winston

Ponder of the Australian Museum (recently retired) and this would be reflected in the Australian Museum's dataset and DEH's AHAS.

The museum is also presently data-basing their water beetle family and odonate records, with funding from DEH (for the AHAS). This collection, too, would be expected to include material from north Western Australia.

Contact: Terry Houston (Senior Curator – Entomology)

Queensland Museum

Freshwater invertebrates have never been a priority in the Queensland Museum's collections. There is a small dataset for freshwater mollusc families, including gastropod families Bithyniidae, Viviparidae and Thiaridae, and the bivalved molluscs Hyriidae and Corbiculidae. The number of specimen lots here would be less than 20 and not all have accurate distributional data associated with them.

Contact: Dr John Stanisic (Senior Curator, Malacology & Biodiversity Scientist).

The best dataset (catalogued and geo-referenced) in the museum's crustacean collection is for the freshwater prawn, *Macrobrachium* (F. *Palaemonidae*), as a consequence of Dr John Short's PhD (Short 2004) on this genera. The museum also holds some patchy distributional information on the Atyidae shrimps though this is biased to the east coast. Currently, freshwater crab (F. Sundathelphusidae) data are being catalogued and geo-referenced and should be completed shortly. The Museum has completed an ABRS-funded taxonomic study (molecular genetics) of this family (Sundathelphusidae) in Australia.

Contact: Peter Davie (Senior Curator - Crustacea)

SA Museum

Two aquatic groups have been data-based from the South Australian Museum's collection, these being water beetle families and the Odonata (DEH funded – Cameron Slatyer). Dr Chris Watts, based at the SA Museum, maintains his own database of all the aquatic coleopteran in the Museum's collection. This dataset contains a wealth of information relevant to the TRP project area that could be sought for this study.

Contact: Jan Forrest (Senior Collections Manager, Terrestrial Invertebrate Sections)

Museum Victoria

The Museum of Victoria has not data-based any of its freshwater macroinvertebrate collections, with the exception of its Trichopterans (adults and larvae). These data are currently being entered into a database which is expected to have been completed by October 2006. The tropical data held here will have an expected east coast bias.

Contact: Dr Richard Marcant (Senior Curator, Terrestrial Invertebrates)

Museum & Art Gallery of the Northern Territory

Collections from the NT wet-dry tropics are only partially data-based by the MAGNT. These freshwater groups include, Gastropoda (F. Planorbidae, Lymnaeidae, Bithyniidae, Neritidae, Thiaridae and Viviparidae), Bivalvia (F. Hyriidae and Corbiculidae), Crustacea (F. Palaemonidae, Atyidae, Parasticidae and Sundathelphusidae) and the insect order Tricoptera (Helicopsychidae, Hydroptildae and Polycentropodidae).

Distributional information is only provided by way of locality name and distance ('km from') and is not extensive. The most complete collection held at MAGNT is for the Odonata, with records being supplied to DEH who have subsequently data-based this information for the AHAS.

Contact: Gavin Dally (Collections Manager, Natural Sciences)

Online Databases

ABRS (Australian Biological Resources Study – Faunal Directory)

The species data in this online database is limited to maps showing distribution within the old drainage basin areas. A species list for those specimens recorded for TRP catchments has been collated.

ANIC

This online publicly-accessible database has a small number of chironomid Diptera, nepid Hemiptera, and elmid, noterid and gyrinid Coleoptera records. Other coleopteran families more extensively data-based here are the hydrophilids and dytiscids. Northern distributed Odonata are extensively data-based though much of the data is based upon adult material, with only a few aquatic nymph entries. The information is provided with locality name and geo-references.

Currently, CSIRO are data-basing theirs and the SA museum's Hemiptera (Nepomorpha) collections into the ANIC database, although, at this stage they are a long way off completion. Dr Tom Weir who is involved in this work maintains his own database of the Gerromorpha hemipteran families (containing over 6770 records obtained from some 49000 specimens), which is clearly a more comprehensive dataset.

OZCAM

"Australia's Fauna" is an online, distributed network of databases that collates information from Australia's museums and other institutional faunal collections. Data pertaining to freshwater macroinvertebrates of Australia's wet-dry tropics is very limited. The best data are held in the ANIC database and this has already been exploited directly. A species list of other holdings has been made as part of the TRP study and can be categorised into drainage divisions, if need be.

Australian Heritage Assessment Tool

This database, currently under construction, comprises about 14 million specimen locality records, derived from state agencies, commonwealth agencies and conservation services. Currently, only a partial range of invertebrate taxa are available, including:

- Freshwater Mollusca (mainly Australian Museum, ~14,000 records biased towards SE Australia)
- Odonata (ANIC and all state museums)
- Adephaga families of diving beetles (mainly SA Museum, ~10, 000 records with good continental coverage)
- Rotifers (4000 records, biased towards the SE Australia)

(Contact - Cameron Slatyer, Assistant Director, Natural Environment Assessment)

Dedicated inventory reports and publications

Relevant inventory reports and publications will be provided at a later date. Species-level information, however, is available for a number of TRP catchments including Ord River (WA), Keep River and tributaries (NT and WA), Daly River, East and South Alligator rivers and some tributaries (NT), as well as some upland sites from the Mitchell and Walsh rivers (QLD).

References

Dostine P 2000. *Patterns in macroinvertebrate community composition and recommendations for monitoring in the Daly River system*. Report NR2000/14. Department of Lands, Planning and Environment, Darwin.

Humphrey C & Thurtell L 1997. External QA/QC of MRHI agency subsampling and sorting procedures. In *Development and implementation of QA/QC protocols for sample processing components of the MRHI agency bioassessment program*, eds C Humphrey, A Storey & L Thurtell, Final Report to Land and Water Resources Research and Development Corporation (Reference No. ARR2), December 1997.

Short JW 2004. A revision of Australian river prawns, *Macrobrachium* (Crustacea: Decapoda: Palaemonidae). *Hydrobiologia* 525, 1-100.

Fish

Analysis of freshwater fish for the project centres around comparing known distributional data with landscape patterns and survey effort. A database of fish records from the published literature has been compiled. The database now contains a total of 929 site surveys. More than 170 fish species are represented.

Some species are widespread and common, being found at many sites. A total of 24 species have been reported from more than 100 sites each (table 5), with spangled perch, bony bream, mouth almighty and barred grunter being the most widely distributed species, all being found at > 400 sites each. Glass perches and rainbowfish would also be within this category if their taxa records were combined. For instance, as a group, *Ambassis spp.* glass perch were present at 516 sites and *Melanotaenia spp.* rainbowfish were recorded from 747 sites. Large-bodied fish (eg. barramundi, catfish, tarpon, sooty grunter, bony bream, sleepy cod) are as well represented in this list as are small-bodied fish.

Sites in the database have been allocated to catchments and catchments to regions to analyse the data at a regional level. An example of this kind of analysis is below in table 6. The numbers of fish in each region can vary depending on how the regions are defined. This will be more fully explained in the final report. The indicative analysis shown below provides some idea of how fish survey effort has been distributed, with the Kimberley and rivers of western Cape York (eg. Mitchell, Archer) being more often surveyed than rivers elsewhere, especially in Arnhem Land, Eastern Cape York (eg. Pascoe, numerous smaller creeks and wetlands) and the rivers of the southern and SW Gulf of Carpentaria (which are presumably not as appealing as those elsewhere, despite the high fish species richness).

A similar analysis as done for regions has also been done for catchments. Only those catchments with >30 species present are listed in table 7. The most number of species recorded are from the Alligator Rivers, due at least in part, to the intensive nature of effort there over many years (unlike most studies which only sample each site once or twice, many of the Alligator sites have been sampled many times). The Mitchell River has been well sampled, also with many sites done on multiple occasions. The diversity of the Wenlock and Jardine rivers reflect their position near the tip of Cape York. The diversity of many rivers further down this list can be expected to rise significantly with more survey effort.

Table 5 Species recorded from >100 sites in the database

Common Name	Species Name	No. Sites
Barred grunter	*Amniataba percoides*	414
Fly-specked hardyhead	*Craterocephalus stercusmuscarum*	264
Glass perch	*Ambassis sp.*	111
Glass perch	*Ambassis agrammus*	146
Glass perch	*Ambassis macleayi*	206
Fork-tailed catfish	*Arius greaffei*	115
Mouth almighty	*Glossamia aprion*	425
Goby	*Glossogobius giurus*	149
Sooty grunter	*Hephaestus fuliginosus*	220
Barramundi	*Lates calcarifer*	243
Spangled perch	*Leiopotherapon unicolor*	593
Tarpon	*Megalops cyprinoides*	188
Rainbowfish	*Melanotaenia spp.*	103
Rainbowfish	*M. spenidida australis*	195
Rainbowfish	*M. splendida inornata*	221
Rainbowfish	*M. spelndida splendida*	165
Gudgeon	*Mogurnda mogurnda*	235
Bony bream	*Nematalosa erebi*	435
Black catfish	*Neosilurus ater*	226
Hyrtl's tandan	*Neosilurus hyrtlii*	278
Sleepy cod	*Oxyeleotris lineolatus*	258
Striped sleepy cod	*Oxyeleotris selheimi*	112
Long tom	*Strongylura kreftii*	227
Archerfish	*Toxotes chatareus*	333

Table 6 Fish Species Richness By Region Across Northern Australia

Region	No. Sites Surveyed	No. Fish Species Recorded
Arnhem Land	42	58
Cape York tip	32	48
Cooktown-Lakefield	64	60
Darwin-Victoria	108	92
Eastern Cape York	66	74
Kimberley	200	86
SW Gulf of Carpentaria	110	94
Western Cape York	157	89

Table 7 Survey Effort and Species Richness by Catchment

Catchment	No. Sites Surveyed	No. Fish Species Recorded
South and East Alligator Rivers	60	61
Mitchell River	53	57
Wenlock River	26	57
Annan-Endeavour	34	46
Nicholson River	31	46
Jardine River	26	42
Flinders River	19	41
Ord River	19	41
Roper River	24	40
Archer River	36	39
Olive River	16	38
Daly River	26	36
Fitzroy River	70	37
Edward River	8	35
Holroyd River	9	34
Coleman River	11	33
Victoria River	24	32
Pascoe River	10	31
Leichhardt River	10	30

The information contained in the database is being used in landscape GIS analysis. The core output currently being worked on is a map of where survey effort has occurred and how many species found at each site. We are also using GIS layers to examine patterns of diversity in relation to distance upstream, fish faunas above and below waterfalls and at various elevations and diversity relationships to stream flow.

Reptiles

Collection of data for reptiles has now ceased, and all data points have been entered into GIS format. A total of 13,687 records of reptiles are now in the Tropical Rivers Project database. These comprise a total of 1750 records extracted from the OZCAM database updated at the end of June 2005 which compares to 1613 records from the previous extraction which was in January 2005 and 11352 records from the Parks and Wildlife Commission of the Northern Territory database from which information was received on 16th June 2005. These data cover 28 catchments in the NT. Of these, 9,330 records were from crocodile surveys. A dataset of 576 records from 1999 crocodile surveys for the Gulf draining catchments in Queensland was obtained from Mark Read of the Crocodile Management Unit, Queensland Parks and Wildlife Service. Wildnet data from Queensland Environmental Protection agency were obtained for only the Flinders River catchment. This comprises only 9 records covering 6 species. The precision of these data ranges from 900 m to 54 km.

A breakdown of number of records and number of species per catchment is shown in table 8, while a species breakdown of the three focus catchments is shown in table 9.

Table 8 Summary of records for each catchment

Catchment	Total Records	No of Species	Catchment	Total Records	No of Species
Cape Levique Coast (OZ)	9	3	Walker (OZ)	8	3
Fitzroy (OZ)	40	10	Walker (DI)	11	4
Lennard (OZ)	7	4	Roper (OZ)	46	15
Isdell (OZ)	58	7	Roper (DI)	435	16
Prince Regent (OZ)	13	6	Towns (OZ)	0	0
King Edward (OZ)	47	13	Towns (DI)	1	1
Drysdale (OZ)	15	10	Limmen Bight (OZ)	3	3
Pentecost (OZ)	5	2	Limmen Bight (DI)	23	8
Ord (OZ)	81	9	Rosie (OZ)	0	0
Ord (DI)	15	6	Rosie (DI)	2	1
Keep (OZ)	9	3	McArthur (OZ)	21	10
Keep (DI)	17	7	McArthur (DI)	46	12
Victoria (OZ)	112	10	Robinson (OZ)	0	0
Victoria (DI)	453	9	Robinson (DI)	5	5
Daly (OZ)	194	18	Calvert (OZ)	7	2
Daly (DI)	729	19	Calvert (DI)	11	6
Fitzmaurice (OZ)	8	4	Settlement Ck (OZ)	17	5
Fitzmaurice (DI)	36	7	Settlement Ck (DI)	18	6
Moyle (OZ)	4	2	Nicholson (OZ)	78	13
Moyle (DI)	112	5	Nicholson (DI)	5	2
Finnis (OZ)	316	17	Leichhardt (OZ)	26	5
Finnis (DI)	2698	19	Leichhardt (Croc surveys)	21	1
Adelaide (OZ)	168	15	Morning Inlet (OZ)	0	0
Adelaide (DI)	2677	17	Flinders (OZ)	4	2
Mary (OZ)	21	10	Flinders (Wildnet)	9	6
Mary (DI)	1045	15	Norman (OZ)	15	9
Wildman (OZ)	17	6	Norman (Croc surveys)	65	1
Wildman (DI)	29	7	Gilbert (OZ)	20	7
Sth Alligator (OZ)	34	10	Staaten (OZ)	1	1
Sth Alligator (DI)	226	16	Staaten (Croc surveys)	49	1
East Alligator (OZ)	84	13	Mitchell (OZ)	59	12
East Alligator (DI)	113	15	Mitchell (Croc surveys)	35	1
Goomadeer (OZ)	3	1	Coleman (OZ)	21	11
Goomadeer (DI)	84	6	Holroyd (OZ)	3	3
Liverpool (OZ)	5	2	Archer (OZ)	48	9
Liverpool (DI)	717	16	Watson (OZ)	12	7
Blyth (OZ)	37	11	Embley (OZ)	5	4
Blyth (DI)	672	10	Embley (Croc surveys)	40	1
Goyder (OZ)	13	3	Wenlock (OZ)	22	3
Goyder (DI)	474	11	Wenlock (Croc surveys)	366	1
Buchingham (OZ)	9	6	Ducie (OZ)	9	6
Buchingham (DI)	659	11	Jardine (OZ)	11	6
Koolatong (OZ)	1	1			
Koolatong (DI)	39	6			

(OZ): OZCAM Record; (DI): DIPE Record; (Croc surveys): 1999 Crocodile Survey; (Wildnet): QLD EPA Wildnet record.

Table 9 Summary of records for the focus catchments

Genus	Species	Fitzroy (OZCAM)	Daly (OZCAM)	Daly (DIPE)	Flinders (OZCAM)	Flinders (Wildnet)
Crocodylus	*johnstoni*	3	12	165		3
Crocodylus	*porosus*		2	341		1
Carettochelys	*insculpta*		5	7		
Chelodina	*canni*					
Chelodina	*rugosa*	9	11	7		1
Chelodina	*novaeguineae*					
Chelodina	*kuchlingi*					
Chelodina	*burrungandjii*		3	2		
Elseya	*dentata*		42	31		
Elseya	*lavarackorum*					
Elseya	*latisternum*		1	1		1
Emydura	*australis*	8	2			
Emydura	*subglobosa*		16	6		2
Emydura	*tanybaraga*		18	20		
Emydura	*victoriae*	6	4	11		
Emydura	*worrelli*			4		
Varanus	*indicus*					
Varanus	*mertensi*	2	24	39	1	1
Varanus	*mitchelli*	1	9	24		
Varanus	*panoptes*	4	2	14		
Varanus	*semiremex*					
Acrochordus	*arafurae*					
Acrochordus	*granulatus*					
Liasis	*fuscus*		3	9		
Cerberus	*rynchops*					
Enhydris	*polylepis*			1		
Fordonia	*leucobalia*	4	1	1		
Myron	*richardsonii*	1				
Stegonotus	*cucullatus*		1	4		
Tropidonophis	*mairii*	2	38	42	3	
TOTAL		**40**	**194**	**729**	**4**	**9**

Data are still very deficient in many of the catchments, a good example being the Flinders, one of the three focus catchments, for which there are thirteen records covering seven species. One catchment (Morning Inlet) contains no records at all while 17 catchments have twenty records or less. Thirty catchments or 59% have 50 records or less spread across a maximum of 30 species. To date most records, 12,648 have been found in the Northern Territory catchments, 194 records are from the Western Australian catchments and 842 records from the Queensland catchments. Efforts so far have failed find any other data from Western Australian and Queensland catchments.

Birds

Dr Don Franklin from the Charles Darwin University (CDU) School for Environmental Research was contracted to complete the birds component of the inventory and mapping. The report, which was completed in March 2006, details the collation and interpretation of waterbird data and its relationship to digital habitat classification systems for the TRIAP. The report's contents will be utilised for the overall analysis and ecological typology and final reporting of sub-project 1. The Executive Summary is reproduced below.

1. As part of the Tropical Rivers Inventory and Assessment Project (TRIAP), a database of 94,148 waterbird records was assembled, comprising 82,596 records from the TRIAP area and 11,552 records from a surrounding 10 km buffer. These records were sourced from databases for Atlas1 and Atlas2 provided by Birds Australia, 99.1% of which are from the Historical Atlas (pre-1977), the first Field Atlas (1977-1981) or the second Field Atlas (1997-2002).

2. Waterbirds were defined to include species of freshwater and coastal wetlands including in-shore but not off-shore marine species. The TRIAP waterbird fauna comprises 145 species from twenty families, of which 112 species are represented in the database by more than ten records.

3. One TRIAP waterbird species – the Australian Painted Snipe – is listed as threatened under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBCA). Eighty-seven species are listed as "migratory" under the EPBCA, 44 species are listed under the Japan-Australia Migratory Bird Agreement and 53 species under the China-Australia Migratory Bird Agreement. The geographical characteristics of all listed species are summarised for the TRIAP area.

4. In the TRIAP area, the Australian Painted Snipe is an infrequent visitor or perhaps rare resident found more frequently in the more arid south. Its preferred habitat of ephemeral wetlands with a mix of mud-flats and dense low vegetation does not closely match habitats recorded for the species in the TRIAP area, which may reflect the marginal nature of its occurrence in this area. Breeding records in the TRIAP area have been in flooded grasslands.

5. A foraging guild classification based on a classification of foraging substrate, foraging methods and food types is presented. Twelve foraging guilds are recognised as occurring in the TRIAP area.

6. No waterbirds are endemic to the TRIAP area. However, the TRIAP area represents a major proportion of the range of the Chestnut Rail, and a major proportion of the Australian range of the Great-billed Heron.

7. A biogeographic classification of TRIAP waterbirds is developed based on breeding distributions. Four classes are recognised: a. species for whom TRIAP is a core breeding area; b. Australasian species for whom TRIAP is marginal to their main distribution; c. Palaearctic / Nearctic migrants – these do not breed in Australia; and d. Non-migratory species with a distribution centre in Asia, or Malesia including New Guinea. Few species other than vagrants have restricted ranges within the TRIAP area, but there is a weak declining gradient in species richness from east to west.

8. The distribution of waterbird families, foraging guilds and threatened species were compared qualitatively with a 1:250 000 classification of waterbodies into seven units. Although the results are "noisy", groups associated with deep water and saline habitats were clearly identifiable. A geomorphic classification of rivers provides only linear data and poor spatial correspondence with waterbird records. Neither classification provides a direct measure of the wetland features most relevant to most species, and whilst quantitative analysis could be pursued, it appears unlikely to identify many definitive habitat relationships.

Estuaries

A range of available classification systems for estuaries has been examined. This has identifed a strong link between the environmental management needs, available information and the scale of the study area to the classification scheme development. In general, there is a scalar effect, whereby small-scale estuarine features such as the entrance channel dimensions, or salt-wedge structure, are essential descriptors for a locally based classification scheme (see Dyer 1998).

At a global or continental scale, the dynamics of individual estuaries are generally too complex for detailed development of a classification scheme, or there is a distinct lack of appropriate information. The potential information needs to develop a scheme suitable for environmental management is illustrated by the detailed multi-variate analysis conducted by Coleman & Wright (1971). As a simplified proxy, Galloway (1978) developed a ternary classification scheme, based upon tide, wave and river flow, which balanced available information with classification needs. This approach was adopted by Boyed et al (1992), Dalrymple et al (1992) and has more recently formed the fundamental basis for the comprehensive analysis of Australian estuarine geomorphology undertaken by Geoscience Australia (Harris et al 2001; Ryan et al 2003).

For estuaries for which there is a higher level of available information, the ternary classification scheme offers a very simple interpretation of active processes. However, it is important to be aware that the three factors used to describe the estuarine system are themselves proxy indicators of the active processes and may be modified by site-specific characteristics. For example, alongshore sediment transport is heavily affected by wave power. However, this is significantly modified through coastal aspect and the sediment character and will produce very different patterns of estuarine evolution and morphology. These aspects and some the potential limitations are identified within the derivation of the estuarine classification system (Harris et al 2001).

On the Northern Australian coast, one of the most significant features affecting the classification and development of the estuarine systems is the episodic character of meteorological conditions. This affects both oceanographic forcing and fluvial runoff, which have been identified as driving processes for the region.

Data Collection

Estuaries

ARC format GIS shape files are available from Geoscience Australia covering a large number of the estuaries across the Tropical Rivers Region. Numerical model outputs may be generated for the salinity and nutrient dynamics of the estuaries contained within the GA database, using the CSIRO Simple Estuary Response Models (SERM and SEM II).

Meteorological Information

Regional long-term meteorological studies are available from the Bureau of Meteorology. These include, annual, seasonal or monthly summaries of rainfall, wind distributions and barometric pressure. Interpolated rainfall, wind and pressure datasets are available from the NCEP-reanalysis database. However, this information is based upon the weather records available from individual BoM sites and may be less representative due to data smoothing and interpolation. To facilitate the analysis of individual events, daily rainfall and wind records have been obtained from the Bureau of Meteorology across all sites in Australia. These observations are not evenly distributed in space and have variable historic data lengths. Such variability needs to be incorporated into any data interpretation. Individual cyclone events are summarised in the Bureau of Meteorology tropical cyclone database and international cyclone and hurricane databases which cover the Pacific and Indian Oceans.

Water Levels

Tidal summaries are available from the Australian National Tide Tables.

Monthly mean sea level observations have been obtained from the Permanent Service for Mean Sea Level. This dataset illustrates the coherence of inter-annual mean sea level fluctuations and supports the relationship between Australian water levels and global climate indicators (particularly SOI) previously identified by Aubrey & Emerey (1986) and Pariwono et al (1986). The data clearly demonstrate variations in the annual sea level signal within the Gulf of Carpentaria are significantly greater than observed along other parts of the Australian coast. This pattern affects the susceptibility of the Gulf region to extreme events.

Short-term surges and tidal fluctuations, including inter-annual cycles (see Wood 2001) must be abstracted from high frequency datasets. Selected long-term tide gauge datasets have been obtained and assessed relative to wind and cyclone databases. These include Port Hedland, Broome, Wyndham, Darwin, Groote Eylandt, Karumba and Weipa.

Wave Information

No regional long-term wave observations have been identified. Regional descriptions of the wave climate are available through ship-board observation (US Navy Marine Atlas, 1976) or more recent global and regional hindcasts (Wavewatch III, Bureau of Meteorology). For the Tropical Rivers Region, ambient wave conditions are strongly linked to monsoon winds. This provides a high level of directional stability, although there may be variations in the intensity or persistance of monsoonal events (Raghavan et al 1973). For more extreme tropical cyclone events, short-term wave observations or hindcast waves offer limited value as they are normally beyond the calibrated model range.

References

Aubrey D & Emery K 1986. Australia – An Unstable Platform for Tide-gauge Measurements of Changing Sea Levels. *Journal of Geology* 94, 699-712.

Boyd R, Dalrymple RW & Zaitlin BA 1992. Classification of clastic coastal depositional environments. S*edimentary Geology* 80, 139-150.

Coleman JM & Wright LD 1971. *Analysis of Major River Systems and Their Deltas: Procedures and Rationale, with Two Examples*. Technical Report No. 95, Coastal Studies Institute, Louisiana State University, Baton Rouge, LA.

Dalrymple RW, Zaitlin BA & Boyd R 1992. Estuarine facies models: conceptual models and stratigraphic implications. *Journal of Sedimentary Petrology* 62, 1130-1146.

Dyer K 1997. *Estuaries: a physical introduction*. John Wiley and Sons, Chichester.

Galloway W 1975. Process framework for describing the morphologic and stratigraphic evolution of deltaic depositional systems. In: Broussard M (ed.) *Deltas: Models for Exploration*. Houston Geologic Soc., Houston TX, pp 87-98.

Heap, Bryce, Ryan, Radke, Smith, Smith, Harris & Heggie 2001. *Australian Estuaries and Coastal Waterways: a Geoscience Perspective for Improved and Integrated Resource Management*. A Report to the National Land and Water Resources Audit. Theme 7: Ecosystem Health.

Pariwono J Bye J & Lennon G 1986. Long-period variations of sea-level in Australasia. *Geophysical Journal of the Royal Astronomical Society* 87, 43-54.

Raghavan K 1973. Break monsoon over India. Monthly Weather Review, pp 33– 43.

Ryan, Heap, Radke & Heggie 2003. *Conceptual Models of Australia's Estuaries and Coastal Waterways*. Applications for Coastal Resource Management. Geoscience Australia Record 2003/09.

US Navy 1995. *Marine Climatic Atlas of the World*. CD Version 1.1.

Webster PJ et al 1998. Monsoons: Processes, predictability and the prospects for prediction. *Journal of Geophysical Research* 103, 14451-14510.

Wood F 2001. *Tidal Dynamics. Volume I: Theory and Analysis of Tidal Forces*. Journal of Coastal Research (JCR) Special Issue No. 30. Coastal Education and Research Foundation.

GIS and mapping

Data management and structure

A transportable ArcGIS map document, *Tropical-Rivers_Datasets.mxd* that links the final collated datasets has been prepared. Together with the accompanying related datasets, this document represents the core of the inventory components information package that will be supplied to Land and Water Australia. This document, when accompanied with the related datasets, opens in the ArcGIS 9 environment to enable the user to query, analyse and overlay the datasets which have been collated, compiled and created for the inventory component of the project. Within the map document, datasets have been grouped initially on a thematic basis, and then on a hierarchical basis (continental and catchment-based) (figure 13). The properties of the datasets have been set to ensure that they are not able to be used or viewed at an inappropriate scale. To help users navigate around the document, a series of bookmarks have been created, to help users zoom to specific catchments, within the study area. A template for the production of maps, *Tropical-Rivers_Datasets.mxt* has also been prepared. Further documentation on how to apply and use the collated datasets is being completed.

Following a review of procedures for the creation and management of metadata within the Department of Environment and Heritage, metadata for databases / datasets has been progressively created / updated to the ISO19115 standard. Significantly,all datasets have a metadata record attached to them (figure 14). However, variations in the availability of information which could be used to populate the records has meant that some records contain very little data.

Modelling and analysis

Within the focus catchments, drainage features representing named and major rivers were selected from the 1:250,000 topographic data, and used as the basis for classification. A significant problem that was identified was that many of these drainage networks were discontinuous. Consequently, drainage networks derived from the 3-second digital elevation model were used in conjunction with drainage data from the 1:250,000 topographic data to ensure the continuity of drainage features selected as representing named or major water courses. In areas where there was no obvious or visible connection between a named drainage line and the rest of the named drainage features in a catchment from other data sources (including geology and ground water datasets) these features were deleted.

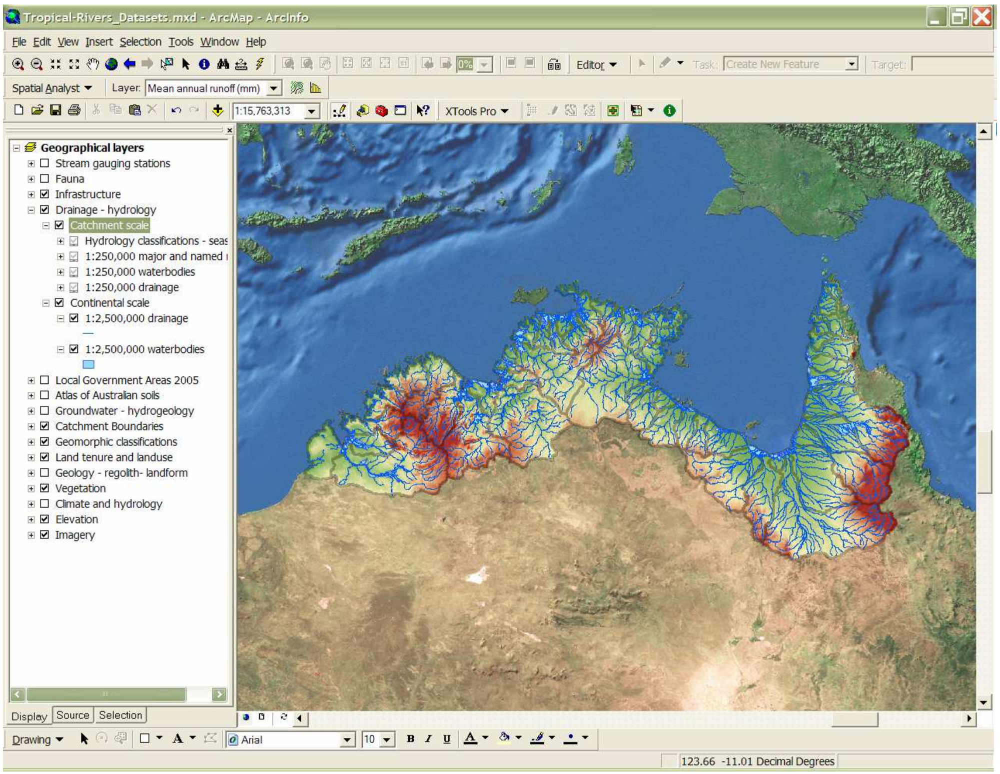

Figure 13 The interface of the Tropical-Rivers_Datasets map document.

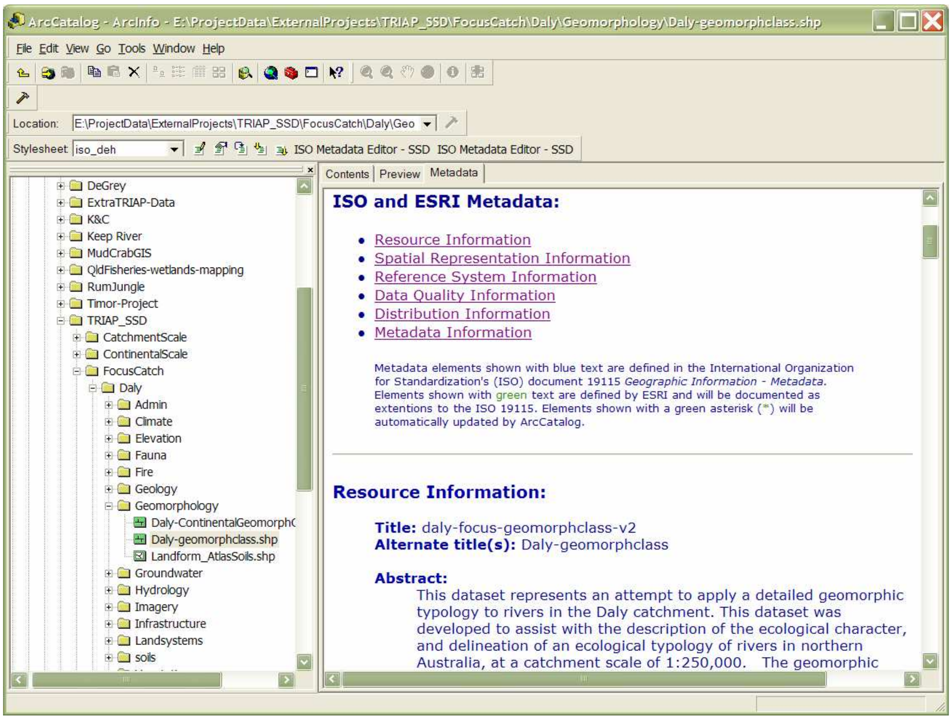

Figure 14 Sample metadata record. Metadata records have been completed for all datasets.

As noted in the hydrology section, climate data obtained from the Bureau of Meteorology has been obtained and used to generate datasets representing rainfall and runoff distribution across the study area. In addition, hydrological data has been obtained for each focus catchment, and analysed to identify the nature of the flow regime within each catchment.

Optical imagery (Landsat 7) has been used to validate the position and integrity of the drainage networks. In the focus catchments, this was complemented with the use of the GoogleEarth software.

As described above in the Geomorphology section, continental and focus catchment geomorphic classifications have been finalised, and mapped in the GIS database.

Issues and constraints

The lack of information on many of the datasets has delayed and hampered the creation of reliable metadata for all of the datasets which have been compiled for this project. The planned purchase of the 1-second DEM, which would have been used to provide more detailed topographic and drainage data within the focus catchments is proceeding by the Department of Environment and Heritage. Unfortunately, the delay in receiving approval for this acquisition has meant that the data will no longer be used by this project. However, this dataset represents a valuable resource that could benefit future projects. Overall, delays in collating and analysing datasets for a number of the biophysical attributes has subsequently delayed the overall analysis and development of a proposed ecological typology for the tropical rivers.

Planned activities

Data acquisition and integration will continue, on a reduced basis, as individual/specific datasets required for inventory are identified. Most data collection/compilation will be of those datasets required for risk assessment activities in the focus catchments. The creation and updating of metadata for datasets will continue as additional information becomes available

The major activity over the next reporting period will revolve around the synthesis of the data and subsequent development of the ecological typology. While this is still largely in a conceptual stage, firm details will be developed within the next month.

Communication and consultation

The relevant activities are described in the separate report at Attachment 2 of the Milestone Report.

Detailed Progress Report for Sub-project 2

Assessment of the major pressures on aquatic ecosystems

Contributing authors: *Renee Bartolo, Peter Bayliss, Rick van Dam*

Project description and objectives

The tropical rivers of northern Australia are under increasing pressure due to environmental threats and human activities. The objective of this sub-project is to develop a risk assessment framework applicable to the key focus catchments and significant locations that meet stakeholder needs, within the region of the TRIAP. As well as providing a broad overview of the major pressures on tropica; Australia's aquatic ecosystems, the key component of this study is more detailed risk assessments for the focus catchments, being the Daly River (NT), Flinders River (Qld) and Fitzroy River (WA). Throughout this sub-project, stakeholders will be involved in providing input and feedback.

There 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, and 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.

The tasks for the semi-quantitative risk analysis are:

- *Effects/consequence analysis* – collate data/information on documented effects of key threats to key assets (possibly apply a semi-quantitative 'consequences' ranking scheme), and document the associated level of confidence in the data/information.
- *Exposure/likelihood analysis* – integrate relevant GIS layers to determine extent or likelihood of exposure of key assets to key threats, and document the associated level of confidence in the data.
- *Risk characterisation* – integrate outcomes of effects and exposure analyses to estimate risks of threats to assets. Outputs include: identification of relative risks (and, therefore, highest risk threats); assets least/most under risk; initial indication of cumulative risks; and articulation of uncertainty.
- Describe applications of semi-quantitative risk outputs to catchment management and NRM – i.e. how do they inform risk management/risk reduction?.

The quantitative risk assessment will follow on from the semi-quantitative risk analysis. Based on outcomes of semi-quantitative risk analyses and stakeholder views, **one** threat/issue will be selected for quantitative risk analysis, and the conceptual model for this threat/issue will be reaffirmed/revised accordingly.

Major outputs within selected major catchments and at important sites will include: specific analyses of major pressures (e.g. weeds, feral animals, infrastructure, water pollution); recommendations for risk reduction/management steps and monitoring; and a database of available information.

Development of risk assessment framework

Following on from the work progressed during the last reporting period, a proposed framework and methodologies report, outlining the ecological risk assessment approach to be used in this Sub-project, has recently been distributed to stakeholders for comment (see Attachment 3). Major progress has been made with the selection of a model to undertake the semi-quantitative analysis. In this project, we will adopt the Relative Risk Model (RRM) (Landis and Wiegers 1997) to assess semi-quantitatively ecological risks at the regional scale. The RRM is a robust methodology that incorporates spatial variability at a large scale to examine the interaction of multiple threats to multiple habitats, and their effects (impacts) on assessment endpoints. The method has been shown to direct the focus of investigative studies and data collection and the decision making process (Landis and Wiegers 1997). Figure 1 illustrates the difference between a risk assessment in the 'traditional' local site application and a regional level.

The steps that will be undertaken in this project in applying the RRM are:

1. Determining the Assessment Endpoints (assets) based on stakeholder input;
2. Describing the Habitats to be examined;
3. Determining the Sources of Threats;
4. Creating a spreadsheet of the conceptual model for ranking purposes;
5. Identifying and creating risk areas;
6. Ranking of Threats based on a 2-point scheme (0, 2, 4, 6);
7. Ranking of Habitats based on the proportion of a particular habitat within a risk region;
8. Relative Risk Calculations; and
9. Risk Characterisation, including sensitivity and uncertainty analyses.

Outputs from applying the RRM at the continental scale will include (but are not limited to) maps illustrating catchments where the highest risk estimates occur, the habitats where most risk occurs, and the spatial distribution of pressures and threats. Risks will be spatially analysed for derived sub catchments at the focus catchment scale as has been reported in the literature (Hession et al 1996; Obery and Landis 2002).

Problem definition/hazard identification

This phase of the risk assessment captures the activities that were scheduled during the reporting period. Problem definition/hazard identification (also termed problem formulation) attempts to build a picture of the nature of the issue that is being investigated, using all available existing information. Thus, the key aim of this phase is to identify and describe (i) the key assets (mostly ecological, but capturing a number of overlapping values of sociocultural and economic importance) and threats to the aquatic ecosystems of northern Australia and of three focus catchments, and (ii) the interactions between the ecological assets and threats. This information is then used to construct conceptual models for the north Australian region and each focus catchment of the interactions between key assets and threats. The conceptual models will drive the risk assessments.

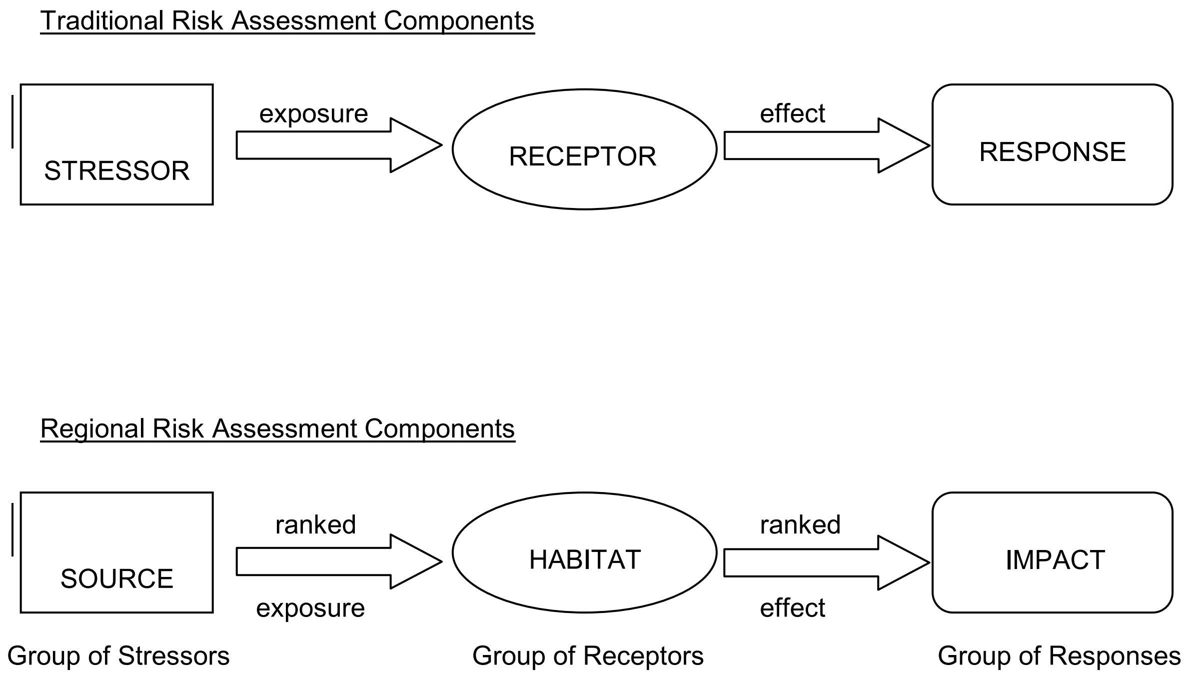

Figure 1 Comparison of risk components applied at the traditional and the regional levels (Landis and Wiegers 1997). *Source* in the context of this project equates to a *group of threats* and *habitat* can be related to a *group of assets*

Draft conceptual models have been developed for the Fitzroy and Daly Rivers. Conceptual models show the potential ecological consequence of a particular threats to a particular asset. Conceptual models can be shown in different ways. Figure 2 shows the skeleton of a conceptual model for the Fitzroy River system as whole (i.e. no disaggregation) highlighting the potential interaction of river regulation on fish diversity. Alternatively, a more detailed model can be constructed for one asset (fish diversity and abundance) as shown by figure 3. Conceptual models can also be presented in different ways, for example, as a series of boxes or with symbols and pictures as shown by the fish diversity and abundance example in figure 4.

Consultations with stakeholders have been conducted for the Fitzroy and Flinders Rivers. On 17 February, 2006 a stakeholder workshop was held in Derby, WA to elicit stakeholder views on the key ecological assets and threats to the tropical rivers of the Fitzroy River Catchment. Fourteen people attended the consultation, with the majority representing the indigenous stakeholders of the region. Sue Jackson from CSIRO held a consultation the previous day centred on social and economic values of tropical rivers in the Kimberley Region as part of an LWA project funded under their Tropical Rivers and Social and Institutional Research Programs. Forty people attended that consultation. The information gained during both consultations has been exchanged between the projects. A follow-up visit is planned for the near future. A workshop report has been distributed to Fitzroy River stakeholders who have provided feedback on the draft (see Attachment 4). On 6 June 2006, a similar stakeholder workshop was held in Richmond, Qld to obtain stakeholder views for the Flinders River Catchment. Twelve people attended the workshop representing graziers, land owners and business proprieters. An interim workshop report is being compiled and will be distributed to Flinders River stakeholders and is available from the TRIAP web site. Stakeholders will be requested to provide feedback that will be incorporated into the report.

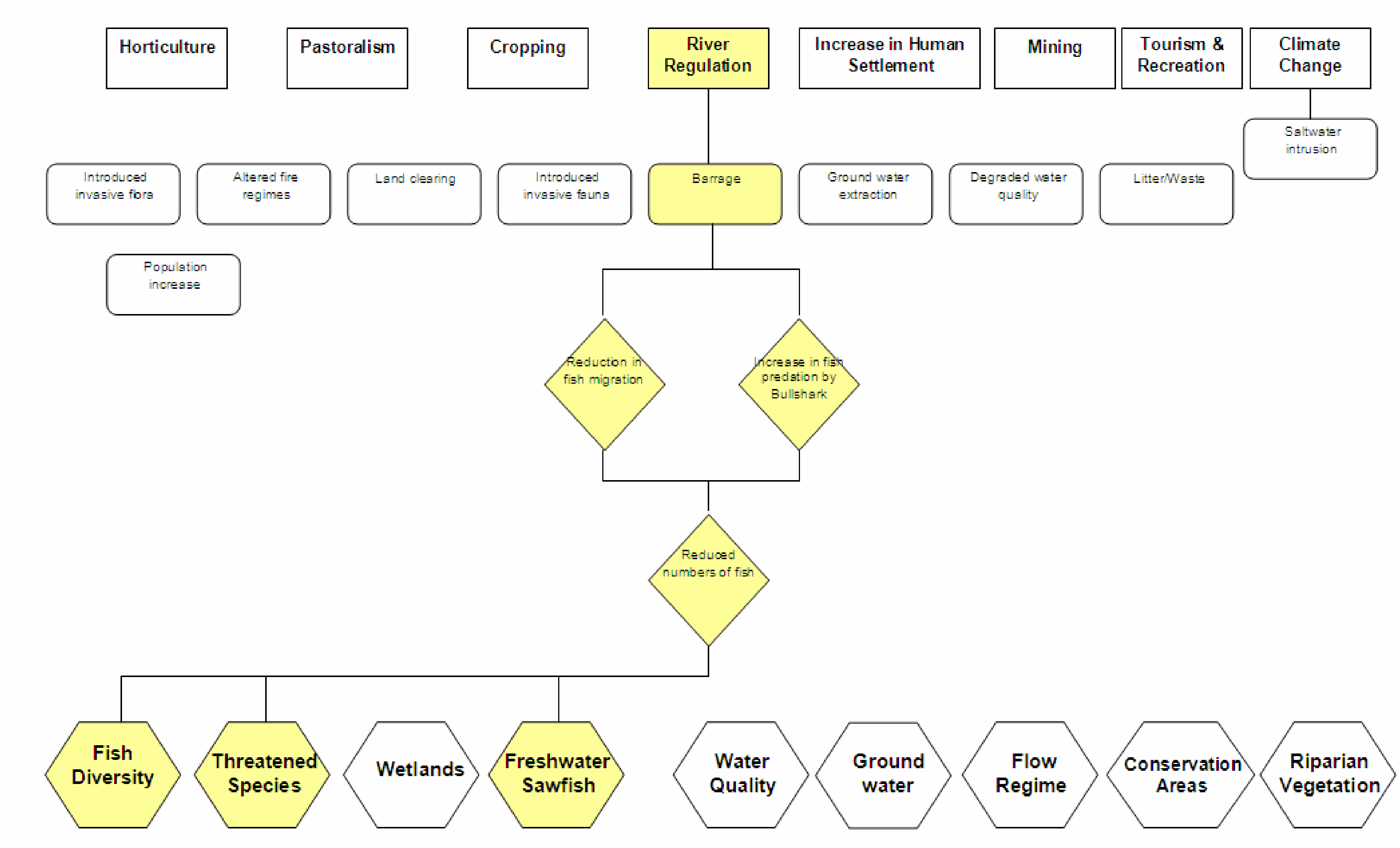

Figure 2 Draft conceptual model of ecological risk assessment for the Fitzroy River highlighting the interaction of river regulation on fish diversity.

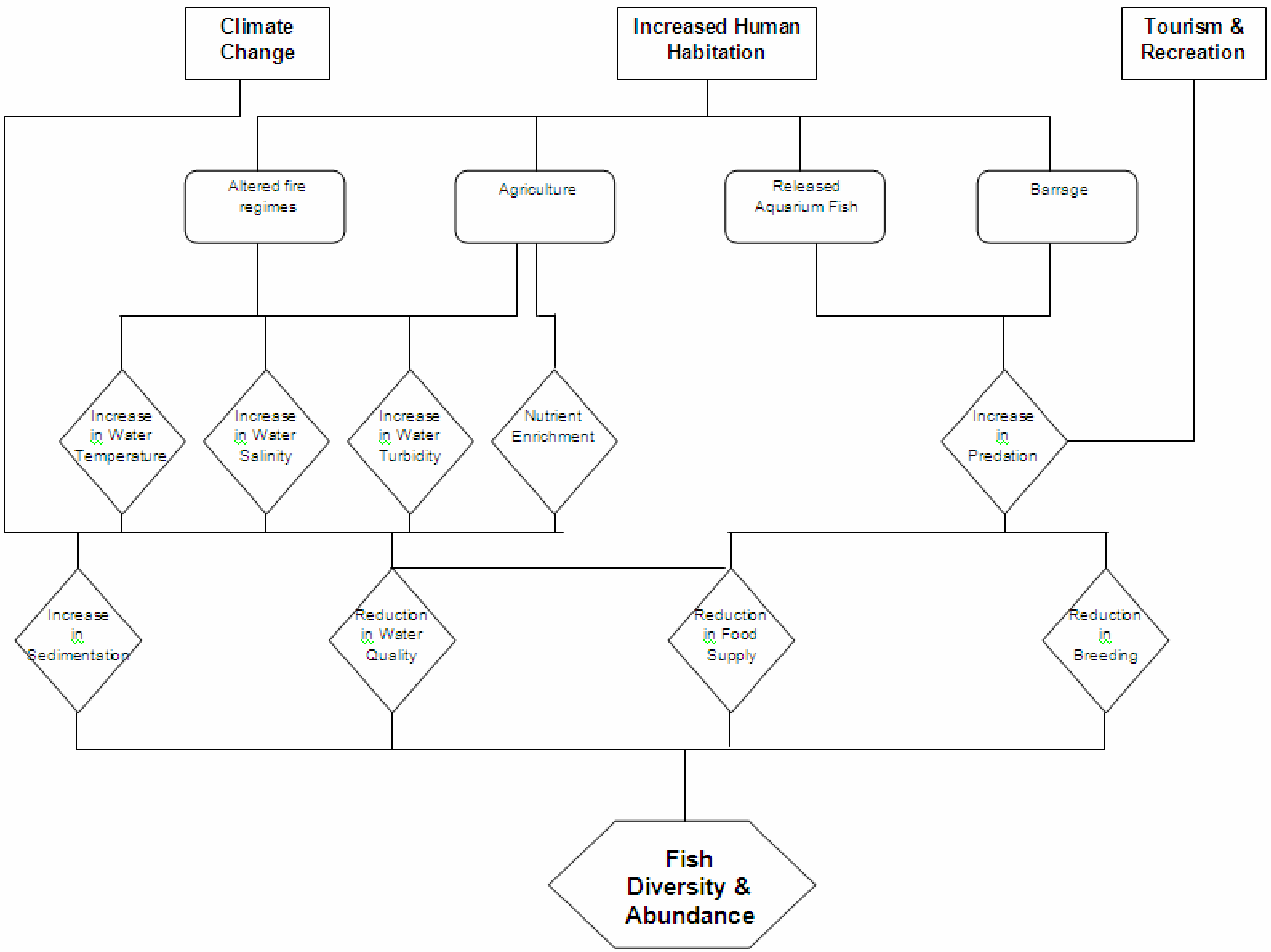

Figure 3 Detailed example of a conceptual model for pressures and threats on fish diversity and abundance in the Fitzroy River.

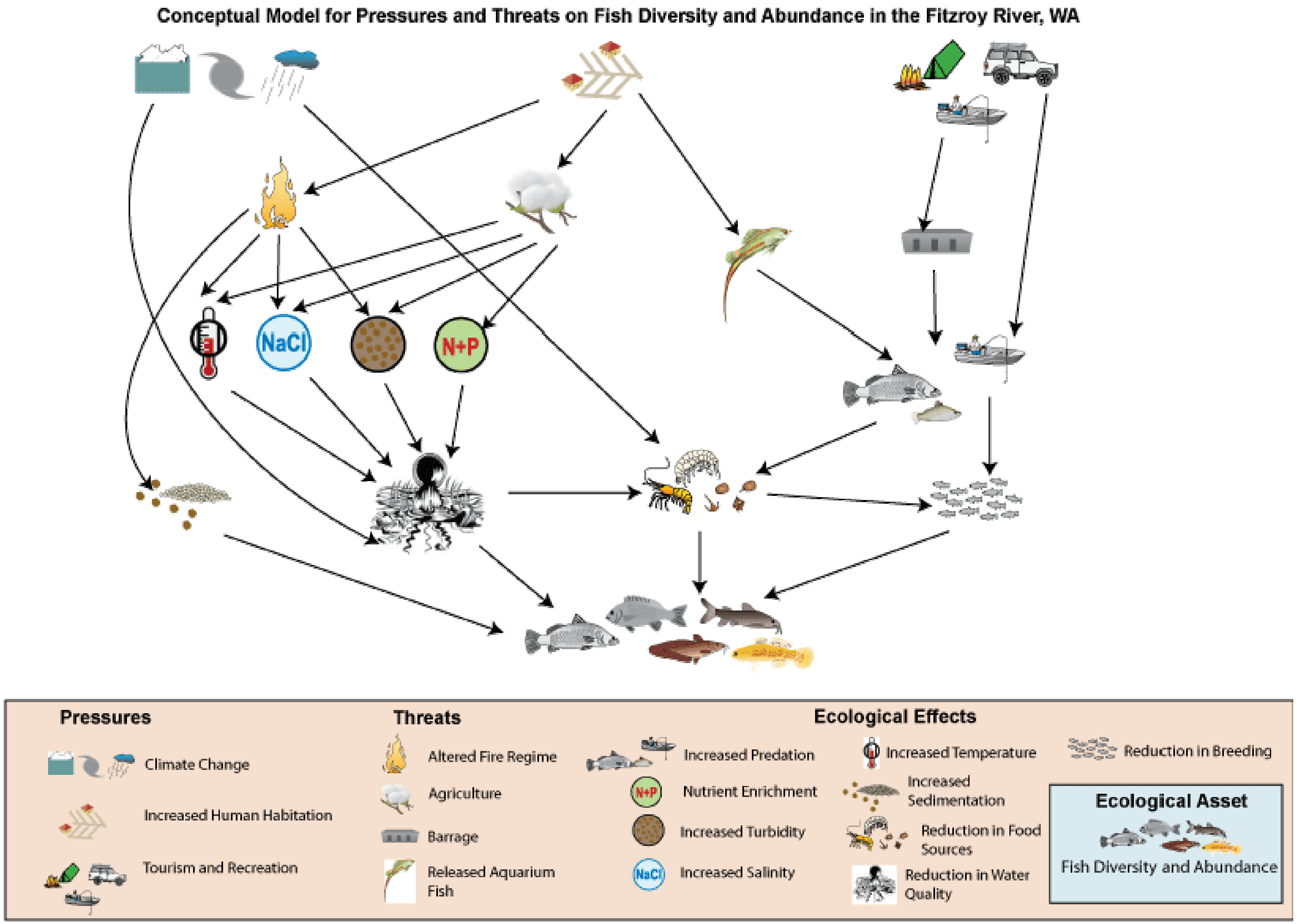

Figure 4 The conceptual model shown in Figure Z presented here in a graphical format with symbols.

With respect to the Daly River Catchment, consultations with stakeholders to date have strongly indicated that there is unlikely to be a need for formal stakeholder workshops to identify and agree on key assets and threats, as this process has occurred in the catchment over the last few years in forums such as the Daly River Community Reference Group Meetings. Consequently, it is considered appropriate to utilise the information produced from these previous efforts, as long as the key stakeholders are kept abreast of progress and utilised to verify/confirm the appropriate usage and interpretation of data/information. Numerous key documents for the Daly River have been obtained, including:

- Daly River Community Reference Group Draft Report, November 2004.
- Draft Conservation Plan for the Daly Basin Region, August 2003 (NT DIPE).
- Environmental Water Requirements of the Daly River, July 2004 (NT DIPE).
- Aquatic Conservation Values of the Daly River Catchment, Northern Territory, September 2005 (WWF, CDU, ECNT).
- Modelling Dry Season Flows and Predicting the Impact of Water Extraction on a Flagship Species, November 2002 (University of Canberra).
- Social Values of the Daly Region, May 2004 (CDU).
- Preliminary report on Aboriginal perspectives on land-use and water management in the Daly River region, Northern Territory, May 2004 (CSIRO).
- Inventory and risk assessment of water dependent ecosystems in the Daly basin, Northern Territory, Australia, 2001 (ERISS).
- Integrated Natural Resource Management Plan for the Northern Territory, March 2005, (NT DIPE, Landcare Council of NT).

A stakeholder consultation plan has been developed for the Daly River Catchment, including a time table outlining the consultative process and feedback mechanisms. This plan will be further refined and implemented with the aid of the NT Government.

Spatial data acquisition

As mentioned in previous milestone reports, the majority of ecological assets spatial data has been collected through Sub-project 1. Whilst a limited amount of threats data has been collected in Sub-project 1 (eg. land tenure), the majority is currently being compiled as part of this Sub-project. In order to complete this task efficiently, an audit of existing spatial data collected under Sub-project 1 has been completed. This has successfully identified gaps in data requirements. Table 1 is a list of pressure and threat data that is being compiled for risk analysis.

Issues and constraints

The main issue that has arisen in this reporting period is time delays due to the stakeholder engagement and the feedback process. With the engagement process near completion there should be only minimal delays as a result of seeking and receiving feedback on particular outputs.

Table 1 List of pressure and threat to be compiled.

Pressure	Threat
Horticulture, Crop Production (Agriculture), Pastoralism Land tenure data	Ground and surface water extraction
Pastoralism Stocking rates	Altered fire regime NAFI data available from: http://www.firenorth.org.au/nafi/app/init.jsp
Urban Development National land use change dataset	Data for fire frequency 1997-2005, late fire frequency 1997-2005 and time since last burnt
Tourism and Recreation Proximity to boat ramps, camping grounds, tourist attractions	Land clearance National land use change dataset National Vegetation Information System (NVIS)
Customary harvest Proximity to Aboriginal communities	Introduced invasive flora and fauna
Mining Location and type of mine	Water impoundment Geoscience Australia Topo 250K data waterbodies theme
Climate Change 5m sea level rise dataset	
Illegal fishing 3 nautical mile data from north Australia coastline from 2001 (quarterly summaries). Obtained through Australian Customs.	

Planned activities

The focus over the next reporting period will be as follows:

- Continue to obtain and compile spatial data for pressures and threats;
- Complete a review of the assets and threats of Australia's tropical rivers and focus catchments incorporating stakeholder feedback;
- Construct conceptual models for the Flinders River Catchment and the TRIAP region, and finalise the conceptual models for the Daly and Fitzroy Rivers;
- Commence qualitative and/or semi-quantitative risk assessments for the focus catchments and the TRIAP region;
- Commence a quantitative risk assessment for the Daly River; and
- Continue to liaise with key stakeholders to seek additional information and ongoing feedback, and to ensure the study is useful to their needs.

References

Hession WC, Storm DE, Haan CT, Burks SL & Matlock MD 1996. A Watershed-Level Ecological Risk Assessment Methodology. *Water Resources Bulletin* 32, 1039-1054.

Landis WG & Wiegers JA 1997. Design Considerations and a Suggested Approach for Regional and Comparative Ecological Risk Assessment. *Human and Ecological Risk Assessment* 3, 287-297.

Obery AM & Landis WG 2002. A Regional Multiple Stressor Risk Assessment of the Codorus Creek Watershed Applying the Relative Risk Model. *Human and Ecological Risk Assessment* 8, 405-428.

Attachment 2 Detailed communication and consultation progress report

Detailed communication and consultation progress report

Contributing authors: *Renee Bartolo, Rick van Dam*

Communication and consultation activities since August 2005

Numerous and varied communication and consultation activities were undertaken during the reporting period (September 2005-June 2006). The main activities are summarised in table 1 with some activities described in greater detail.

Cross-project communication through regular meetings

There are numerous projects underway or proposed that are focussed on tropical river systems in northern Australia. With the various programs and many ideas resulting from this research activity, the NAIF, TRIAP, Charles Darwin University and NRETA researchers working in this area realised there is a need to communicate with each other regarding their research and examine ways of increasing efficiencies in research effort. The mechanism for achieving this is to have regular meetings of key project leaders in the major tropical rivers projects.

The regular meetings are designed to share knowledge, ensure relevant linkages between projects are built through regular communication and minimise duplication. One key aspect that the meetings address, is the coordinated approach by the various projects in engaging stakeholders. A summary of the meetings are posted on relevant websites to inform the wider community of the outcomes (including the TRIAP website).

To date, six meetings have been held via tele-conference. The meetings are currently held on a monthly basis but are likely to move to every second month. Representatives of the organisations participating in meetings are as follows:

- Jeff Camkin and Keith Bristow (NAIF)
- Michael Douglas (CDU)
- Ian Smith (NRETA)
- Rick van Dam and Renee Bartolo (TRIAP)

Stakeholder workshops

Two stakeholder workshops have been held to date for this sub-project. On Friday 17 February, a TRIAP stakeholder consultation was convened in Derby, WA, at the King Sound Resort. The workshop focused on the ecological assets/values and associated pressures and threats for the Fitzroy River. The main objective of the workshop was to agree on the key ecological assets and threats and to prioritise these. Renee Bartolo and John Dowe facilitated the workshop. Fourteen people attended the consultation, with the majority representing the indigenous stakeholders of the region.

Table 1 Description of TRIAP key communication and consultation activities since August 2005.

Type of communication	Date	Outcome
Stakeholder-communications-meeting	7 October 2005	Meeting attendees: Rick Van Dam, David Jones, Fergal (NTG), John Lowry, Ben Bravery, Chris Humphrey, Stuart Blanch (WWF), Renee Bartolo, Chris Wicks (NTG), Ian Smith (NTG), Keith Bristow (NAIF), Cuan Petheram (NAIF). Discussion of synergies between the NAIF and TRIAP and NTG requirements. Outcome: Ian Smith (NTG), Keith Bristow (NAIF) and Rick van Dam (SSD) will have regular tele-meetings to discuss new issues of interest to all parties.
Stakeholder-communications-meeting	18 October 2005	Meeting with Brendan Edgar and Tom Aldred (LWA). Discussion regarding DEH as a data custodian for CERF tropical rivers project if successful. Discussion of risk assessment methodology.
Cross-project-communications-meeting	31 October 2005	Introduction/update on each organisation's involvement in tropical rivers research. Future meetings' standing agenda, meeting frequency and reporting/communication mechanisms were agreed upon.
Stakeholder-communications-meeting	15 November 2005	Rick van Dam and Renee Bartolo met with Paul Lloyd from Greening Australia. Update on TRIAP, Paul provided briefing on the IW project briefs submitted locally. Strong link between an IW application for risk assessment coordinated by Maria Kraatz and the TRIAP risk assessment sub-project.
Project team- update meeting	Monday 21 November, 2005	Key outcomes included: Discussion of the major outputs for Sub-project 1, including final GIS format for delivery to LWA and stakeholders; and Discussion of outputs for the macroinvertebrate theme within Sub-project 1, including multivariate analysis of distribution and geomorphic classification and contribution to the JCU macroinvertebrate Atlas in the area of mayflies and their habitats.
Stakeholder-communications-meeting	22 November 2005	Meeting to discuss Australian National Committee on Irrigation and Drainage annual conference in Darwin October 2006 with Kim Russell (ANCID), Stephen Mills (ANCID), Jeff Camkin (CSIRO/NAIF). Submit paper to 2006 conference
Stakeholder-communications-meeting	24 November 2005	Meeting with Jeff Camkin (CSIRO/NAIF) to brief him on details of TRIAP.
Stakeholder-communications-newsletter	Third issue released in November 2005	The newsletter provided stakeholders with an update on communication activities and sub-projects, and notification of publications and presentations. Other features included how the TRIAP is building linkages with other Tropical Rivers projects.
Cross-project-communications-meeting	1 December 2005	Update on each organisation's involvement in tropical rivers research and discussion of collaborative opportunities.
Stakeholder-meeting- DEH-Coasts and Water Branch	December 2005	Renee Bartolo met with Taron Brearley who provided advice on the form of the final product and what should be included. ERIN is the likely repository for the data generated from this project.
Cross-project-communications-meeting	2 February 2006	Update on each organisation's involvement in tropical rivers research and discussion of collaborative opportunities. Collaborative opportunities highlighted were: Linkages between NAIF and SKI proposal; and Linkages between Daly Discussion Group, NAIF and Daly River Resources Management Committee.
Project team-progress meeting	Tuesday 7 February 2006	Theme leaders reported on status of their themes under Sub-project 1. Discussion on the ecological typology component of the Sub-project. Work load between ERISS and ACTFR for Sub-project 2 was discussed.

Table 1 (Cont.)

Type of communication	Date	Outcome
Stakeholder-workshop	Friday 7 February 2006	Fourteen people attended a workshop in Deby to determine the key ecological assets and threats for the Fitzroy catchment. Workshop report has incorporated stakeholder feedback on an interim version and has been distributed.
Stakeholder-meeting- LWA	Friday 24 February, 2006	TRIAP project leaders met with Brendan Edgar to discuss project progress and associated issues including: - The timeline for completion of Sub-project 1 and options for an extension; - The risk assessment methodology to be applied to the focus catchments; and - Options for incorporating a northern Australia overview of threats to aquatic ecosystems.
Stakeholder-meeting- NRM	Tuesday 14 March	Rick van Dam and Renee Bartolo met with Clare Taylor to discuss Fitzroy River risk assessment approach. Key outcomes were: - Informed of the Water Advisory Group, convened to assist with the NRM Investment Plan; and - ensure risk assessment is linked to the NRM Mgt Action Targets/ Resource Condition Targets.
Project team-meeting	Thursday 16 March	Meeting via video-link with JCU to discuss conceptual models.
Stakeholder-communications-newsletter	Fourth issue released in April 2006	The newsletter provided stakeholders with a summary of the outcomes of the Derby, Fitzroy River workshop. Other features included a report on the Ecological Risk Assessment workshop that a couple of project team members attended, upcoming presentations and sub-project updates.
Cross-project-communications-meeting	7 April 2006	Update on each organisation's involvement in tropical rivers research and discussion of collaborative opportunities. Collaborative opportunities highlighted were: • Meeting: Jeff Camkin, Ian Smith and Michael Douglas to talk about: -The link between the Daly Discussion Group and the Daly River Resources Management Committee -The relationship between TRACK and NAIF -Possibilities of a workshop run by Henrique Chaves (Brazil) on water resource management to be held in Darwin. • Water Commission funding opportunities-keep each other informed on progress.
Cross-project-communications-meeting	4 May 2006	Update on each organisation's involvement in tropical rivers research. Discussion of the possibility of a North Australian workshop or session at ANCID 2006 in Darwin and the North Australian session being run at Riversymposium.
Cross-project-communications-meeting	1 June 2006	Update on each organisation's involvement in tropical rivers research and discussion of collaborative opportunities. Collaborative opportunities highlighted were: • Renee Bartolo and Bart Kellet are to exchange information on Bayesian network approaches. • Michael Douglas and Jeff Camkin may conduct a gap analysis on the work CDU has collated on research in the Daly River.
Stakeholder-workshop	Tuesday 6 June 2006	Twelve people attended a workshop in Richmond, Queensland to determine the key ecological assets and threats for the Flinders catchment. An interim workshop report is currently being drafted and will be sent out for stakeholder feedback.
Internal communications-SSD-newsbrief	2006	3 articles on the TRIAP in the Newsbrief

Sue Jackson from CSIRO held a consultation the previous day centred on social and economic values of tropical rivers in the Kimberley Region as part of an LWA project funded under their Tropical Rivers and Social and Institutional Research Programs. Forty people attended this consultation.

The information gained during both consultations has been exchanged between both the projects. It was a productive and successful trip where we were able to obtain the information required for the current stage of the risk assessment project.

An interim workshop report has been distributed to Fitzroy River stakeholders and feedback has been incorporated and the record of consultation has been distributed.

On Tuesday 6 June a TRIAP stakeholder consultation was convened in Richmond, Qld, at the Ammonite Inn. The focus of the workshop was similar to the Derby workshop except the riverine environment was that of the Flinders catchment (see above). Once again Renee Bartolo and John Dowe facilitated the workshop. Twelve people attended the workshop. They included graziers, land owners, business proprieters and one Queensland Government stakeholder.

The workshop included brief powerpoint presentations with lots of discussion from the participants. The original workshop format was altered to allow for the stakeholders to be engaged in a meaningful and inclusive manner.

Stakeholder representation was an issue influencing the information elicited during the workshop. Although government stakeholders were invited, only one attended. The workshop was framed in an ecological risk assessment context, however due to the composition of stakeholders, assets and management issues were loosely related to ecological aspects though economic drivers.

Ecological risk assessment frameworks refer to ecological assets, pressures and threats. Stakeholders at the Richmond workshop expressed they felt that the terms ‘pressure’ and ‘threat’ encouraged a pre-determined answer and suggested that the term ‘management issue’ should be used in their place. Therefore the interim workshop report will refer to pressures and threats as ‘management issues’ when reporting on stakeholder views.

Project web site

All reports and newsletters and other relevant information have been uploaded on the ***nctwr*** web site (www.nctwr.org.au/publications/tropical-rivers.html).

Other activities

The National Biennial Conference of the Spatial Sciences Institute, 12-16 September 2005 in Melbourne

Renee Bartolo presented a paper on behalf of John Lowry titled ‘Integration of Data for Inventory and Assessment of Australia’s Northern Rivers’.

International Riversymposium, 6-9 September 2005 in Brisbane

Max Finlayson presented a paper titled ‘Benchmarking Northern Australia’s Rivers Before Further Degradation – Practical Approaches and Constraints’.

Australian Water Association-NT Branch Annual Conference, 20 October 2005 in Darwin

Rick van Dam delivered a talk titled ‘Benchmarking the attributes of Northern Australia’s tropical rivers-The basis for informed management decisions’.

Submitted abstracts/papers for upcoming conferences

SWS/AMSA "Catchments to Coast", 9-14 July 2006 in Cairns

Mirjam Alewijnse will be presenting a paper titled 'Australia's Tropical Rivers – a Multiple Scale Inventory for Resource Management and Risk Assessment'.

9th International Riversymposium, 4-7 September 2006 in Brisbane

Wayne Erskine will be presenting a paper titled 'Classification of Australian Tropical Rivers to Predict Climate Change Impacts'.

ANCID (Australian National Committee on Irrigation and Drainage) Conference, 16-18 October 2006 in Darwin.

Renee Bartolo will be presenting a paper titled 'Ecological Risk Assessment for Australia's Tropical Rivers'.

30th Hydrology and Water Resources Symposium, 4-7 December 2006 in Launceston

Dene Moliere will be presenting a paper titled 'Flow characteristics of streams in the tropical rivers region'.

Attachment 3 ERA overview and proposed framework and methodologies document

Ecological risk assessments of key threats to Australia's tropical rivers

Overview, proposed framework and methodologies for the Tropical Rivers Inventory and Assessment Project

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June 2006

Background

The tropical rivers of northern Australia are under increasing pressure due to environmental threats and human activities. The objective of this sub-project (sub-project 2) of the *Tropical Rivers Inventory and Assessment Project* (TRIAP; www.nctwr.org.au/publications/tropical-rivers) is to develop a risk assessment framework applicable to the key focus catchments and significant locations that meet stakeholder needs, within the region of the TRIAP. In addition to providing a broad overview of the major pressures on tropical Australia's aquatic ecosystems, the key component of this study is more detailed risk assessments for the focus catchments, being the Daly River (NT), Flinders River (Qld) and Fitzroy River (WA). Throughout this sub-project, stakeholders will be involved in providing input and feedback.

This paper firstly describes the generic elements of ecological risk assessment then details the process that will be followed for the project and the approaches that will be used.

Ecological risk assessment

Overview

Ecological risk assessment (ERA) is the process of predicting or estimating the likelihood and magnitude of adverse ecological effects occurring as a result of one or more threats (also referred to as stressors – see *Terminology*, below) (US EPA 1998; Burgman 2005). It provides a structured, iterative approach for making rational and transparent decisions based on the best available knowledge and recognition of the associated uncertainties. A generic paradigm for ERA is shown in figure 1, and is the basis for the framework developed for this project. Generally, ERA encompasses the following steps – *problem formulation/hazard identification*, *analysis*, which consists of effects (consequences) assessment and exposure (likelihood) assessment, and *risk characterisation* (figure 1), and these are described further below. Additional steps, such as risk communication, risk reduction and monitoring are also critical in the overall decision making process and are necessary to complete the risk management cycle (Burgman 2005). Moreover, identification and quantification of the key uncertainties and knowledge gaps enables prioritisation of research and data acquisition, which, through iteration of the risk assessment, decreases uncertainty in the risk predictions.

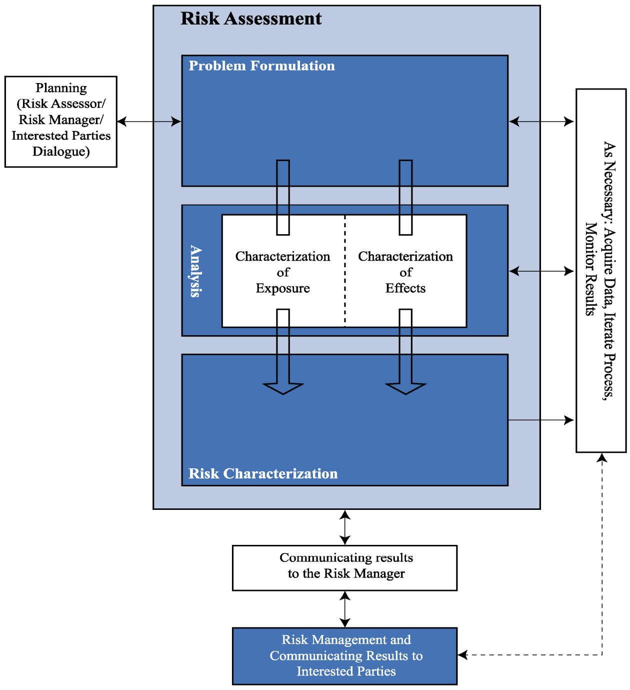

Figure 1 General framework for ecological risk assessment (modified from US EPA 1998).

Applications of ecological risk assessment are numerous and include assessments that range from: screening-level (qualitative) to detailed (quantitative) or a combination of both (ie. tiered ecological risk assessment); predictive to retrospective in temporal scale; local to global in spatial scale; and single threat to multiple threats (US EPA 1998; Burgman 2005). Increasingly, risk assessment is being used in a catchment or basin context, to assess, prioritise and manage multiple threats, pathways, ecological resources/assets and competing social values (Serveiss 2001; Hart 2004).

Terminology

Consistency and clarity in terminology for risk assessment is crucial. Inconsistencies and lack of clarification can lead to miscommunication and incorrect interpretation amongst stakeholders. Table 1 lists definitions of common terms that are used and their intended use for this project.

Risk assessments focus on how (or if) certain agents or processes might affect things that are valued and need to be protected. However, the terminology used to define these two components can differ between risk assessments. This project uses the terms *ecological asset* (or simply *asset*) to define an attribute of a natural ecosystem that the community values and wants to see protected, and *threat* to define an agent or process (including an action or activity) that could adversely affect the asset and its values. The term *value* (or *ecological value*) in this context refers to the specific reasons an asset is considered important. An asset can have multiple values, which can be vastly different for different stakeholders. For example, a series of permanent river pools on a seasonally flowing river might be valued by someone for its good recreational fishing, by someone else because it provides crucial habitat for a threatened species, and by someone else because it holds great spiritual value. This study focuses on ecological values whilst recognising their links with other values (eg. cultural,

Table 1 Definitions of terms used in risk assessment.

Term	Definition	Reference	Context for this study
Ecological Assets	Attributes (eg. components, processes, functions, products) of natural ecosystems, which are valued by the community (eg. river, wetland, biodiversity, environmental flow, water supply, primary production).	Modified from Hart et al (2005)	Used as defined.
Ecological Values	Qualities or characteristics of ecological assets that make the community value and want to protect them (eg. an ecologically healthy river; a biologically productive wetland; an upland stream rich in endemic fauna and flora).	Modified from Hart et al (2005)	Used as defined.
Ecosystem services	The conditions and processes through which natural ecosystems, and the species that make them up, sustain and fulfil human life. They maintain biodiversity and the production of ecosystem goods (eg. seafood, forage timber, biomass fuels)	MEA (2003)	Relevant to, but not used to a great extent for, this study.
Endpoint	*Assessment endpoint* – explicit expression of the actual environmental value(s) to be protected (eg. invertebrate community diversity). *Measurement endpoint* – measurable responses to a threat that can be correlated with or used to predict changes in the assessment endpoints (eg invertebrate reproduction, macroinvertebrate monitoring).	US EPA (1998)	Used as defined.
Hazard	The potential, or capacity of a threat to cause adverse effects on man or the environment, under the conditions of exposure.	US EPA (1998)	Used as defined
Pressure	Any human activity that has the potential to impact the natural environment. "Pressures" here cover underlying or indirect pressures (ie. human activities themselves and trends and patterns of environmental significance) as well as proximate or direct pressures (ie. the use of resources and the discharge of pollutants and waste materials).	OECD (2003)	Used as defined.
Risk	The probability of occurrence of an adverse effect of specific magnitude and timeframe on man or the environment resulting from a given exposure to a stressor.	Adapted from US EPA (1998) & Burgman (2005)	Used as defined.
Stakeholder	An individual or a representative of a group affected by or affecting the issues in question.	Glicken (2000)	Used as defined.
Stressor	Any physical, chemical, or biological agent or process arising from a pressure, which can induce an adverse environmental response.	US EPA (1998)	Synonymous with *Threat*, and generally not used for this study.
Threat	As above for *Stressor*, OR An action or activity that has the capacity to adversely affect an ecological asset and its value.	 Hart et al (2005)	Used as defined.

economic) where they exist. Threats arise from *pressures* (or *environmental pressures*) We have chosen to use the terms *assets* and *threats* largely because they are consistent with the terminology used in the Integrated Natural Resource Management (INRM) planning processes currently underway in northern Australia and funded under the Natural Heritage Trust (NHT). This will hopefully facilitate the link between the assessments conducted under this project and the on-the-ground INRM programs. It is also important to note that threats arise from *pressures* (or *environmental pressures*), which are defined as human activities (eg. mining, urban development) and human-induced trends and patterns of environmental significance (eg. climate change and sea level rise) that have the potential to impact the natural environment.

The risk assessment process

The key steps in the ERA process are briefly explained below.

Problem formulation/hazard identification

This step involves the collation of existing information to determine the nature of the issue or problem. At the outset, decisions need to be made and clearly articulated on the specific objectives and scope of the risk assessment (eg. qualitative or quantitative analysis of a single or multiple threats to a single or multiple environmental assets; determination of spatial and temporal scale). These decisions will guide the type of data and information that need to be gathered, and help to identify knowledge gaps. Typically, existing information needs to be compiled for the following:

- the environment of interest, particularly its most important assets (and their values), or at least those that need to be protected or are potentially at risk;
- the threat(s) to which the environmental assets are, or may be, exposed; and
- the types of effects that the threats(s) may have on the environmental assets.

The synthesis of such information should be done in consultation with stakeholders through an agreed process. It is possible that the information may reveal that the scope and objectives need to be refined or more clearly articulated. This is one example of the iterative nature of ERA. Once the information on the relevant assets and threats has been acquired, the next step is to construct a hazard matrix, identifying specific threats that will potentially cause adverse effects on specific assets (or values) (see table 2). A following step would be to identify the types of effects on the assets that could be caused by the threats, and based on this, determine relevant, and measurable endpoints on which the ERA will focus. Such endpoints are often referred to as *measurement endpoints* (US EPA 1998; see table 1), and they represent measurable (and ecologically relevant) indicators of the environmental assets to be protected (US EPA 1998). The relevant information is then brought together to develop a conceptual model of the issue or problem. The conceptual model, which can be presented in numerous ways, but is often shown as a type of flow diagram, represents the current understanding of the relationships between the threat(s) and environmental asset(s), and is used to develop working hypotheses that guide the remainder of the risk assessment (Solomon et al 1996, US EPA 1998). Consequently, conceptual models are critically important components of risk assessments, as the assessments can only be as adequate and appropriate as the conceptual models on which they are based (Burgman 2005).

Table 2 Example hazard matrix based on information for the Daly River, Northern Territory.

Values	Threats							
	Groundwater extraction	Surface water extraction	Altered fire regime	Land clearance	Invasive flora	Invasive fauna	Water impoundment	Water quality
Water dependent ecosystems								
Biodiversity	✔	✔	✔	✔	✔	✔	✔	✔
Threatened species	✔	✔	✔	✔	✔	✔	✔	✔
Nurseries & refugia	✔	✔		✔	✔		✔	✔
Erosion control / sediment retention	✔	✔	✔	✔	✔	✔	✔	
Water regulation	✔	✔		✔	✔		✔	
Water supply								
Perennial flow of Daly R.	✔	✔						
L'stone & karst geology	✔			✔			✔	
Water quality	✔	✔	✔	✔	✔	✔	✔	✔
Riparian vegetation								
Monsoon vine thickets	✔	✔	✔	✔	✔	✔	✔	✔
Erosion control	✔	✔	✔	✔	✔	✔	✔	✔
Habitat for wildlife	✔	✔	✔	✔	✔	✔	✔	✔

Analysis – effects (consequences) and exposure (likelihood) assessment

The analysis phase incorporates both effects assessment and exposure assessment. These are described separately, below. For both components, the most pertinent information sources and techniques should be used, although these will vary depending on the assessment. Some types and sources of information include (AS/NZS 2004a, b):

- past records, including relevant published literature;
- experiments and investigations;
- modelling;
- practice and relevant experience;
- the results of public consultation; and
- specialist and expert judgements.

Effects and exposure assessment are often carried out con-currently and in an iterative fashion: simple assessments are often performed initially, followed by more comprehensive (eg. quantitative) assessments if considered necessary (van Dam et al 1999). The outputs of the effects and exposure assessments should be cross-checked with stakeholders to ensure that data and information were used and interpreted appropriately.

Effects (consequences) assessment

Effects assessment aims to determine the impacts or consequences of the threat(s) on the measurement endpoints selected during problem formulation (van Leeuwen 1995, US EPA 1998). For example, reduced water quality (for whatever reason) might impact aquatic ecosystems as measured by reduced species diversity and abundance of macroinvertebrate and/or fish communities. It is desirable to quantify the magnitude of impact to the extent possible.

Exposure (likelihood) assessment

Data on the effects of a threat to an asset (or appropriate endpoint) provide little useful information without knowledge on the actual level of exposure of the asset to the threat. Thus, exposure assessment aims to determine the likelihood that the ecological asset(s) will be exposed to the threat, and therefore, that an effect will be realised. For a biological threat, such as an invasive weed, exposure assessment might involve integrating information on the source of the weed, the potential route of entry into the ecosystem of interest, rate of spread, habitat preferences, and associated distribution. Existing information (eg. remotely sensed imagery) or habitat suitability modelling can be used for such purposes.

Risk characterisation

This step integrates the outcomes of the effects (consequences) and exposure (likelihood) assessments in order to determine the level of risk (ie. consequences × likelihood). In general, there are three levels at which this analysis of risks can be undertaken: *qualitative*; *semi-quantitative*; and *quantitative*. Often, risk assessments are undertaken in a tiered manner, with initial screening-level qualitative or semi-quantitative analyses being done prior to more detailed quantitative analyses. The purpose of this is to first rank the threats and associated hazards so that more effort can be allocated to quantitative risk analyses for the most important (ie. highest priority) threats and associated hazards. This is the approach proposed for this study, and is described in more detail in the next section. Whilst the output of risk characterisation need not be a quantitative estimate of risk, sufficient information should, at the very least, be available for appropriate experts to make judgements based on a weight-of-evidence approach. In the event of insufficient information being available, it is possible to proceed with another iteration of one or more phases of the risk assessment process in order to obtain more information (US EPA 1998). Regardless of the approach, uncertainty associated with the risk assessment must always be described and, if possible quantified, while interpretation of the ecological significance of the conclusions must also be carried out (Pascoe 1993, US EPA 1993). In addition, the risks must be sufficiently well defined to support a risk management decision, as discussed below.

Proposed ERA framework and method for TRIAP

As mentioned above, the risk assessments will adopt an *assets* and *threats* approach, with the key ecological assets, and threats to these assets, being described and inter-linked through conceptual models. Generically, the risk assessment framework will follow that described above. The workplan tasks (see Attachment 1) reflect this framework. Specific aspects of the risk assessments are detailed below.

Scope of risk assessment

We propose to adopt a hierarchical (ie. tiered) approach to the risk assessments, with analyses at increasing levels of detail/quantification as spatial scale becomes smaller. Several assessments are proposed, as follows:

Northern Tropical Rivers Study Area

- Hazard assessment of threats to the aquatic ecosystems of the tropical rivers

Daly River

- Semi-quantitative risk assessment of multiple threats to multiple assets
- Quantitative risk assessment of 1–2 key threats to selected assets

Fitzroy River

- Semi-quantitative risk assessment of multiple threats to multiple assets
- Quantitative risk assessment of 1–2 key threats to selected assets

Flinders River

- Semi-quantitative risk assessment of multiple threats to multiple assets
- Quantitative risk assessment of 1–2 key threats to selected assets

The focus for the ecological assets and their values will be on those that are directly related to the surface water ecosystems (ie. the river and its associated surface wetlands). Socio-cultural and economic assets and values will also be identified, although they will not be assessed except where there is large overlap with ecological assets and values. This decision was based largely on funding constraints, but also following discussions with numerous stakeholders.

In general, the assessments will focus on the risks posed by current land and water use. With the possible exception of the quantitative risk assessments, no future or potential land and water use and associated threat scenarios will be developed or tested.

The risk assessment framework and associated risk analysis approaches that will be adopted for this project are not new and have been well described elsewhere (eg. US EPA 2003; Bayliss et al 2004; Hart et al 2005). Thus, it is not the intention of the project to develop a new risk assessment framework for application to tropical rivers.

Objectives of risk assessment

The objectives of the project are three-fold:

1. to identify and describe the key threats to the aquatic ecosystems of the tropical rivers;
2. to identify, and where possible, quantify the risks of key threats to key ecological assets of the aquatic ecosystems of the selected focus catchments;

and in doing so,

3. illustrate the application and utility of ecological risk assessment as a decision making tool for natural resource management.

Problem formulation/hazard identification

Within the above-defined scope of the assessments, data collation will focus on the key assets and threats for the area of interest. Thus, the aim of this phase is to identify and describe: (i) the key assets (mostly ecological, but capturing a number of overlapping values of socio-cultural and economic importance) and threats to the aquatic ecosystems at the study area and focus catchment scale; and (ii) the interactions between the ecological assets and threats (ie. an initial description of how the threats might impact on the assets and also how the threats themselves might affect each other). The assets data will be derived largely from Sub-project 1 (*Inventory and mapping*), whilst the threats data are being collated as part of this project. Identification of assets and threats within the focus catchments will be undertaken through a combination of consultations with stakeholders and reviews of existing reports and management plans. Both spatial and non-spatial data related to assets and threats will be collated, and all spatial data will be linked to the inventory GIS. The initial outputs of this task will be a description of the key assets and threats, and a matrix of assets and threats that will be used as the basis for (i) constructing the conceptual models (see below) and (ii) focusing data/information searches.

Tropical Rivers Study Area

Ecological assets and threats information for the whole of the study area will be drawn mostly from broad scale national datasets and existing national scale reporting efforts. Examples of both reporting efforts and specific spatial datasets include:

- National Land and Water Resources Audit (NLWRA);
- State of the Environment (SoE) Reporting;
- GEODATA TOPO 250K Series 2 (GeoScience Australia); and
- Vegetation of the Australian Tropical Savannas (CRC-Tropical Savannas).

This information will be synthesised to provide a narrative and spatial overview of the key pressures and threats to the tropical rivers, including a matrix of threats against the catchments across the whole study area.

Focus catchments

The need for workshops with a broad range of stakeholders for the focus catchments will be determined on a case-by-case basis following consultation with key government stakeholders. To date, consultations with stakeholders from the Daly and Fitzroy Rivers have strongly indicated that there is unlikely to be a need for up-front stakeholder workshops to identify and agree on key assets and threats, as this process has occurred in both catchments for various purposes over the last few years. Consequently, it is considered appropriate to use the information produced from previous consultation processes, as long as stakeholders are kept abreast of progress and have the opportunity to verify/confirm the appropriate usage and interpretation of data/information (ie. through regular consultation and communication).

Ecological assets and threats information for the focus catchments will be drawn from the national scale sources where relevant, but also from more detailed, finer scale datasets held by the relevant government jurisdictions and other organisations (eg. local research institutions, non-government organisations – NGOs, NRM bodies). For example, key reports and spatial datasets for the Daly River catchment include:

- Draft Conservation Plan for the Daly Basin Bioregion, August 2003 (NT DIPE);
- Daly River Community Reference Group Draft Report, November 2004;
- Environmental Water Requirements of the Daly River, July 2004 (NT DIPE);
- Inventory and risk assessment of water dependent ecosystems in the Daly basin, Northern Territory, 2001 (ERISS);
- Aquatic conservation values of the Daly River Catchment, Northern Territory, September 2005 (WWF);
- Mapping of locations of weeds surveyed from 1999 to 2003 (Daly_point_220801_g94); and
- Mapping of *Mimosa pigra* from 2003 aerial survey (Daly_mimosa_survey_g9)

The assets and threats information for each catchment will be used to construct a hazard (or threat) matrix (see table 2). The assets and threats information and hazard matrices will be distributed to key stakeholders for comment, with the primary aim to ensure that the key information has been captured, and that is has been appropriately represented and interpreted. Once this process has been completed, the information will be used to construct a conceptual model for each focus catchment, representing the interactions between key assets and threats. The final form of the models is yet to be determined, but for practical reasons, may involve disaggregation of the complex systems into a series of simpler, more useable sub-models. The conceptual models, which will also be fed through a stakeholder consultation/feedback phase, will drive the subsequent semi-quantitative and quantitative risk analyses.

Analysis and risk characterisation

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A semi-quantitative approach to determining an overall hazard/risk ranking for each of the study area catchments will be developed that relies heavily on the GIS but also on other available information on the severity and extent of the pressures and threats. A spatially explicit methodology, which the use of GIS lends to, is a practical means by which to characterise ecological risk. A spatially explicit ERA can be defined as estimating the differences in risk for different locations (Woodbury 2003). In a spatial context and of relevance to this particular project is the fact that water catchments are increasingly being used as the unit for integrated landscape assessment and management (Aspinall and Pearson 2000).

The use of GIS facilitates the incorporation of multiple anthropogenic and natural threats at the regional level. Within this context, GIS and spatial analysis have been used in various ERA applications (Hession et al 1996; Kienast et al 1996; Hogsett et al 1997; Aspinall and Pearson 2000; Gordon and Majumder, 2000; Diamond and Serveiss 2001; Ferdinands et al 2001; Gustafson et al 2001; McDonald and McDonald 2002; Preston and Shackelford 2002; Rouget et al 2002; Xu et al 2004; Billington 2005). Also, see Bayliss et al (2006) for an ecological risk assessment of Magela floodplain from landscape-wide risks such as invasive species (wetland weeds & pig rooting damage) and uncontrolled fire. The landscape risk assessments were conducted spatially and combined with point-source risks to downstream surface water quality from three major pollutants released from Ranger uranium mine.

In this project, we will adopt the Relative Risk Model (RRM) (Landis and Wiegers 1997) to assess, semi-quantitatively, ecological risks at the regional scale. The RRM is a robust methodology that incorporates spatial variability at a large scale to examine the interaction of multiple threats to habitats, and their effects (impacts) on assessment endpoints. The method has been shown to direct the focus of investigative studies and data collection and the decision making process (Landis and Wiegers 1997). Figure 2 illustrates the difference between a risk assessment in the 'traditional' local site application and a regional level. Landis and Wiegers (1997) define the following terms used in the RRM as follows:

- Sources – group of stressors (threats); and
- Habitats – group of receptors; where the receptors reside.

The RRM has been applied successfully in numerous studies and environments including: the marine environment of a fjord in Alaska (Wiegers et al 1998); Mountain River catchment in Tasmania, Australia (Walker et al 2001); an Atlantic Rain Forest reserve in Brazil (Moraes et al 2002); the Codorus Creek Watershed, Pennsylvania (Obery and Landis 2002); a near shore marine environment, Cherry Point, USA (Hayes and Landis 2004); and threats to sensitive species from military land uses in New Mexico and Texas (Andersen et al 2004).

Relative risk estimates are determined by combining source and habitat ranks. The results of the RRM are 'relative' so that one risk region can be compared with another and the results should not be used outside of this comparative context. In the process, risk characterisation results in a comparison of risk estimates among sub-regions, sources, habitats and endpoints to identify: the sub-regions where most risk occurs; the sources contributing the most risk; the habitats where most risk occurs; and the ecological assets most at risk in the study area.

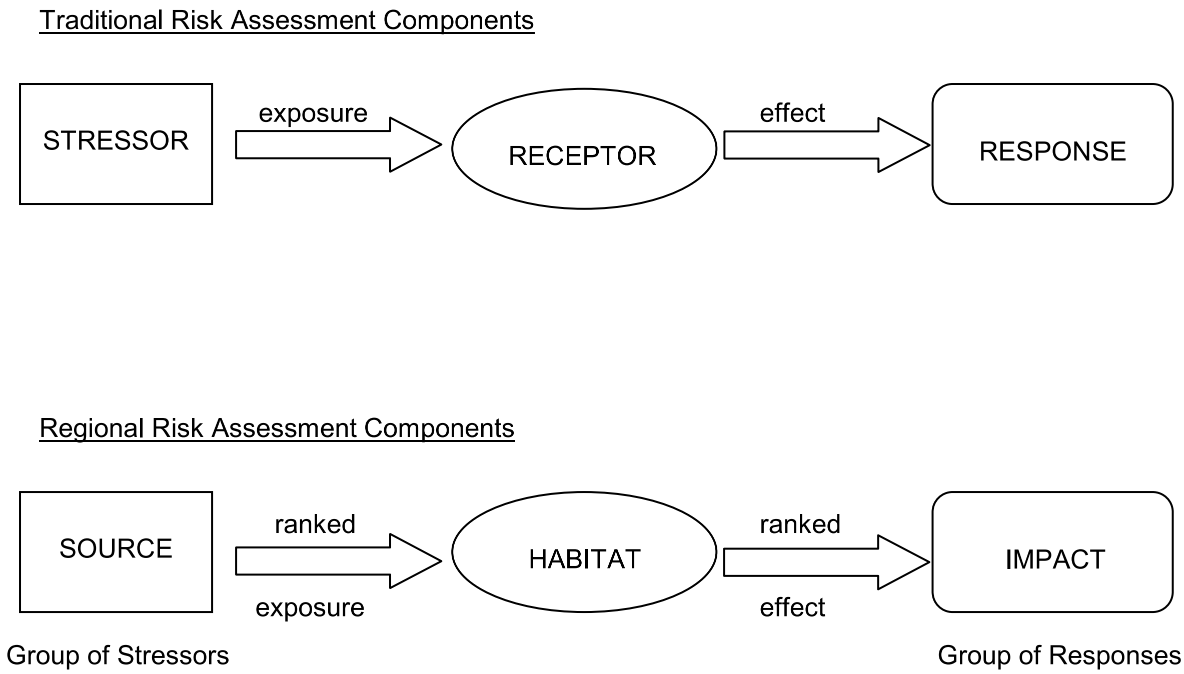

Figure 2 Comparison of risk components applied at the traditional and the regional levels (Landis and Wiegers 1997). *Source* in the context of this project equates to a *group of threats* and *habitat* can be related to a *group of assets.*

The steps that will be undertaken in this project in applying the RRM are:

10. Determining the Assessment Endpoints (assets) based on stakeholder input;
11. Describing the Habitats to be examined;
12. Determining the Sources of Threats;
13. Creating a spreadsheet of the conceptual model for ranking purposes;
14. Identifying and creating risk areas;
15. Ranking of Threats based on a 2-point scheme (0, 2, 4, 6);
16. Ranking of Habitats based on the proportion of a particular habitat within a risk region;
17. Relative Risk Calculations; and
18. Risk Characterisation, including sensitivity and uncertainty analyses (via Monte Carlo simulation).

Some of the advantages of the RRM as suggested by Landis and Wiegers (1997) include: few assumptions are required; the impacts of ranking decisions upon the final outcome can be examined by quantifying uncertainties in rankings via a sensitivity analysis; rule driven approaches can be easily incorporated into the ranking system; and the rankings are testable hypotheses. Limitations in using the RRM are that the approach uses an additive model, although some threats may have multiplicative effects on the impact to an asset (Andersen et al

2004), and threats and habitats are ranked on their relative likelihood of occurrence, opposed to their relative consequence of occurrence (Walker et al 2001). Points of caution include firstly, ranks may be misinterpreted (eg. should not be used in regression analysis) and end users may rely on the ranking system without validating the projected risks (Landis and Wiegers, 1997). Additionally, the geographic extent of the habitat will influence the magnitude of the effects, particularly with different size populations (Hayes and Landis 2004), and variable distances between sources and effects will add complexity and so increase uncertainty.

Concordant with the broad scale of this analysis, the habitat of interest is simply the entire riverine ecosystems (including wetlands) of the catchment. The risk sub-regions at the continental scale will be the catchments themselves. Any pressure on the catchment that has the potential to impact on the riverine ecosystems is included in the analysis. The GIS will be used to determine the pressures that occur in each of the catchments, and where possible, the areal extent of those pressures. In addition, the pressures will be ranked according to their perceived severity in terms of the potential magnitude of impact on the riverine ecosystems. This will be based on existing information; for example, a pressure that is listed under the EPBC Act as a Key Threatening Process will be ranked higher in terms of its severity than a pressure that is not listed as such. Outputs from applying the RRM at the continental scale will include (but are not limited to) maps illustrating catchments where the highest risk estimates occur, the habitats where most risk occurs, and the spatial distribution of pressures and threats.

Focus catchments

Semi-quantitative risk analysis

The semi-quantitative risk analyses for the focus catchments will be undertaken using the type of standard matrix approach detailed in AS/NZS (2004a, b) and shown in figure 3 and within the RRM framework. In this process, values need to be assigned to what would normally be qualitative scales for both *consequences* and *likelihood* to produce a more expanded ranking scale. These scales will be underpinned by various data and information, including that contained within the GIS and will be based on a 2-point scale as described above (Obery and Landis 2002). For example, the consequences scale will be based on an analysis of data/information on documented effects of the threats to the types of assets being assessed (eg. see example provided above for the whole-of-study area analysis), while the likelihood scale will primarily be based on GIS modelling to determine the extent or likelihood of exposure of the assets to the threats. Risks will be spatially analysed for derived sub catchments at the focus catchment scale as has been reported in the literature (Hession et al 1996; Obery and Landis 2002).

For both the consequences and likelihood analyses, there will be a description of, and, where possible, an attempt to quantify, the associated level of confidence in the outputs. The inclusion of spatial data in ecological risk assessment contributes to the overall uncertainties inherent in site specific through to regional scale risk assessments (Woodbury 2003). Uncertainty has been addressed in numerous studies (Clifford et al 1995; Hogsett et al 1997; Landis and Wiegers 1997). The uncertainty in this instance arises from an inability to fully resolve the spatial heterogeneity of parameters such as land use and vegetation due to scale (Obery and Landis 2002), error propagation through analysis (Woodbury 2003), and aggregation of spatial data (Hession et al 1996; Woodbury 2003). Hayes and Landis (2004) used Monte Carlo analysis to describe uncertainty in their rank-based regional risk assessment. In this project a number of approaches will be tested to describe and measure uncertainty based on the RRM literature.

Likelihood Label	Consequences Label				
	I	II	III	IV	V
A	Medium	High	High	Very high	Very high
B	Medium	Medium	High	High	Very high
C	Low	Medium	High	High	High
D	Low	Low	Medium	Medium	High
E	Low	Low	Medium	Medium	High

NOTE: The relationship between consequence and likelihood will differ for each application: the level of risk assigned to each cell needs to reflect this.

Figure 3 Example matrix for determining level of risk (from AS/NZS 2004a).

The outputs of the semi-quantitative risk analysis will include:

- Identification of relative risks of the threats to multiple assets (ie. across all the assets, which threats pose the most risk), and to individual assets (ie. for individual assets, which threats pose the most risk);
- Identification of the relative vulnerability of the assets (ie. the assets least/most at risk);
- Identification of the cumulative risks of the threats to the assets; and
- Description of the degree of uncertainty in the overall assessment; and
- Description of the applications of semi-quantitative risk outputs to catchment management and NRM bodies (ie. how do they inform risk management/risk reduction?).

Quantitative risk analysis

The quantitative ecological risk analysis (QERA) will flow from the semi-quantitative risk analysis. A few key threats and assets will be selected for quantitative analysis based on outcomes of the semi-quantitative risk assessment, a process essentially and appropriately driven by stakeholder views. Depending on results of the RRM at regional (catchment-subcatchment) scales, the conceptual model for each selected threat will be reaffirmed and, if necessary, revised. A Bayesian Network (BN) will then be developed that explicitly identifies links between hypothesised causes and effects, and highlights complexities and uncertainties in the system. The influence of different interventions used to manage risks to the chosen ecological endpoints (usually a condition metric along the species-population-habitat continuum) will be examined using “what if” scenario simulation. Uncertainty will be incorporated into the risk assessment using Monte Carlo simulation and sensitivity analysis. Hence, the BN will form the start of an adaptive Decision Support System (DSS) framework that can be improved over time, especially with additional and/or better information flowing from targeted and well-designed future monitoring programs.

However, apart from the Daly River focus catchment (see below), at this stage we cannot be prescriptive about the QERA methodologies to be adopted in the other three focus catchments and, hence, the details of their associated work plan. The methods used will ultimately depend on the nature of the threats that are eventually selected for quantitative analysis, the type, coverage, quantity and quality of available data, and their linkages to other research projects (eg. NAIF). Regardless, the following generic approach will be adopted in all focus catchments: (i) where adequate empirical data exist frequentist approaches will be used, unless there are better existing statistical and/or ecological models; (ii) where there is combined reliance on empirical data and expert opinion/knowledge, and/or where decisions need to be made in the face of uncertainty, Bayesian networks will be employed; and (iii) where possible and desirable, the quantitative risk assessment will be spatially explicit with respect to assets and threats, in order to provide a better basis for on-ground management. Irrespective of what final quantitative methods will be used within the above mentioned analytical and DSS framework, all approaches will be consistent with the most recent national and international guidelines with respect to robustness, transparency, coherency and reliability (eg. see US EPA 1998, 2003; Cain 2001, AS/NZS 2004a, b; Burgman 2005). Needless to say, all uncertainties will be made explicit and their influence on the outcomes of all assessments examined by sensitivity analysis. In summary, we will highlight the benefits of using spatially explicit QERA methods and Bayesian Networks as decision making and communication tools for environmental managers, methodologies that recognise the dual nature of probability, that is chance (via frequentist statistics) and belief (via Bayesian statistics and expert opinion).

We propose to use the Daly River catchment in the NT to test the utility of various QERA approaches. Three key threats to a range of key natural assets were chosen *a priori* from previous stakeholder consultations and community-based preliminary risk assessments (see CRG Report 2004). Additionally, the chosen assets and, hence, ecological endpoints are likely "at risk" from multiple regional stressors and so will comprise ideal candidates to assess the utility of Relative Risk Models (see above). Nevertheless, before we begin we will consult with NTG stakeholders (mainly DPIFM and NRETA; with cross-reference to the CRG Report 2004) to confirm or re-confirm choice of key threats, appropriateness of the conceptual models and ecological endpoints. Potential key threats to be assessed are described below.

Land clearing

First-cut ERA conceptual models (CRG Report 2004) identified land clearing as a potential key threat to the condition of riparian habitats, in-stream water quality, in-stream and floodplain environmental flows and, hence, the "condition" of associated biotic habitats. In turn changes in habitat condition will ultimately affect species or population level ecological endpoints. Land clearing will lead to loss of vegetation cover and, hence, increased erosion rates. This in turn will influence sediment, chemical and nutrient loads and concentrations, and flow (via less vegetation more ground & surface water flows). The combined "downstream" effects of land clearing are hypothesised to affect a range of ecological endpoints, such as primary and secondary aquatic production and productivity, habitat condition and ultimately biodiversity (eg. habitat diversity, species community structure & composition, species by populations). Needless to say, the direction and magnitude of all hypothesised landuse affects on aquatic ecosystems will depend strongly on end landuse type. For example, cleared native vegetation may be replaced with annual pastures, horticulture crops or commercial forests, and non-native vegetation cover classes may either ameliorate or accelerate negative land clearing effects.

Barramundi & in-stream impacts

The correlation between increasing environmental flow and increased commercial fisheries production are well known (eg. total prawn catch, barramundi year class strength, growth rates of crabs) from some catchment to coast studies are well known (eg. see Griffith 1987, Sawynok 1998 & Staunton-Smith 2004 for barramundi, Glaister 1978 for prawns, and Loneragan & Bunn 1999 in general), and can be indirectly used to predict the tradeoffs between reduced flow from extractions on fisheries revenue. Although the main value of barramundi in the Daly River catchment is recreational fishing, it cannot be underestimated in terms of generating economic revenue and external non-monetary benefits. NT Fisheries have offered access to their time series catch data on the "Barramundi Classic Tournament" series (1981-2006) for the Daly River. Long-term catch-effort and length frequency data will be analysed for trends in relation to effort (harvesting impact *per se*) and long-term flow patterns (as potentially affecting fecundity, survival & dispersal processes via habitat change). Hence, the relative importance of changes in water quality, flow and fishing effort on the "barramundi" ecological endpoint will be assessed simultaneously and their relative effects ranked. An attempt will be made to link the results of this single-species analysis with work recently commenced by CDU on fish biodiversity in the Daly River. A Bayesian Network will be constructed using empirical data and expert opinion (via recreational fishers & NTG fisheries scientists) to examine potential causal links between changes in river flow (here predicted increases) and possibly quality, to changes in barramundi populations and, hence, recreational catch after variations in effort and management regimes are factored out.

Magpie geese & floodplain impacts

Bayliss et al (2006) showed with CUSUM and time series analysis a strong relationship between apparent 20-year population cycles of magpie geese (*Anseranus semipalmata*) across the NT and a similar periodicity in flow cycles for the Katherine River and Magela Creek, two stream gauging stations with the longest flow records in the NT. The time lag between geese numbers and flow is about a year, which concords with ecological relationships found between regional geese population dynamics and regional rainfall (Bayliss 1989). Bayliss et al (2006) also found similar relationships between long-term flow and long-term population trends of fish-eating egrets and rainbow fish (see Humphrey et al 2006) on the Magela Creek floodplain and associated billabongs, respectively. The Daly River floodplain encompasses key wet season nesting and dry season refuge habitats for magpie geese in the NT (30% of the NT population, respectively; see Bayliss & Yeomans 1990a&b). Hence, decadal trends in river flow at the nearest long-term stream gauging station (& hence by inference floodplain overflow) will be matched by time series analysis to spatial and temporal trends in nesting success and population size. As for barramundi, a Bayesian Network will be constructed using empirical data and expert opinion (indigenous & non-indigenous geese hunters & NTG wildlife scientists) to examine potential causal links between changes (here increases) in flow to changes in magpie geese populations.

Water extraction

Early community stakeholder consultations (see Daly River Community Reference Group Draft Report 2004) identified water extraction as a potential key threat to in-stream and floodplain environmental flows and, hence, the "condition" of associated biotic and riparian habitats. For example, Georges (2002) modelled the negative impact that various dry season flow reductions due to water harvests in the Daly River would have on populations of the iconic pig-nose turtle (*Carettochelys insculpata*) as mediated through changes in ambient water temperatures and, hence, temperature-dependent sex ratios. Although significant dry season water extraction is not considered a highly likely landuse scenario for the Daly River in the near to intermediate future (Jolly pers. Com.), we nevertheless will consider its potential impact on both the magpie geese and barramundi ecological endpoints. The reasons are twofold: if water extraction is not a serious future risk to the Daly River then it must be the exception rather than the rule in Australia, and we would rather hedge our bets than accept an assumption. Given rapidly converging economic and social drivers in the Daly region (eg. increasing pressures from agro forestry & horticulture ventures in nearby catchments, the aspirations of Aboriginal communities in remote northern Australia to make a living independent of welfare, a 10% p.a. increasing Aboriginal population in the NT & other stakeholders wishing to diversify away from rocks, cattle & tourists), future dry season water extractions in the Daly River cannot be absolutely discounted. Accordingly, the above QERA for land clearing is retouched in terms of water harvesting as a key stressor *per se*. The above Bayesian Network and "what if" scenario modelling results that may predict increased flows due to land clearing will be used in combination with additional and linked scenarios that predict reduced flows due to water harvesting. The effects of the two stressors in combination, however, would not necessarily "cancel out" when considering the relative risks of multiple threats at a regional scales because of complex and possibly non-intuitive ecological interactions.

Invasive species (weeds)

In contrast to the overwhelming ecological pressures due to flow extraction, drainage and habitat alteration experienced by wetlands and waterways in south-eastern Australian, wetland weeds have been identified as possibly the key threat to our relatively "pristine" northern aquatic ecosystems (Finlayson et al 1988). Accordingly, two of the most serious tropical wetland weeds were chosen for impacts analysis on the Daly River floodplain and these are the mimosa shrub (*Mimosa pigra*) and para grass (*Urocloa mutica*) (see Walden *et al*. 2004 for mimosa & Walden & Bayliss 2003 for mimosa & para grass). The choice was based on their ability to rapidly colonise most wetland habitats whilst simultaneously forming dense monocultures with maximum impact or effects on native plant biodiversity and associated wildlife habitat. In a QERA of the Magela floodplain, Bayliss et al (2006) showed that para grass is currently the major landscape-scale ecological risk because of its extent (15% cover), effect (a monoculture that displaces native vegetation) and rapid spread rate (14% p.a.). They showed also that the potential spread rate and impacts of mimosa, which is well documented on the adjacent Oenpelli floodplain (Longsdale 1993), is currently controlled on Kakadu National Park through an annual "search and destroy" investment of about $0.5 million. Ferdinands et al (2001) demonstrated also that para grass is a major risk to the biodiversity of the Mary River floodplains.

Summary

One of the objectives of the *Tropical Rivers Inventory and Assessment Project* (TRIAP) is to undertake ecological risk assessments (ERAs) of the key threats to Australia's tropical rivers. This paper outlined the proposed approach to these assessments. Risk assessments will be undertaken at various levels of detail and spatial scale. A hierarchical approach is proposed that is consistent with the concept of tiered ERA and the associated requirements for working across multiple spatial scales. As spatial scale and the number of threats being assessed reduces, the level of quantification of risk and uncertainty will increase. The project will utilise aspects of established risk assessment frameworks and methodologies, and will involve the following key components:

- Semi-quantitative assessment of risks to Australia's tropical rivers;
- Semi-quantitative assessment of risks to three focus catchments; and
- Quantitative assessment of risks of key threats to selected sites within the focus catchments.

The process of problem formulation/hazard identification will rely heavily on existing reports/data and stakeholder consultation, and will result in the construction of conceptual models of region/catchment aquatic ecosystem *assets* and *threats* and their inter-relationships. The conceptual models will be used to guide the semi-quantitative and quantitative analyses. Semi-quantitative risk analyses for the tropical rivers study area and focus catchments will rely on spatial risk modelling using a GIS-based approach known as the Relative Risk Model. Uncertainty analyses, using Monte Carlo and other methods, will be incorporated into the model. Quantitative risk analyses at the focus catchment (or selected sub-catchment) scale will be undertaken for selected threats and assets, depending on the results of the semi-quantitative analyses and stakeholder views. Most likely, Bayesian Networks (BNs) will be developed that explicitly identify links between hypothesised causes and effects, and highlight the complexities and uncertainties in the system. Again, uncertainty will be incorporated into the assessments using Monte Carlo simulation and other techniques such as sensitivity analysis.

Overall, it is envisaged that the ecological risk assessment sub-project of the TRIAP will illustrate (i) the need for, (ii) the various approaches to, and (iii) the benefits that can arise from the use of, ecological risk assessment for managing and protecting Australia's tropical rivers.

References

Andersen MC, Thompson B & Boykin K 2004. Spatial risk assessment across large landscapes with varied land use: lessons from a conservation assessment of military lands. *Risk Analysis* 24, 1231-1242.

Aspinall R & Pearson D 2000. Integrated geographical assessment of environmental condition in water catchments: Linking landscape ecology, environmental modelling and GIS, *Journal of Environmental Management* 59, 299-319.

AS/NZS 2004a. *Risk Management*. AS/NZS 4360:2004, Standards Australia International, Sydney.

AS/NZS 2004b. *Risk Management Guidelines Companion to AS/NZS 4360:2004*. HB 436:2004, Standards Australia International, Sydney.

Bayliss P, van Dam R, Boyden J and Walden D 2006. Ecological risk assessment of Magela floodplain to differentiate mining and non-mining impacts. In, Evans KG, Rovis-Hermann J, Webb A & Jones DR (eds). *eriss research summary 2004–2005*. Supervising Scientist Report 189, Supervising Scientist, Darwin NT.

Bayliss P, Finlayson M & van Dam R 2004. *Progress and review of the ISP Landscape Program (2002–2004) in the Alligators Rivers Region: ARRTC Key Knowledge Need 5.1 – Landscape scale analysis of impacts.* Internal Report 492, October, Supervising Scientist, Darwin. Unpublished paper.

Bayliss P & Yeomans KM 1990a. Use of low-level aerial photography to correct bias in aerial survey estimates of Magpie Goose and Whistling Duck density in the Northern Territory. *Aust. Wildl. Res.* 17, 1-10.

Bayliss P & Yeomans KM 1990b. Seasonal distribution and abundance of Magpie Geese Anseranas semipalmata Latham, in the Northern Territory, and their relationship to habitat, 1983-86. *Aust. Wildl. Res.* 17, 15-38.

Bayliss P 1989. The population dynamics of magpie geese in relation to rainfall and density: implications for harvest models in a fluctuation environment. *Journal Applied Ecology* 26, 913-924.

Billington K 2005. *The River Murray and Lower Lakes Catchment Risk Assessment Project for Water Quality-Concepts and Methods.* Environmental Protection Authority, South Australia.

Blanch S, Rea N & Scott G 2005. *Aquatic conservation values of the Daly River Catchment, Northern Territory, Australia*. A report prepared by WWF-Australia, Charles Darwin University and the Environment Centre NT, Darwin.

Burgman MA 2005. *Risks and Decisions for Conservation and Environmental Management.* Cambridge University Press, Cambridge, UK.

Cain J 2001. *Planning improvements in natural resources management. Guidelines for using Bayesian networks to support the planning and management of development programmes in the water sector and beyond.* Natural Environment Research Council, Centre for Ecology and Hydrology (CEH) Wallingford, UK. 124 pp.

Daly Region Community Reference Group (CRG) 2004. *Daly Region Community Reference Group Draft Report, November 2004*.

Diamond JM & Serveiss VB 2001. Identifying Sources of Stress to Native Aquatic Fauna Using a Watershed Ecological Risk Assessment Framework. *Environmental Science & Technology* 35, 4711-4718.

DIPE (Department of Infrastructure, Planning and Environment) 2003. *Draft Conservation Plan for the Daly Basin Bioregion*, Northern Territory Government, Darwin. Ferdinands K, Devonport C & Whitehead P 2001. The use of GIS-based predictive models to examine the potential impact of Para grass Urochloa mutica (Forssk) on landscape structure in the Mary River floodplains, NT. *Proceedings of the North Australian Remote Sensing & GIS Conference*, Darwin.

Ferdinands K 2006. *Assessing the relative risk of para grass invasion in the Magela Creek wetlands*. Unpublished consultancy report to the Supervising Scientist Division, Darwin, NT.

Finlayson CM, Bailey BJ, Freeland WJ & Flemming MR 1988. Wetlands of the Northern Territory. In *Conservation of Australian Wetlands*. Eds McComb AJ & Lake PS, Chipping Norton, NSW, Surrey Beatty and Sons, 103-126.

Georges A, Jolly P & Stewart 2002, *Modelling dry season flows and predicting the impact of water extraction on a flagship species*. Final Report. National River Health Program. CRC for Freshwater Ecology and the Applied Ecology Research Group, University Canberra, ACT.

Glaister JP 1978. The impact of river discharge on distribution and production of the school prawn *Metapenaeus macleayi* (Haswell)(Crustacea: Penaedae) in the Clarence River region, northern New South Wales. *Australian Journal of Marine and Freshwater Research* 28, 311-323.

Glicken J 2000. Getting stakeholder participation 'right': a discussion of participatory processes and pitfalls. *Environmental Science and Policy* 3, 305-310.

Gordon SI & Majumder S 2000. Empirical stressor-response relationships for prospective risk analysis. *Environmental Toxicology and Chemistry* 19, 1106-112.

Griffin RK 1987. Life history, distribution, and seasonal migration of barramundi in the Daly River, Northern Territory, Australia. *American Fisheries Society Symposium* 1, 358-363.

Gustafson EJ, Murphy NL & Crow TR 2001. Using a GIS model to assess terrestrial salamander response to alternative forest management plans. *Journal of Environmental Management* 63, 281-292.

Hart BT 2004. Environmental risks associated with new irrigation schemes in Northern Australia. *Ecological Management and Restoration* 5, 107-111.

Hart B, Burgman M, Webb A, Allison G, Chapman M, Duivenvoorden L, Feehan P, Grace M, Lund M, Pollino C, Carey J & McCrae A 2005. *Ecological risk management framework for the irrigation industry.* Report to National Program for Sustainable Irrigation (NPSI), Water Studies Centre, Monash University, Clayton, Australia.

Hayes EH & Landis WG 2004. Regional Ecological Risk Assessment of a Near Shore Environment: Cherry point, WA. *Human and Ecological Risk Assessment* 10, 299-325.

Hession WC, Storm DE, Haan CT, Burks SL & Matlock MD 1996. A Watershed-Level Ecological Risk Assessment Methodology. *Water Resources Bulletin* 32, 1039-1054.

Hogsett WE, Weber JE, Tingey D, Herstrom A, Lee EH & Laurence JA 1997. An Approach for Characterizing Tropospheric Ozone Risk to Forests. *Environmental Management* 21, 105-120.

Humphrey CH, Buckle D & R Pidgeon 2006. Fish communities in channel billabongs. In, Evans KG, Rovis-Hermann J, Webb A & Jones DR (eds). *eriss research summary 2004–2005*. Supervising Scientist Report 189, Supervising Scientist, Darwin NT.

Kienast F, Brzeziecki B & Wildi O 1996. Long-term adaptation potential of Central European mountain forests to climate change: a GIS-assisted sensitivity assessment. *Forest Ecology and Management* 80, 133-153.

Landis WG & Wiegers JA 1997. Design Considerations and a Suggested Approach for Regional and Comparative Ecological Risk Assessment. *Human and Ecological Risk Assessment* 3, 287-297.

Loneragan NR & Bunn SE 1999. River flows and estuarine ecosystems: implications for coastal fisheries from a review and case study of the Logan River, southeast Queensland. *Australian Journal of Ecology* 24, 431-440.

Longsdale WM 1993. Rates of spread of an invading species – *Mimosa pigra* in the Northern Territory. *Journal of Ecology* 81, 513-521.

McDonald TL & McDonald LL 2002. A new ecological risk assessment procedure using resource selection models and geographic information systems. *Wildlife Society Bulletin* 30, 1015-1021.

Millenium Ecosystem Assessment 2003. *Ecosystems and human well being – a framework for assessment*. World Resources Institute, USA.

Moares R, Landis WG & Molander S 2002. Regional risk assessment of a Brazilian rain forest reserve. *Human and Ecological Risk Assessment* 8, 1179-1803.

Obery AM & Landis WG 2002. A regional multiple stressor risk assessment of the Codorus Creek Watershed applying the Relative Risk Model. *Human and Ecological Risk Assessment* 8, 405-428.

OECD 2003. *OECD Environmental indicators: Development, measurement and use.* Reference Paper. OECD Environment Directorate, Environmental Performance and Information Division, Paris, France.

Pascoe GA 1993. Wetland risk assessment. *Environmental Toxicology and Chemistry* 12, 2293-2307.

Preston BL & Shackelford J 2002. Multiple stressor effects on benthic biodiversity of Chesapeake Bay: implications for ecological risk assessment. *Ecotoxicology* 11, 85-99.

Robins JB, Halliday IA, Staunton-Smith J, Mayer DG & Sellin MJ 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*, 56, 343-360.

Rouget M, Richardson, DM, Nel JL & Van Wilgen BW 2002. Commercially important trees as invasive aliens-towards spatially explicit risk assessment at a national scale. *Biological Invasions* 4, 397-412.

Sawynok B 1998. *Fitzroy River effects of freshwater flows on fish: impact on barramundi recruitment, movement and growth*. Report for the National Fishcare Project 97/003753. Infofish Services, Rockhampton.

Solomon KR, Baker DB, Richards RP, Dixon KR, Klaine SJ, La Point TW, Kendall RJ, Weisskopf CP, Giddings JM, Giesy JP, Hall, LW & Williams WM 1996. Ecological risk assessment of atrazine in North American surface waters. *Environmental Toxicology and Chemistry* 15, 31-76.

Staunton-Smith J, Robins JB, Mayer DG, Sellin MJ & Halliday IA 2004. Does the quantity and timing of fresh water flowing into a dry tropical estuary affect year-class strength of barramundi (*Lates calcarifer*)? *Marine and Freshwater Research* 55, 787-797.

Serveiss VB 2001. Applying ecological risk principles to watershed assessment and management. *Environmental Management* 29, 145-154.

US EPA (U.S. Environmental Protection Agency) 1998. *Guidelines for Ecological Risk Assessment.* EPA/630/R-95/002F. Risk Assessment Forum, Washington, DC, USA.

US EPA (U.S. Environmental Protection Agency) 2003. *Framework for Cumulative Risk Assessment.* EPA/630/P-02/001F. Risk Assessment Forum, Washington, DC, USA.

van Dam RA, Finlayson CM & Humphrey CL 1999. Wetland risk assessment: a framework and methods for predicting and assessing change in ecological character. In: *Techniques for Enhanced Wetland Inventory, Assessment and Monitoring,* Eds C.M. Finlayson & A.G. Spiers. Supervising Scientist Report 147, Supervising Scientist, Canberra, Australia. pp. 83-118

van Leeuwen CJ 1995. General introduction. In *Risk assessment of chemicals: An introduction*, eds CJ van Leeuwen & JLM Hermens, Kluwer Academic Publishers, Dordrecht, Netherlands, pp. 1–17.

Walden D, van Dam R, Finlayson M, Storrs M, Lowry J & Kriticos D 2004. *A risk assessment of the tropical wetland weed Mimosa pigra in northern Australia*. Supervising Scientist Report 177, Darwin.

Walden D & Bayliss P 2003. *An ecological risk assessment of the major weeds on the Magela Creek floodplain, Kakadu National Park.* Internal Report 439, Supervising Scientist Division, Darwin.

Walker R, Landis W & Brown P 2001. Developing a regional ecological risk assessment: a case study of a Tasmanian agricultural catchment. *Human and Ecological Risk Assessment* 7, 417-439.

Wiegers JK, Feder HM, Mortensen LS, Shaw DG, Wilson VJ & Landis WG 1998. A regional multiple-stressor rank-based ecological risk assessment for the Fjord of Port Valdez, Alaska. *Human and Ecological Risk Assessment* 4, 1125-1173.

Woodbury PB 2003. Dos and Dont's of spatially explicit risk assessments. *Environmental Toxicology and Chemistry* 22, 253-262.

Xu X, Lin H & Fu Z 2004. Probe into the method of regional ecological risk assessment-a case study of wetland in the Yellow River Delta in China. *Journal of Environmental Management* 70, 299-319.

Attachment A

National Rivers Consortium (Tropical Rivers)

Australia's tropical rivers – an integrated data assessment and analysis

Detailed Work Plan for Sub-Project 2

Assessment of the major pressures on aquatic ecosystems

Duration

2 person equivalents at each of ERISS and ACTFR for 16.5 months each (Years 1 and 2)

Description

The tropical rivers of northern Australia are under increasing pressure due to environmental threats and human activities. The objective of this sub-project is to develop a risk assessment framework applicable to the key focus catchments and significant locations that meet stakeholder needs, within the region of the Tropical Rivers Project. In developing the risk assessment framework, semi-quantitative and quantitative risk analysis will be undertaken where possible, for selected threats. The key focus catchments that will be assessed are: the Daly River Catchment (Northern Territory); Flinders (Queensland); and Fitzroy River Catchment (Western Australia). Throughout this sub-project stakeholders will provide input and feedback.

There 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 non-spatial data related to assets and threats will also be collated. Spatial data will then be compiled in a GIS. Secondly, conceptual models for each of the focus catchments will be developed, focussing on the links between key assets and threats. Finally, both semi-quantitative and quantitative risk analysis will be conducted on selected threats.

Responsibilities

Database development and quantitative ecological risk assessments will be led by ERISS. Collation of information on pressures will be led by ACTFR with assistance from ERISS.

Outputs

Within selected major catchments and at important sites: specific analyses of major pressures (eg. weeds, feral animals, infrastructure, water pollution); recommendations for risk reduction/ management steps and monitoring; and a database of available information.

Work Plan & Schedule

The project tasks and associated task leads and timeframes are detailed below.

1. Develop risk assessment framework and describe methodology

1.1 Prepare internal paper describing the risk assessment framework and proposed methodology, including clarification of terminology (eg. threat v. stressor v. hazard).

2. Problem definition/hazard identification

2.1 Agree on risk assessment focus catchments (most likely Fitzroy – WA, Daly – NT, Flinders – Qld) and, in liaison with State/Territory Govts, NRM bodies and TRP Steering Committee, determine need for stakeholder workshops.

2.2 Identify key stakeholders (eg. Commonwealth/State/Territory/Local Govts, NRM bodies, industry groups, community groups, environment groups) for each catchment.

2.3 Liaise with key stakeholders to identify key catchment assets and threats (may involve workshops).

NB – perceptions of assets and threats will depend on stakeholders' interests. This issue will be clearly articulated, with a possibility of defining assets and threats based on 2–3 generic stakeholder types (eg. biodiversity conservation, agricultural development).

2.4 Acquisition of relevant spatial and non-spatial data/information on assets and threats.

- most of the 'assets' data will already have been collected as part of sub-projects 1 and 3. Most of the 'threats' data will need to be collected as part of this sub-project.
- A second search/request for new data will be made during the last half of the project.

2.5 Compile new GIS data layers based on spatial assets and threats data additional to those acquired in sub-project 1 (and ensure consistency/compatibility with existing GIS datasets).

2.6 Recording/creation and updating of metadata and evaluation of data/information quality.

∗∗ *Most of Task 2 will be undertaken in parallel for each focus catchment* ∗∗

3. Development of conceptual models

3.1 Describe the key ecological assets (ecological values) and threats, and their inter-relationships (focus is on conceptualising which assets are potentially at risk from which threats).

3.2 Use the above information to develop conceptual models of the interactions between key assets and threats for each focus catchment (the final form of the models is yet to be determined, but for practical reasons, may involve disaggregation of the complex systems into a series of simpler, more useable sub-models).

3.3 Seek feedback and confirmation on the models from key stakeholders, and iterate/finalise models as required (may involve workshops).

3.4 Agree on scope of semi-quantitative and quantitative risk analyses with respect to the threats and assets being assessed (agreement to be reached internally and with key stakeholders).

∗∗ *Focus catchments will be assessed sequentially, thereby focusing resources on one catchment at a time* ∗∗

4. Semi-quantitative risk analysis

4.1 *Effects/consequence analysis* – collate data/information on documented effects of key threats to key assets (possibly apply a semi-quantitative ‘consequences’ ranking scheme), and document the associated level of confidence in the data/information.

4.2 *Exposure/likelihood analysis* – integrate relevant GIS layers to determine extent or likelihood of exposure of key assets to key threats, and document the associated level of confidence in the data.

4.3 *Risk Characterisation*– integrate outcomes of effects and exposure analyses to estimate risks of threats to assets. Outputs include: identification of relative risks (and, therefore, highest risk threats); assets least/most under risk; initial indication of cumulative risks; and articulation of uncertainty.

4.4 Describe applications of semi-quantitative risk outputs to catchment management and NRM – ie. how do they inform risk management/risk reduction?.

∗∗ *Focus catchments will be assessed sequentially, thereby focusing resources on one catchment at a time* ∗∗

5. Quantitative risk analysis

5.1 Based on outcomes of semi-quantitative risk analyses and stakeholder views, select one threat/issue for quantitative risk analysis, and reaffirm/revise the conceptual model for this threat/issue.

5.2 **Land clearing**

- Review and, if necessary, modify the Daly River “Land clearing” impacts conceptual model presented in the CRG Report (2004). Undertake the review in consultation with NTG senior water policy advisors and technical experts in the field.

- Confirm with NTG senior water policy advisors and technical experts in the field the magpie geese and barramundi ecological and measurement endpoints identified *a priori* and, link them via “cause-effect” mechanisms to measurement endpoints.

Barramundi & in-stream impacts:

- Obtain NTG Fisheries time series catch data on the “Barramundi Classic Tournament” series (1981-2006) for the Daly River. Analyse catch-effort and length frequency data for trends in relation to effort (harvesting impact *per se*) and long-term flow patterns (as potentially affecting fecundity, survival & dispersal processes via habitat change).

- Simultaneously assess the relative importance of changes in water quality, flow and fishing effort on the “barramundi” ecological endpoint and rank effects.

- Attempt to link the results of this single-species analysis with work recently commenced by CDU on fish biodiversity in the Daly River.

- Construct a Bayesian Network using empirical data and expert opinion to examine potential causal links between changes in river flow (here predicted increases & possibly quality) to changes in barramundi population measurement endpoints and, ultimately, to recreational catch after variations in effort and management regimes are factored out.

Magpie geese & floodplain impacts

- Use time series and CUSUM analyses to match decadal trends in river flow at the nearest long-term stream gauging station to major magpie geese nesting colonies, and assess its influence on spatial and temporal trends in nesting success and population size.

- Construct a Bayesian Network using empirical data and expert opinion to examine potential causal links between changes (here increases) in flow to changes in magpie geese population measurement endpoints.

5.3 Water extraction

- Review and if necessary revise previous conceptual models on risks to in-stream and floodplain environments associated with dry season water extractions. Undertake the review in consultation with NTG senior water policy advisors and technical experts in the field.

- Confirm with NTG senior water policy advisors and technical experts in the field the magpie geese and barramundi ecological and measurement endpoints identified *a priori* and, link them via "cause-effect" mechanisms to measurement endpoints (eg. reduced flood extent & altered timing).

- Repeat above quantitative ecological assessments for reduced flow rather than increased flow, and its effect on the ecological and measurement endpoints for magpie geese and barramundi.

- Develop a Bayesian Network that predicts reduced flows due to water harvesting and combine with the above Bayesian Network predicting increased flows due to land clearing. Re-examine the above "what-if" management scenarios.

5.4 **Invasive species (weeds)**

- Review and, if necessary, revise previous conceptual models on conceptual model for ecological risks associated with the colonisation of mimosa and para grass weeds on the Daly River floodplain. Undertake the review in consultation with NTG senior water policy advisors and technical experts in the field.

- Confirm with other stakeholders and technical experts in the field the magpie geese and ecological and endpoints identified *a priori* and, link them via "cause-effect" mechanisms to measurement endpoints (eg. extent of floodplain vegetation communities, extent of nesting & rearing floodplain habitats, nest and geese numbers & densities).

- Profile ecological risks to Daly River floodplain assets in greater detail, specifically risks to native wetland vegetation *per se* and magpie geese breeding habitat. Examine possible links to the condition of sustainable barramundi populations (eg. if floodplain act as major nursery habitats).

- Develop Bayesian habitat suitability models for both weeds and combine with existing spread rate models to spatially predict exposure and effects within identified time frames. Use the spatial model to highlight ecological risks to floodplain vegetation and wildlife habitat by encompassing current distribution, habitat preferences of both weeds, distance to source and potential invasion pathways.

- Develop a Bayesian Network using empirical data and expert opinion to assess different control scenarios via "what if" simulations. Use existing bioeconomic sub-models (control-cost functions) in the BN to asses the benefits and costs of different weed control scenarios.

6. Communication and consultation

6.1 Establish contact with agencies, boards and representative panels in WA, Qld & NT to notify of the commencement of the project, reiterate its objectives and links to the other two sub-projects, and seek collaboration and support and access to information.

6.2 Establish schedule and purpose for continued consultation, including ongoing exchange of information, collaboration and reporting and demonstrating initial analyses and outcomes.

NB – consultation tasks are embedded in all the tasks described for this sub-project

7. Reporting

7.1 Coordinated final draft risk assessment report.

Timeline for tasks

Task	**04-05**			**05-06**												**06-07**		
	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1.1 Risk assessment framework																		
2.1 Select focus catchments																		
2.2 Identify key stakeholders																		
2.3 Identify key assets & threats																		
2.4 Data acquisition																		
2.5 Compile new GIS layers/datasets																		
2.6 Metadata & data quality																		
3.1 Describe assets & threats																		
3.2 Develop conceptual models																		
3.3 Incorporate stakeholder feedback																		
3.4 Agree on scope of risk analyses																		
4.1 Semi-quant. effects analysis																		
4.2 Semi-quant. exposure analysis																		
4.3 Semi-quant. risk characterisation																		
4.4 Describe application of outputs																		
5.1 Select threat & reaffirm conceptual model																		
Quantitative risk analyses																		
6.1 Initial consultation																		
6.2 Ongoing communication and consultation																		
7.1 Reporting (interim and final milestones)																		
Risk assessment workshops	To be advised																	

Attachment 4 Stakeholder views: assets and threats to the tropical rivers of the Fitzroy catchment, WA

STAKEHOLDER VIEWS: ASSETS AND THREATS TO THE TROPICAL RIVERS OF THE FITZROY CATCHMENT, WA

WORKSHOP REPORT

DERBY

FRIDAY 17 FEBRUARY, 2006

Fitzroy River, Willare Bridge

national centre for tropical wetland research

Australian Government
Land & Water Australia

Natural Heritage Trust
Helping Communities Helping Australia
An Australian Government Initiative

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Date of Report

May 2006

Contents

1. Introduction

The Tropical Rivers Inventory and Assessment Project (TRIAP) Fitzroy catchment community consultation workshop was held in Derby on Friday 17 February, 2006. The workshop was organised by the National Centre for Tropical Wetland Research (NCTWR- www.nctwr.org.au), which is undertaking the TRIAP. The TRIAP is funded under Land & Water Australia's Tropical Rivers Program.

The TRIAP is examining the assets and threats to Australia's tropical rivers in terms of risk assessment. The Fitzroy catchment is one of the project's '*focus catchments*' and as such, is being analysed in as much detail as possible.

One of the first steps in the risk assessment project is to document the assets and threats in the Fitzroy catchment. We have collected some information from existing reports and workshops held previously. Appendix 1 provides a list of reports and workshops referenced to date. It is important we get the views of people who live and work in the catchment on these aspects, so that the project produces meaningful results and relevant outputs.

The major aim of the workshop was to agree on the key ecological assets and threats to the tropical rivers of the Fitzroy catchment and to prioritise assets and threats to be examined within the TRIAP. An information sheet (see Appendix 2) and flyer about the workshop was distributed to stakeholders who then passed it on to people they thought may be interested in attending.

Fourteen people attended the workshop (see Appendix 3 for a list of workshop participants). They included traditional owners, representatives from the Department of Environment, Kimberley Land Council and Clean Up the Kimberley. The workshop included brief powerpoint presentations with lots of discussion from the participants combined with breakout sessions where small groups discussed their views. The workshop format is outlined in Appendix 4. The concept of ecological risk assessment was discussed in the beginning of the workshop.

This report includes:

- A summary of what is risk assessment and conceptual models as presented at the workshop
- A summary of the ecological assets collected from other reports and the ecological assets discussed at the workshop
- A summary of the threats to ecological assets collected from other reports and the threats discussed at the workshop

- Priorities for the TRIAP as identified at the workshop

2. What is risk assessment?

***Ecological risk*:** the chance of a harmful effect taking place of a certain level on man/environment because of exposure to a threat

***Pressure**: Water impoundment*

***Threat**: Change in water flow*

***Risk**: Chance of a fish kill*

Ecological asset: parts of the natural environment/country which are valued or important to the community

Photo: David Morgan

Sawfish

River Flow

Riparian Vegetation

Value: qualities/characteristics of assets that make us value and want to protect the asset

Pressure: any human activity that can impact the natural environment

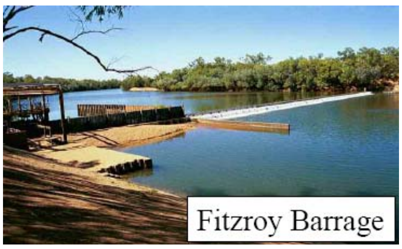


Photo: Andrew Storey

River Regulation

Irrigated Cropping

Threat: an action or activity caused by a pressure that can negatively affect an ecological asset and its value

Another word used for threat is ***Stressor***

Weeds

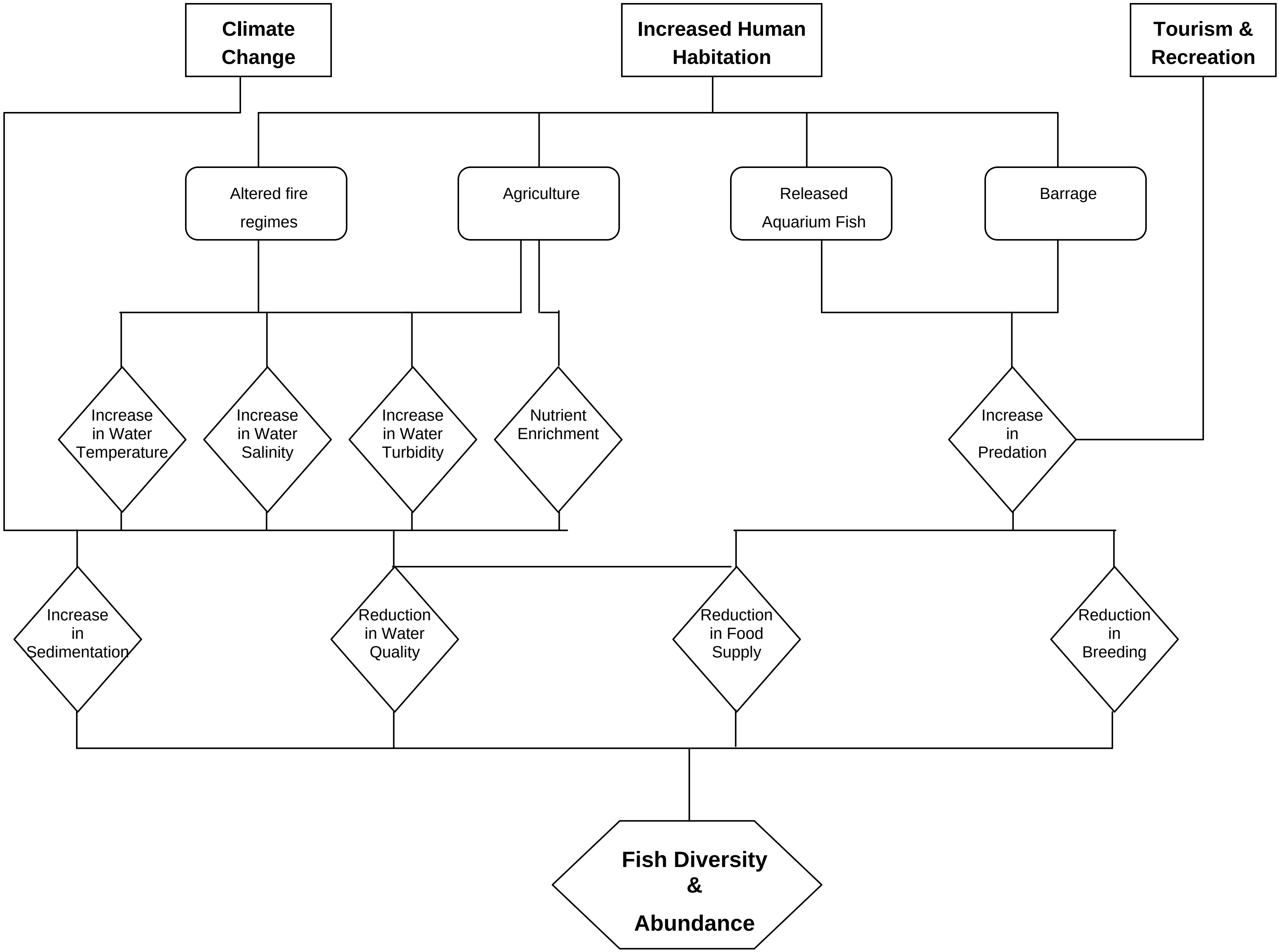
Cattle

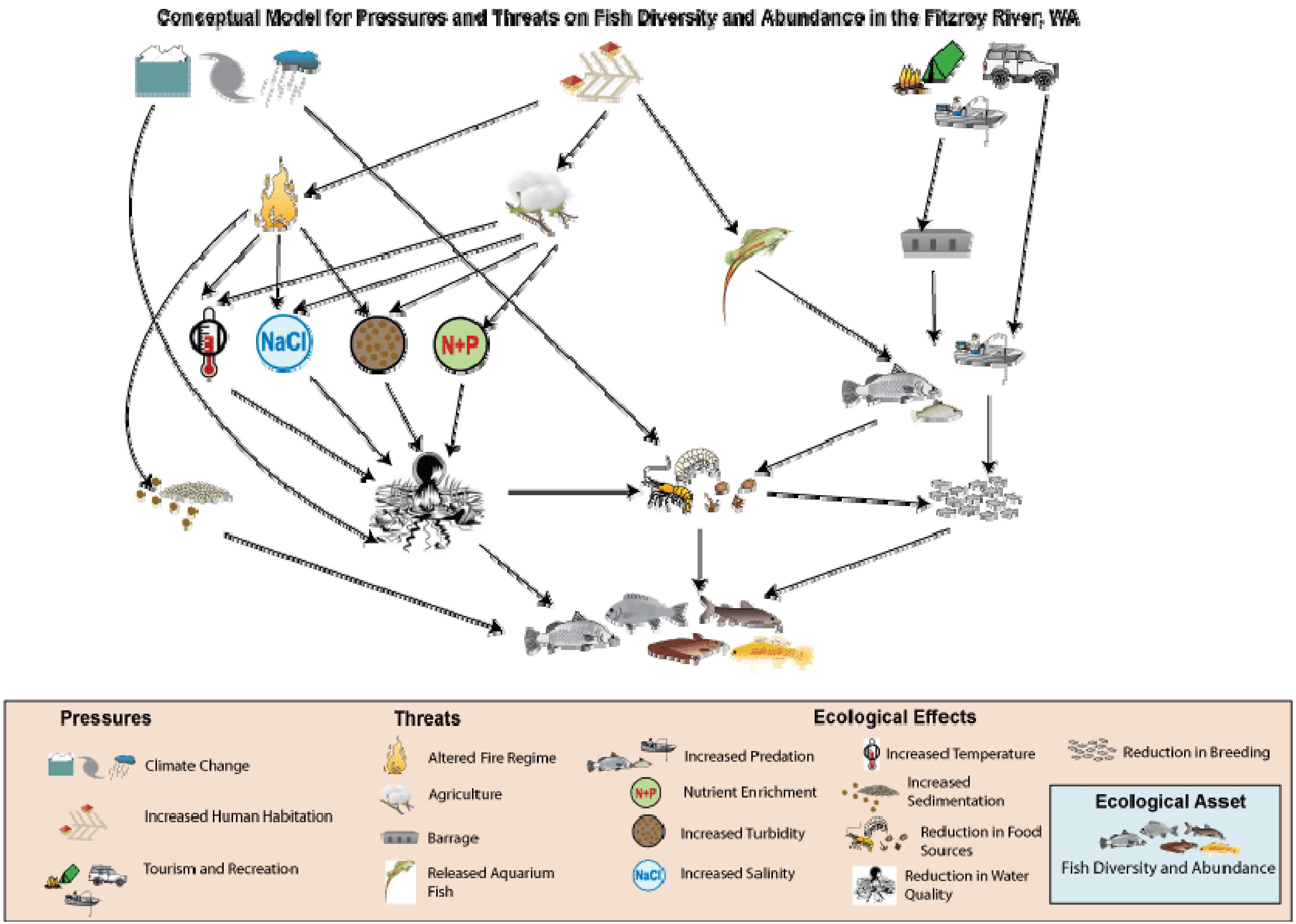
2.1. How does this all fit together: the conceptual model

A conceptual model tells a story of how pressures and threats affect ecological assets. It shows the potential ecological consequence of a particular threat to a particular asset. Conceptual models can be shown in different ways. You can show a model for the whole river system as shown in Appendix 5 or you can show a model for one asset (fish diversity and abundance) as shown in the example below. Conceptual models can be presented as a series of boxes with words or with symbols and pictures as also shown by the fish diversity and abundance example below.

The group spoke about fish kills in the context of conceptual models. After the first rain, the first flood is hot because of the dry sand bank and the fish die of these natural causes.

Example Conceptual Model for Pressures and Threats on Fish Diversity and Abundance in the Fitzroy River, WA





Conceptual Model for Pressures and Threats on Fish Diversity and Abundance in the Fitzroy River, WA
NaCl
N+P
Pressures
Climate Change
Increased Human Habitation
Tourism and Recreation
Threats
Altered Fire Regime
Agriculture
Barrage
Released Aquarium Fish
Ecological Effects
Increased Predation
Nutrient Enrichment
Increased Turbidity
Increased Salinity
Increased Temperature
Increased Sedimentation
Reduction in Food Sources
Reduction in Water Quality
Reduction in Breeding
Ecological Asset
Fish Diversity and Abundance

3. Ecological Assets

3.1. Summary of Ecological Assets Identified from Previous Stakeholder Consultations in the Region and Reports

Table 1 summarises the key ecological assets identified in previous stakeholder meetings and reports on the Fitzroy River. These were presented at the workshop and discussed by participants. In addition to the references cited, the workshop notes from the Broome, Derby and Fitzroy Crossing Kimberley Natural Resource Management meetings in 2004 were reviewed.

Table1: Summary of key ecological assets identified in previous stakeholder meetings and reports on the Fitzroy River.

Ecological Asset	Consultation/Report Source
Freshwater Sawfish (*Pristis microdon*) Dwarf Sawfish (*Pristis clavata*)	1. Thorburn *et al*. (2004) Biology & cultural significance of the freshwater sawfish (Pristis microdon) in the Fitzroy River Kimberley, Western Australia.
	2. Morgan, D.L., Allen, M.G., Bedford, P. and Horstman, M. (2002) Inland Fish Fauna of the Fitzroy River Western Australia, including the Bunuba, Gooniyandi, Ngarinyin, Nyikina and Walmajarri Aboriginal names.
	3. Pillsbury, J. (2005) The International and Heritage Significance of Doctor's Creek.
	4. Storey, A.W., Davies, P.M. and Froend, R.H. (2001) Fitzroy River System: Environmental Values (for Water & Rivers Commission).
Fish Diversity and Endemicity	1. Morgan, D.L., Allen, M.G., Bedford, P. and Horstman, M. (2002) Inland Fish Fauna of the Fitzroy River Western Australia, including the Bunuba, Gooniyandi, Ngarinyin, Nyikina and Walmajarri Aboriginal names.
	2. Storey, A.W., Davies, P.M. and Froend, R.H. (2001) Fitzroy River System: Environmental Values (for Water & Rivers Commission).
	3. Draft Kimberley Natural Resource Management Plan (December 2004)
	4. Kimberley Land Council Land & Sea Unit. (2004) "Looking After Country" Workshop Report 14-15 September 2004, Bungarun.
	5.Kimberley Appropriate Economies

	Roundtable. (2005) Interim Report.
Aquatic Threatened Species Freshwater Sawfish (Vulnerable), Freshwater Whipray (Vulnerable), Northern River Shark (Endangered)	1. Morgan, D.L., Allen, M.G., Bedford, P. and Horstman, M. (2002) Inland Fish Fauna of the Fitzroy River Western Australia, including the Bunuba, Gooniyandi, Ngarinyin, Nyikina and Walmajarri Aboriginal names.
	2. Storey, A.W., Davies, P.M. and Froend, R.H. (2001) Fitzroy River System: Environmental Values (for Water & Rivers Commission).
	3.Thorburn *et al*. (2004) Biology & cultural significance of the freshwater sawfish (Pristis microdon) in the Fitzroy River Kimberley, Western Australia.
	4. Draft Kimberley Natural Resource Management Plan (December 2004)
	5. Pillsbury, J. (2005) The International and Heritage Significance of Doctor's Creek.
	6.Kimberley Appropriate Economies Roundtable. (2005) Interim Report.
Wetlands Camballin Floodplain Geikie Gorge	1. Storey, A.W., Davies, P.M. and Froend, R.H. (2001) Fitzroy River System: Environmental Values (for Water & Rivers Commission).
	2. Environment Australia (2001) A Directory of Important Wetlands in Australia (3rd edition)
	3.Draft Kimberley Natural Resource Management Plan (December 2004)
Flow Regime *"floodwaters come every year and clean the country"* *"we must make sure the Fitzroy River flows freely and is not interfered with or blocked"*	1. Storey, A.W., Davies, P.M. and Froend, R.H. (2001) Fitzroy River System: Environmental Values (for Water & Rivers Commission). 2. Kimberley Land Council Land & Sea Unit. (2004) "Looking After Country" Workshop Report 14-15 September 2004, Bungarun. 3.Kimberley Appropriate Economies Roundtable. (2005) Interim Report.
Riparian Vegetation	Storey, A.W., Davies, P.M. and Froend, R.H. (2001) Fitzroy River System: Environmental Values (for Water & Rivers Commission).

	Kimberley Land Council Land & Sea Unit. (2004) "Looking After Country" Workshop Report 14-15 September 2004, Bungarun.
Groundwater	Draft Kimberley Natural Resource Management Plan (December 2004)

3.2. Ecological assets discussed in the workshop

This session involved a general discussion followed by break out groups who then reported back to the whole group.

The general discussion highlighted that the ecological assets were also cultural assets and so some assets are referred to as *eco-cultural assets* as they can not be assigned as either type. Examples of eco-cultural assets given were fish, the black water goanna (Merton's Water Monitor- *Varanus mertensi*) and the water rat (Golden Backed Tree Rat - *Mesembriomys macrurus*) because there are traditional stories associated with them. Riparian vegetation such as pandanus and freshwater mangrove was discussed by everyone as an eco-cultural asset also. Not only does it play an important ecological role in the river's health, but it is an important source of bushtucker, bush medicine and bush tools. For example, "*you have a headache…go to a tree and get your medicine from the tree*"-Leena Fraser Buckle. Alan Lawford also talked about fire as an asset. He told a story showing that if people burn at the right time fire was good and also spoke about the problems of the wrong fire regime for the river. Two other assets that were highlighted in group discussions were the remoteness and low human population of the region.

Alan Lawford telling his fire story

The break out session involved three groups summarising what ecological assets they thought were important and prioritising the most important ones to them. Group 1 was predominantly the Department of Environment (Katya Tripp, Scott Goodson, Michael Harris) stakeholders and Alan Lawford. Table 2 summarises their findings they presented back to the group. Group 2 included Charles Prouse, Lucy Marshall and Jake Zahl and their discussion is summarised in Table 3. Group 3 included Leena Fraser Buckle, Erica Spry, Annette, Hugh Wallace Smith, Mick, Rosie and Aggie Puertollano and their findings are summarised in Table 4.

Group 1

Group 2

Group 3

Table 2: Group 1 Summary of Ecological Assets. Maintenance of natural flow regimes was identified as a priority.

Fish- Barramundi, Sawfish, Cherabin, mussels etc.
Mammals- water rat and river wallaby.
***Maintained natural flow regimes* – unimpeded flow**
Billabongs, permanent pools, flood flush pools and fill billabongs
Riparian vegetation – stable banks, vegetation structure and assemblages
Water Quality- clean, use for drinking
Birds- Gouldian Finch, Purple Crowned Fairy Wren
Reptiles – lizards, goannas, turtles, snakes
Water supply – communities, pastoralism, bores - economic development and industry
Access to river- physical (weeds) and land tenure

Table 3: Group 2 Summary of Ecological Assets. Diversity of wildlife, abundance and quality of water and diversity of native flora were identified as being important.

Ecological Asset	**Nyikina Name**
Bait Fish	
Perch	Jalmonnga
Bony Bream	Budijal
Red Eye Mullet	Lowidingi
Black Bream	Walnga
Mudskippers	
Barramundi	Walja
Freshwater Crocodile	Wyania
Saltwater Crocodile	Linguida
Short Neck Turtle	Mullawai
Long Neck Turtle	Goolarboolu
Water Goanna	Wabada?
Fruit Bat	Nimanbur
Cobbler (Flathead)	Mwahlay
Stingray	Bire
Waterbird-cormorant	
Eagles-Sea Eagle	
Plover	
Pelicans, Spoonbills	
Ducks	
Brolga, Jabiru	
Diversity of wildlife	
Abundance and quality of water	
Diversity of native flora	

Table 4: Group 3 Summary of Ecological Assets. Sawfish, bait fish, seasonal variations, water quality and flow, snags/trees (habitat), frogs, goannas, eagles, pelican, invertebrates, bush medicine, vegetation, flooding, bush tucker, groundwater and billabongs were identified as being important.

Cultural sites (scared stories)
Barramundi
Cherabin
Catfish
Sawfish
Mullet
Long Neck Turtle
Bream
Crocodile
Stingray
Mussels
Oysters
Salmon
Freshwater Crabs
Archer Fish
All the little ones (Bait fish- about 40)
Long Tom
Mangrove Jack
Bull Shark
Eels
Seasonal Variations
Water quality and flow
Snags/Trees (Habitat)
Frogs
Goanna
Kanagaroos
Water Python
Eagles, Pelicans
Egrets

Hawks/Kite
Turkey
Brolga
Emu
Cormorant
Ducks
Magpie Geese
Invertebrates
Bush medicine
Bats (mammals)
Vegetation (e.g. water lily, bush cucumber, figs)
Flooding
Bush tucker (honey)
Groundwater
Billabongs

4. Pressures and Threats

4.1. Summary of Pressures and Threats Identified from Previous Stakeholder Consultations in the Region and Reports

Table 5 summarises the pressures and threats identified in previous stakeholder meetings and reports on the Fitzroy River. These were presented at the workshop and discussed by participants. In addition to the references cited, the workshop notes from the Broome, Derby and Fitzroy Crossing Kimberley Natural Resource Management meetings in 2004 were reviewed.

Table 5: Summary of the pressures and threats identified in previous stakeholder meetings and reports on the Fitzroy River.

Pressures	Threats
Water diversion	Cattle
Water regulation	Weeds
Broad scale Irrigated Agriculture	Dams/Barrages
Pastoralism	Cane toads
Horticulture	Litter/Rubbish
Mining	Run-off (Pesticides/Fertilisers)
Tourism/Recreation	Wrong Fire Regime
Human Settlement	Cotton
Climate Change	Saltwater Intrusion
	Illegal Fishing/Netting
	Pigs/Feral Cats
	Bullshark
	Aquarium Fish

4.2. Pressures and Threats discussed in the workshop

Table 6 is a summary of the pressures and threats discussed by the workshop group.

Table 6: Summary of the pressures and threats discussed by the group.

Fencing through rivers when flooded	Stops access of cattle to river and is not well managed.
Infrastructure such as tracks and roads	Enables more access to the river. Results in more sand in the river. People get bogged.
Government is a threat	Support for development in the region
Stormwater/Sewage	Mudflats/artificial wetland filters
Feral animals: pigs are a big problem	Bank erosion Water quality Water chestnut
Feral animals: cats	Impact on birds, insects, reptiles and fish.
Proposed canal development	Not much information supplied to the community (how, what is the science behind it) Creation story will be destroyed (if it is made by nature there is no problem)
Wrong fire regime	Unbalance Early burning is the proper way-low intensity Different country type-soil
Cane Toad	Important threat to examine
Illegal fishing-freezer chiller	No enforcement of the law 7 permits only in Kimberley for netting
Flood	Frogs disappeared in Derby after a big flood
Bullshark-flow, water regulation	Threat to fish diversity Run out of eating fish and starting eating each other, crocs, birds Breed at barrage Increasing in numbers Even jumping up and getting birds
Weeds	Always finding new weeds- “white flowers all

	round”
Weeds: N. burr	Threat to riparian vegetation Cattle can’t get down to river Blocks access
Weeds: Parkinsonia	Cattle eat it
Weeds: Passionfruit vine	
Weeds: Rubber Tree	Becoming extensive
Weeds: Different type to M.pigra	Has spread through floodplain
Climate Change	King Sound protects Derby from cyclones Cherabin numbers have changed because of changes in river flow Tidal creek expansion Marshes and mudflats are expanding 11m king tide Extreme temperatures-build up before rains affects vegetation. - dry and dusty - barrage stagnant and algae present (November) Increase in fire-desert encroaching on floodplain last 50 years Two-three years ago there was an extended cold season until August.
Recreational pressure is high	
Aquarium Fish: swordtails (telapia)	Aggressive Sold in Derby pet shop Eat native fish People use as bait fish Project educating people last year in communities about this problem
Human settlement	Aboriginal people moving into town from country because of no opportunities on country Not a large threat
Mining	Blina Swamp-oil Diamond mine?

	20 years down the track: -mineral wealth -low-grade coal (BHP exploration) -uranium?
Tourism	Controlled tourism is OK Camping at the Erskine Range (where the Fitzroy meets the Leonard) is unmanaged Litter/rubbish Wrong fire regime- 120 000 ha country burnt last year (lit by tourists) At Telegraph Pool, the tourists affect sawfish (both species)- they are trophy hunted (chop off rostrum) Telegraph-Langi: 60 caravans at a time (a lot of grey nomads) with generators and rubbish.
Barrage	Why was this put in, in the first place? Diverts water down Snake Creek White elephant Seasons did not allow for fish migrations sometimes Affects spawning and migration of some fish e.g. barramundi Window of migration reduced from 4 months to 2 months Bullsharks also get trapped and eat all the other trapped fish
Increasing salinity of system upstream	Christmas Creek- Alan Lawford told a story about Christmas Creek. He used to be able to only catch cherabin, perch, catfish and black bream. In the last 3 years he has been able to catch barramundi. Now he can't dig a freshwater soak like he could when he was a kid. Saltwater fish are going up as far as the Crossing where it is freshwater. For example the red snapper are up at the Crossing when the river is flowing.
Grazing and mammals	Grazing on river bank affects mammals (wallaby, Golden Backed Tree Rat (water rat) and quolls) differently compared with birds

	and fish Wallaby are starting to come back after being poisoned in the 1970s Lucy Marshall said she has not seen a Golden Backed Tree Rat (water rat) since the 1940s and maybe it was because of grazing that she has not seen them. These rats are rare and use the river bank.
Litter	Jake Zahl informed the group that in peak flow (every 3-4 years) the Fitzroy discharges 400 000 plastic bags into King Sound. Affects wildlife

5. Summary

The major aim of the workshop was to agree on the key ecological assets and threats to the tropical rivers of the Fitzroy catchment and to prioritise assets and threats to be examined within the TRIAP. This aim was achieved. River flow and water quality was determined to be a priority asset for the TRIAP to examine because' *nothing else would exist without it*'. Other assets that were recognised as priorities were the riparian vegetation and diversity of wildlife, however it was agreed that they would not be examined in the same detail as river flow/water quality in the TRIAP due to limited time and resources. The Cane Toad was recognised as an immediate threat and water extraction/regulation was identified as a priority pressure.

Fire was viewed as an asset by some participants rather than a threat. This is because the correct use of fire as a management tool promotes healthy country. It is wrong fire regime that is a threat.

It was agreed that the NCTWR will supply the workshop participants with Cane Toad risk assessment work that the Department of the Environment and Heritage's Supervising Scientist Division based in Darwin has conducted for Kakadu National Park. This report will be distributed to as many stakeholders as possible for comment. Feedback will be incorporated into a final version of the report. It was agreed that the TRIAP risk assessment Project Coordinator will undertake a return visit to the region in late may/June dependent on the advice of local people.

Appendix 1: List of References Used Prior to the Derby Workshop

Kimberley Land Council (Land and Sea Unit). (2004) *"Looking After Country" Workshop Report*, Bungarun 14-15 September 2004, pp.74.

Kimberley Land Council, Australian Conservation Foundation, Environs Kimberley. (2005) *Kimberley Appropriate Economies Roundtable*, Fitzroy Crossing 11-13 October 2005, pp.80.

Morgan, D.L., Allen, M.G., Bedford, P and Horstman, M. (2002) *Inland Fish Fauna of the Fitzroy River Western Australia, including the Banuba, Gooniyandi, Ngarinyin, Nyikina and Walmajarri Aboriginal names*. Report to the Natural Heritage Trust, Project Number 003123, pp.97.

Rangelands NRM Co-ordinating Group and Interim Kimberley Natural Resource Management Group. (2004) *Draft Kimberley Natural Resource Management Plan*, pp.139.

Storey, A.W., Davies, P.M. and Froend, R.H. (2001) *Fitzroy River System: Environmental Values*, Report for Waters and River Commission, pp.63.

Thorburn, D., *et al*. (2004) *Biology and cultural significance of the freshwater sawfish (Pristis microdon) in the Fitzroy River Kimberley, Western Australia*, Report to the Threatened Species Network, pp.57.

Appendix 2: Information Sheet Distributed to Stakeholders

Tropical Rivers Inventory and Assessment Project
www.nctwr.org.au/publications/tropical-rivers.html

National Centre for Tropical Wetland Research

Cnr of Pederson Road & Fenton Court
Marrara NT 0812
Postal: GPO Box 461, Darwin
Northern Territory 0801
Phone: (08) 8920 1175
Fax: (08) 8920 1190

www.nctwr.org.au

12 December 2005

Stakeholder Views Workshop: Assets and threats to the tropical rivers of the Fitzroy catchment

(Derby, Friday 17 February 2006)

All stakeholders and community members in the Fitzroy region are welcome to attend and participate in a workshop to agree on the key assets and threats to the Fitzroy River. This forms a component of the Tropical Rivers Inventory and Assessment Project (TRIAP).

The TRIAP is funded under Land & Water Australia's 'Tropical Rivers Program'. The project aims to provide an information base for determining and applying management priorities and land use practices of relevance to stakeholders, including local and indigenous people, private sectors and governmental agents. 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. This component of the project is known as *Sub-project 1: Inventory of the biological, chemical and physical features of aquatic ecosystems*;
- Develop a risk assessment framework and undertake risk analyses for key catchments/significant locations and pressures, which meet stakeholder needs. This component of the project is known as **Sub-project 2: Assessment of the major pressures on aquatic ecosystems**; and
- Provide a framework for analysis of the ecosystem services (e.g. provision of water for multiple uses) provided by the habitats and biota of the rivers and wetlands of northern Australia. This component of the project is known as *Sub-project 3:*

Development of a framework for the analysis of ecosystem services provided by aquatic ecosystems.

The tropical rivers are being assessed at two scales in this project. Firstly there is what we are calling the *continental scale* which encompasses the whole of the northern tropical rivers region. Secondly we are assessing *focus catchments* in more detail. The focus catchments for the TRIAP are the Fitzroy (WA), Daly (NT) and Flinders (QLD). Further information on the TRIAP can be found on the project website: www.nctwr.org.au/publications/tropical-rivers.html

This stakeholder views workshop is focussed on Sub-project 2: Assessment of the major pressures on aquatic ecosystems. Throughout this sub-project stakeholders will be involved in providing input and feedback. At the workshop we will be seeking advice and your views on:

- The key ecological assets and values of the Fitzroy River; and
- The major pressures and threats to the Fitzroy River.

We have defined assets, values pressures and threats as follows for the TRIAP.

Ecological Assets: Attributes (eg. components, processes, functions, products) of natural ecosystems, which are valued by the community (eg. river, wetland, biodiversity, water regulation, primary production).

Ecological Values: Qualities or characteristics of ecological assets that make the community value and want to protect them.

Pressures: Any human activity that has the potential to impact the natural environment. "Pressures" here cover indirect pressures (ie. human activities themselves and trends and patterns of environmental significance) as well as direct pressures (ie. the use of resources and the discharge of pollutants and waste materials).

Threat: An action or activity that has the capacity to adversely affect an ecological asset and its value.

We have already collected some information on assets and threats from existing reports. These reports include:

- Storey, A.W., Davies, P.M. and Froend, R.H. (2001) Fitzroy River System: Environmental Values.
- Draft Kimberley Natural Resource Management Plan (December 2004)
- Thorburn, D., et al. (2004) Biology and cultural significance of the freshwater sawfish (*Pristis microdon*) in the Fitzroy River, Kimberley, WA.

Everyone is most welcome to attend and participate in the workshop:

Friday 17 February, 2006

10:00 am-3:00pm

King Sound Resort

Loch Street, Derby

Morning tea and lunch will provided, but you need to RSVP by Friday 10 February to

Renee Bartolo (ph: (08) 8920 1392, e: renee.bartolo@deh.gov.au)

Any questions relating to the project or workshop can also be directed to the above contact.

Please pass this information on to anyone who may be interested.

Appendix 3: List of Workshop Participants

Name	Stakeholder Group
Charles Prouse	Kimberley Land Council
Erica Spry	Kimberley Land Council
Hugh Wallace Smith	Yiriman Project
Leena Fraser Buckle	Nyikina
Lucy Marshall	Nyikina
Aggie Puertollano	Nyikina
Mick Michaels	Nyikina/Walmajarri
Rosie Mulligan	Nyikina
Annette Kogolo	Walmajarri
Alan Lawford	KAPA
Jake Zahl	Clean Up the Kimberley
Michael Harris	Department of Environment
Scott Goodson	Department of Environment
Katya Tripp	Department of Environment
Renee Bartolo	TRIAP Risk Assessment Sub-project Coordinator (Darwin, NT)
John Dowe	TRIAP Risk Assessment Sub-project (Townsville, QLD)

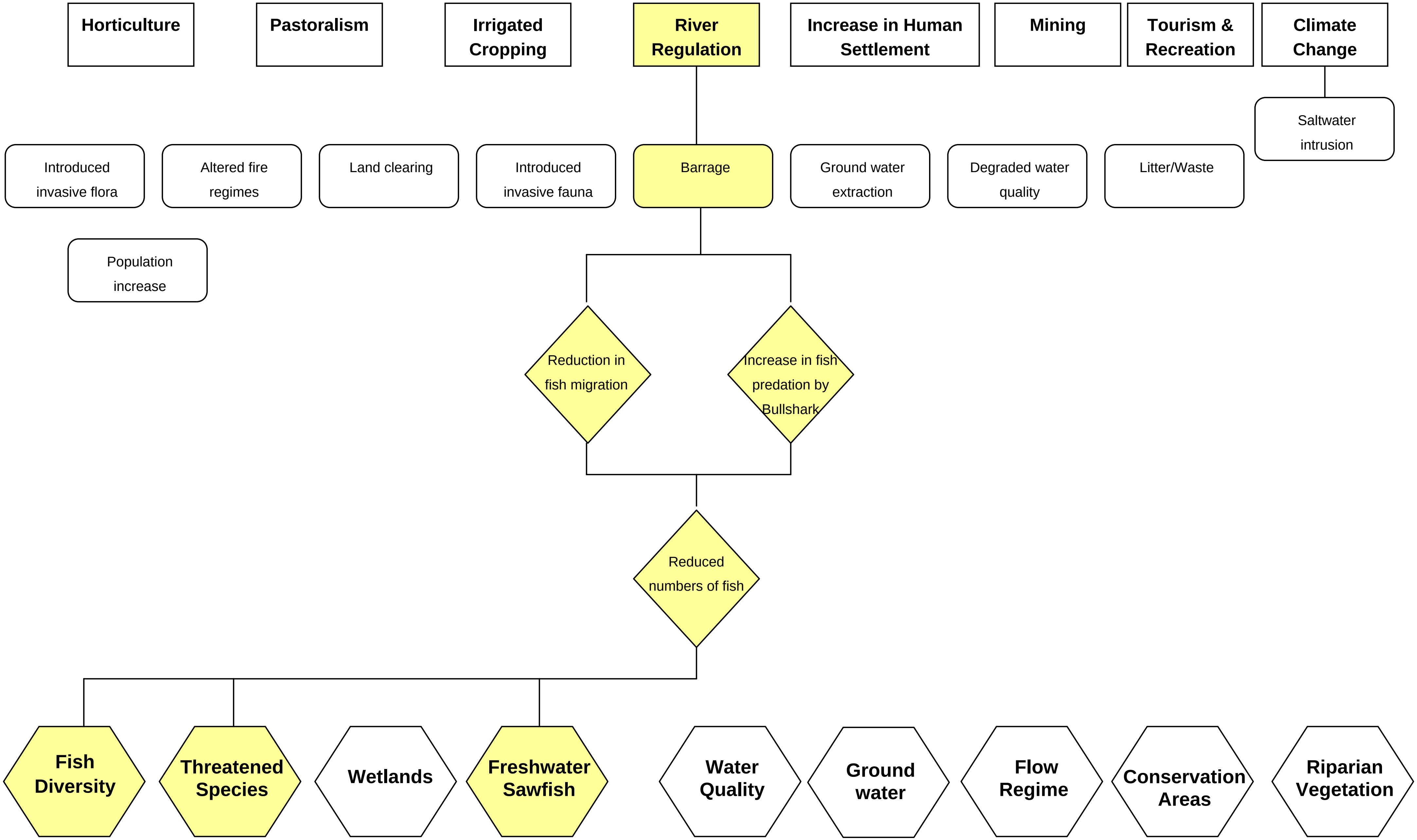
Appendix 4: Workshop Format

Tropical Rivers Inventory and Assessment Project: Sub-Project 2

Fitzroy River Risk Assessment Consultation Friday 17 February 2006

Time	Activity	How
10:00-10:15am 15 mins	*Informal introductions and Morning Tea*	
10:15-10:35am 20 mins	• *Introduction to the TRIAP* • *How does Sub-project 2 fit into existing work that has been done on the Fitzroy River?* • *What is ecological risk assessment?*	Powerpoint presentation (Renee Bartolo)
10:35-10:45am 10 mins	*Questions from workshop participants*	Open floor
10:45-11:05am 20 mins	• *Definitions for ecological risk assessment* • *Ecological assets that have been identified through previous consultations in the region*	Powerpoint presentation (Renee Bartolo) Audience feedback
11:05-11:35 am 30 mins	*Breakout session: ranking of ecological assets in importance to people*	Groups of 4 or 5 people
11:35am-12:00pm 25 mins	*Discussion of ecological assets based on breakout session*	Audience views
12:00-1:00pm 1 hour	LUNCH Provided	
1:00-1:15pm 15 mins	*Review of pressures and threats identified through previous consultations in the region*	Powerpoint presentation (Renee Bartolo) Audience feedback
1:15-1:45pm 30 mins	*Breakout session: identification of pressures and threats which are of the highest priority to stakeholders*	Groups of 4 or 5 people
1:45-2:30pm 45 mins	Discussion of pressures and threats based on breakout session	Audience views
2:30-2:45pm 15 mins	BREAK	
2:45-3:00pm 15 mins	*Closing-summary*	Renee Bartolo

Appendix 5: Draft Conceptual Model of Ecological Risk Assessment for the Fitzroy River



Appendix 6: Stakeholder feedback on the Interim Workshop Report

Jake Zahl (Clean Up the Kimberley): Impact of rubbish on biodiversity

Goannas of the species *Varanus acanthurus* get their heads trapped in softdrink and beer cans (see Figure A.6.1).

“Cans are a perfect trap for many species as the ants go in after the sugar even after the residue has dried up and the animal goes in after the ants. Most of the victims hop or crawl off blindly into the bush to die.”

“I am still concerned about the dissapearance of *Varanus Mertensii* from the lower Fitzroy R. It is in plentiful supply on the pristine upper reaches of the river and at gorges throughout the sandstone country. As anyone who has swam in these gorges will tell you this species is very inquisitive and could easily fall victim to an aluminium can”.

There are large volumes of rubbish along the lower reaches of the Fitzory River from Fitzroy Crossing to King Sound (see Figure A.6.2). This rubbish ends up in the Fitzroy River during floods.

Figure A.6.1: Goanna with head trapped in can

Figure A.6.2: Rubbish in an area downstream of Fitzroy Crossing

Troy Sinclair (CALM): Rubber Vine (*Cryptostegia grandiflora*)

There was discussion of rubber vine (*Cryptostegia grandiflora*) in the workshop held by Sue Jackson on Thursday 16 February, however it was not discussed in detail during the workshop on Friday 17 February.

An outbreak of rubber vine was found at Willare Bridge in 2005. Rubber vine is a Weed of National Significance due to its ability to spread, invasiveness and economic and environmental impacts.

CALM are searching for outbreaks other than the Willare outbreak.

Keith Anderson (Jubilee Downs Station): Pastoral Perspective and Issues

Fencing is a major issue.

Jubilee Downs fence their property abutting the Fitzroy and Cunningham Rivers so stock don’t get into the river. Communities leave the gates open because of flooding. There is a need for rangers for fence management. Nobody is managing the influx of people onto the river (vehicles, pig shooting and fishing). Other pastoralists allow cattle to go down to the river because they don’t fence due to people not closing gates. This requires government management. Allowing cattle down to the rivers causes erosion.

Pastoral industry maintains a healthy environment in a lot of areas of the Fitzroy. The situation is alot better than in 1960s when cattle numbers were high.

In two decades the riverbank vegetation has gone down hill but the Fitzroy is still a healthy river. There is alot of *Noogoora burr*.

The barrage is an impediment to the natural flow. In years of low flow, wildlife can’t get upstream. Saltwater fishes are unlikely to be getting up to Fitzroy Crossing.

In the future, what has happened at Camballin will happen everywhere. Keith is against damming the Fitzroy River but can see the possibilities of the Magaret River being dammed (it may be beneficial).

Tanya Vernes (WWF): Ecological Assets

Other assets that have been previously recorded that could be included are:

1. Mangrove communities

Storey, A.W., Davies, P.M. and Froend, R.H. (2001) *Fitzroy River System: Environmental Values*, Report for Waters and River Commission, pp.63.

- 15 species of mangroves are found within this region, most diverse and dense stands of mangal are found near the mouth of the Fitzroy River
- 17 species of bird have been recorded in King Sound mangroves in the vicinity of the Fitzroy estuary
- There have been few detailed surveys of waterbird usage of the Fitzroy River estuary and King Sound
- Unlike most mangrove systems which are aggrading, the mangroves of the Fitzroy estuary are eroding, and gradually retreating inland. This gives the system intrinsic scientific interest

- Discharge from the Fitzroy River modifies the salinity of the estuary, with the system being fresher during the wet season; this undoubtedly influences the ecology of the system, but the extent to which this occurs is unknown.

2. Waterbirds (especially those listed under JAMBA/CAMBA)

Halse, S. & Jaensch, R. (1998) *Waterbirds and other fauna of the Fitzroy river and associated wetlands*. Limnology of the Fitzroy River, WA: A technical workshop. Proceedings of a workshop held on 18th Feb 1998 at Edith Cowan University, Claremont, WA

For listings of natural heriatge criteria (rare species etc for Fitzroy), another reference to include for Camballin Floodplain:
Livesey, N. J. (1993) *Camballin floodplain and wetland system.* Supporting documentation for inclusion on the register of the National Estate. Report to the Australian Heritage Commission and the Heritage Council of Western Australia, June 1993.

Attachment 5 Tropical Rivers Project Newsletters, November 2005 and April 2006

TROPICAL RIVERS INVENTORY & ASSESSMENT PROJECT NEWSLETTER

November 2025

www.nctwr.org.au/publications/tropical-rivers.html

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Confluence of Magela Creek and East Alligator River, NT
(photo: C Camilleri)

For comment or suggestions on this newsletter, please contact:

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Communications Officer

Office of the Supervising Scientist

Ph: (08) 8920 1125

Email: jacqui.rovis-hermann@deh.gov.au

Tropical Rivers Inventory and Assessment Project

A project funded under Land & Water Australia's Tropical Rivers Program

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. Although these systems are considered public resources, they are increasingly subject to degradation, restrictions on access, and claims for development. For the vision of sustainable development in northern Australia to be effectively realised, a better understanding of the tropical river systems is required. A first step in the process to achieve this is to integrate existing data and information for the biophysical and socio-economic characteristics of the tropical rivers. To address this, the Australian Government (Land & Water Australia and The Natural Heritage Trust 2) has funded a National Rivers Consortium project titled '*Australia's tropical rivers - an integrated data assessment and analysis*'. The project is being conducted over two years (2004-2006) by the National Centre for Tropical Wetland Research (NCTWR), 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.

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Project Update Meeting, 21 November 2005 — Darwin

A TRIAP update meeting for project team members was held in Darwin, at the Supervising Scientist Division, on Monday 21 November. Team members from James Cook University and the University of Western Australia joined ***eriss*** staff to review the project status. The meeting was scheduled for a half day, however, the group built up good momentum, resulting in the meeting continuing for the whole day.

Some of the key outcomes included:

- Discussion of the major outputs for sub-project 1, including final GIS format for delivery to LWA and stakeholders.
- Outputs for the macroinvertebrate theme within sub-project 1, including multivariate analysis of distribution and geomorphic classification and contribution to the JCU macroinvertebrate Atlas in the area of mayflies and their habitats.

The next TRIAP team meeting will be held on Monday 6 February 2006 via video link-up.

Stakeholder Communication Activities

Milestone 4 Report to LWA Available

Project Milestone 4 Report was submitted to LWA in August. The report is available on the TRIAP web site under the Reports page. This Milestone report is focussed on the progress made on sub-projects 1 and 2 up until the report submission date and provides a good overview of the project.

Stakeholder Workshop Scheduled

In the March newsletter, there was a stakeholder workshop announcement. There were two options outlined for workshop. One option was to hold the workshop in conjunction with Riversymposium in Brisbane. The other option was to hold a workshop in Townsville around the same time. Due to logistical and resourcing problems, the workshop was unable to be convened at this time.

The stakeholder workshop is now being scheduled for May 2006 and will take place in north Queensland, at a location to be advised. Stakeholders will be notified late January/early February 2006 of the details of this workshop.

Fitzroy River (WA) Stakeholder Consultations

Stakeholder consultation plans are currently underway for the Fitzroy River (WA). It is hoped that consultations will occur in February 2006, in conjunction with CSIRO consultations. The TRIAP consultations will be specifically related to sub-project 2 (the risk assessment component).

For further stakeholder related communications, see the *Linkages with other Tropical Rivers Projects* section of this Newsletter.

Publications and Presentations

Publications relating to the TRIAP will be made available on the web site on the Reports and Publications web page. Presentations, with no formal paper appearing in conference or workshop proceedings will be made available on the same web page in MS-PowerPoint (or pdf) format.

Recent Publications

Lowry, J. and Alewijnse, M. (2005) 'Integration of Data for Inventory and Assessment of Australia's Northern Rivers', *Proceedings of the North Australian Remote Sensing and GIS Conference*, Darwin, 4-7 July, 2005.

Moliere, D., Boggs, G. and Lowry, J. (2005) 'Spatial Analysis of Stream Runoff Response in the Tropical Rivers Region', *Proceedings of the North Australian Remote Sensing and GIS Conference*, Darwin, 4-7 July, 2005.

Van Dam, R. and Bartolo, R. (2005) 'Australia's tropical rivers: an integrated data assessment and analysis', *RipRap-River and Riparian Lands Management Newsletter*, 28: pp. 15-16.

Lowry,J., Bartolo, R. and Alewijnse, M. (2005) 'Integration of Data for Inventory and Assessment of Australia's Northern Rivers', *Proceeding of SSC 2005 Spatial Intelligence Innovation and Praxis: The National Biennial Conference of the Spatial Sciences Institute*, September, 2005. Melbourne: Spatial Sciences Institute, pp. 953-962.

Recent Presentations

Finlayson, M., Lukacs, G., Lowry, J., van Dam, R., Bartolo, R. and De Groot, R. (2005) 'Benchmarking Northern Australia's Rivers Before Further Degradation-Practical Approaches and Constraints', *International Riversymposium*, Brisbane, 6-9 September, 2005.

van Dam, R., Finlayson, M., Lowry, J., Bartolo, R. and Lukacs, G. (2005) 'Benchmarking the attributes of Northern Australia's tropical rivers-The basis for informed management decisions', *Water in the Bush*, Austalian Water Association – NT Branch Annual Conference, Darwin, 20 October.

Representation at Upcoming Events

ANCID Annual Conference

October 2006 in Darwin

The Annual Australian National Committee on Irrigation and Drainage (ANCID) Conference 2006 will be held in Darwin. ANCID have invited the NCTWR to present a paper at the conference on the outcomes of the TRIAP. The ANCID Annual Conference 2005 was held recently in Mildura, Victoria between 23-26 October. Further information on ANCID and the Annual Conference is available at:

www.ancid.org.au

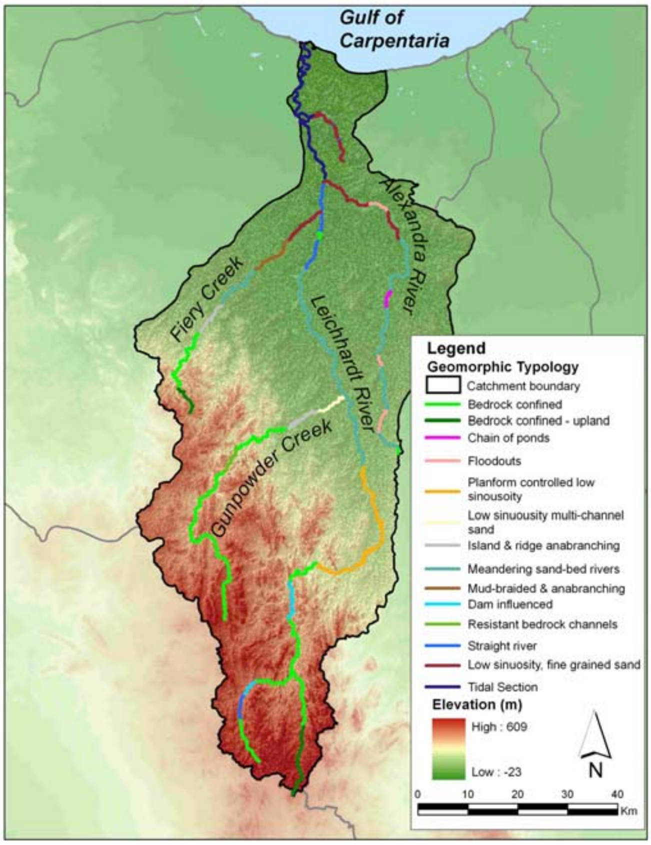
Update on TRIAP sub-projects

Sub-project 1: Inventory of the biological, chemical and physical features of aquatic ecosystems

The project team are currently working on implementing a geomorphic classification at both the continental and focus catchment scales. Following the geomorphic classification mini-workshop that was held in July, an approach for this component of sub-project 1 was agreed upon internally and with stakeholders such as Dr Andrew Brooks, and was accepted by LWA. The classes applied at the focal catchment scale are subcomponents of the broader classes developed for the whole of the project area. The two classifications thus fit within the overall hierarchical framework of the project.

The compilation of relevant spatial data in a GIS is continuing. Coupled with this is the metadata compilation and reporting. A process for metadata quality checking and reporting is currently being finalised.

Key activities over the next couple of months will be centred on developing a methodology for the application of an ecological typology to the various themes.



Geomorphic classification for the Leichhardt catchment, QLD

The timeline for this sub-project has been recently extended, and it is now due for completion by the end of May 2006.

Sub-project 2: Assessment of the major pressures on aquatic ecosystems

Renee Bartolo (formerly the Communications Officer) has taken up a position in coordinating sub-project 2, which is now well underway. Initial documentation of the ecological assets and threats across the broader project region and the focus catchments is near completion. This information will be subject to stakeholder comment/feedback on the key assets and threats for the focus catchments, prior to the risk assessments progressing to the next stage.

Early in 2006 the conceptual models for the key assets and threats in each of the focus catchments will be developed. These models will drive the subsequent semi-quantitative and targeted quantitative risk analyses. Sub-project 2 is scheduled for completion by the end of September 2006. As components of the risk assessment are completed, they will be made available to stakeholders through the TRIAP web site.

Sub-project 3: Development of a framework for the analysis of ecosystem services provided by aquatic ecosystems

The final draft synthesis report for sub-project 3, *Integrated assessment of wetland services and values as a tool to analyze policy trade-offs and management options: A case study of the Daly and Mary River catchments in northern Australia*, was submitted to LWA in August.

The main task of this (pilot) project was to develop a comprehensive framework to analyse ecosystem services provided by wetlands in the Northern Territory. Such a framework has been presented as a part of the report. The framework was used to analyse the goods and services provided by wetlands in the Daly River and Mary River catchments. The main results were summarised in six Masters thesis reports, with the key components and outcomes being integrated into the synthesis report. Further access to data on ecosystem services valuation can be found on www.naturevaluation.org.

We are awaiting comments on the draft report from LWA, after which Max Finlayson (International Water Management Institute) and Dolf deGroot (Univeristy of Wageningen) will undertake final edits and provide a final report. The final copy will be made available to stakeholders through the TRIAP web site.

Linkages with other Tropical Rivers Projects

Cross-Project Communication through Regular Meetings

There are numerous projects underway or proposed that are focussed on tropical rivers. With the various programs and many ideas resulting from this research activity, researchers/staff of TRIAP, Northern Australian Irrigation Futures (NAIF), Charles Darwin University and the NT Department of Natural Resources, Environment and the Arts (NRETA) working in this area realised there is a need to communicate with each other regarding their research and examine ways of increasing efficiencies in research effort. The mechanism for achieving this is to have regular meeting of key project leaders in the major tropical rivers projects.

The regular meetings are designed to share knowledge, ensure relevant linkages between projects are built through regular communication and minimise duplication. One key aspect that the meetings will address, is the coordinated approach by the the various projects in engaging stakeholders, particularly in the NT's Daly River catchment. A summary of the meetings will be posted on relevant websites to inform the wider community of the outcomes (check out the TRIAP website in the near future for summaries).

Further information about the various projects can be found at the following web links:

NAIF: www.clw.csiro.au/naif/

TRIAP: http://www.nctwr.org.au/publications/tropical-rivers.html

NRETA: http://www.nreta.nt.gov.au/whatwedo/dalyregion/index.html

Charles Darwin University: http://www.cdu.edu.au/ser/WaterResearchConsortium.html

http://www.cdu.edu.au/ehs/research/TEDS/land_clearing.html

TROPICAL RIVERS INVENTORY & ASSESSMENT PROJECT NEWSLETTER

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Fitzroy River at Willare Bridge, WA

For comment or suggestions on this newsletter, please contact:

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Tropical Rivers Inventory and Assessment Project

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Fitzroy River Stakeholder Workshop, 17 February 2006 Derby, WA

On Friday 17 February, a TRIAP stakeholder consultation was convened in Derby, WA, at the King Sound Resort. The workshop focused on the ecological assets/values and associated pressures and threats for the Fitzroy River. The main objective of the workshop was to agree on the key ecological assets and threats and to prioritise these. Renee Bartolo from the Department of the Environment and Heritage's Supervising Scientist Division and John Dowe from the Australian Centre for Tropical Freshwater Research (located at James Cook University, QLD) ran the workshop. Fourteen people attended the consultation, with the majority representing the indigenous stakeholders of the region.

Sue Jackson from CSIRO held a consultation the previous day centred on social and economic values of tropical rivers in the Kimberley Region as part of an LWA project funded under their Tropical Rivers and Social and Institutional Research Programs. Forty people attended this consultation.

The information gained during both consultations has been exchanged bewteen both the projects. It was a productive and successful trip where we were able to obtain the information required for the current stage of the risk assessment project. A follow-up visit is planned for late May/early June.

An interim workshop report has been distributed to Fitzroy River stakeholders and is available along with the workshop presentation from the TRIAP web site at http://www.nctwr.org.au/publications/tropical-rivers.html. Stakeholders have started providing valuable feedback that will be incorporated into the report.

Our thanks go to all the people who attended the workshop and who have provided feedback. Special thanks go to the Kimberley Land Council staff for organising people to attend the workshop and in providing advice in the lead up.

Upcoming Stakeholder Consultations

Flinders River Catchment, QLD

A community consultation workshop to agree on the key ecological assets and threats to the rivers of the Flinders catchment is being held in Richmond on Tuesday 9 May. The venue is the Ammonite Inn and the workshop time is 12:00-5:00pm with lunch and afternoon tea included. For catering purposes, please RSVP by Friday 5 May to John Dowe (ph: (07) 4781 5654 or e: john.dowe@jcu.edu.au).

Daly River Catchment, NT

Stakeholder consultations for the Daly River catchment will be taking place over the next couple of months. A number of mechansims will be used to distribute information including through the Australian Goverenment NRM facilitator and land management facilitators in the region. If stakeholders state that there is a need for a formal workshop to examine assets and threats within a risk assessment framework, this will be accomodated. The TRIAP is conscious of over-consultation in this region.

Upcoming Presentations

Publications and presentations relating to the TRIAP will be made available on the web site on the Reports and Publications web page. Presentations, with no formal paper appearing in conference or workshop proceedings will be made available on the same web page in MS-PowerPoint (or pdf) format.

SWS/AMSA "Catchments to Coast"
9-14 July 2006 in Cairns

M Alewijnse, J Lowry, G Lukacs, M Saynor and J Dowe "Australia's Tropical Rivers – a Multiple Scale Inventory for Resource Management and Risk Assessment" .

9th International River*symposium*
4-7 September 2006 in Brisbane

W Erskine, M Saynor & J Lowry "Classification of Australian Tropical Rivers to Predict Climate Change Impacts"

30th Hydrology and Water Resources Symposium
4-7 December 2006 in Launceston

D Moliere, J Lowry, G Staben & C Humphrey "Flow characteristics of streams in the tropical rivers region"

Ecological Risk Assessment Workshop, 20-21 February Sydney

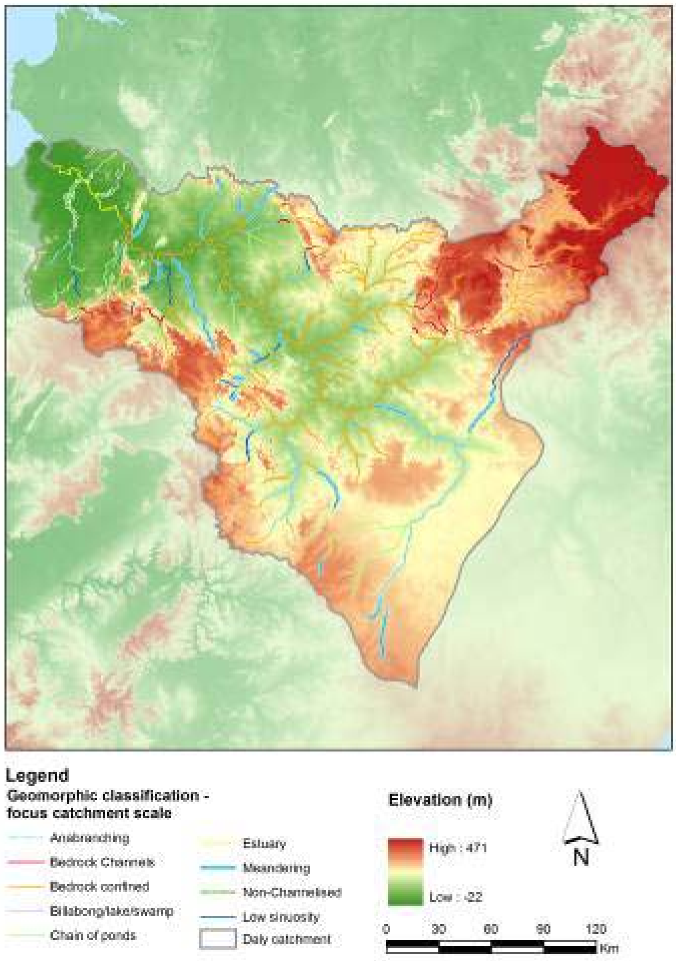
During February 20-21, three members of the sub-project 2 risk assessment team attended the IEWS Ecological Risk Assessment course held in Sydney. The course was run by Barry Hart and Carmel Pollino from the Water Studies Centre at Monash University. We were fortunate to be able to have the TRIAP Fitzroy River risk assessment used as a case study by the course participants. Carmel demonstrated the construction of a Bayesian network framework for threats to riparian vegetation in the Fitzroy using Netica. The course was extremely useful and provided us with a framework by which to complete the TRIAP risk assessment project.

Update on TRIAP sub-projects

Sub-project 1: Inventory of the biological, chemical and physical features of aquatic ecosystems

The Geomorphology team (Wayne Erskine and Mike Saynor) have developed and applied a geomorphic classification scheme for application at the focus catchment scale. Using 1:250,000 drainage data , Landsat imagery, and the wonders of Google Earth, they have enhanced the earlier continental-scale geomorphic classification and applied it to each of the focus catchments (the Fitzroy, Daly and Flinders). A significant feature of the focus-catchment classification is that it 'nests' within the broader continental scale classification, enabling focus-scale classes to be 'lumped' at the broader continental scale. Conversely, broad scale geomorphic classes may be split, into more detailed geomorphic classes at the focus catchment scale.

In addition to the ongoing collation of data, a key task undertaken by sub-project 1 has been the creation, and collation of metadata for each of the datasets which have been collated. 'Metadata' is simply information about information. It describes, amongst other things, when data was created, who created it, how it was created, and what it was intended to be used for. Consequently, metadata is an extremely important means of managing data. Collating metadata on the existing datasets is one of the key outcomes of the project.



Focus catachment scale geomorphic classification for the Daly River catchment, NT.

The biophysical data from this sub-project is currently being collated. The intention is to have the data compiled within a GIS on CD/DVD by mid-June. We have had several discussions with the Department of the Environment and Heritage relating to the form of the final product.

Sub-project 2: Assessment of the major pressures on aquatic ecosystems

Work has progressed on a document summarising the assets and threats to the broad tropical rivers region, and in increased detail for the focus catchments. The overview, proposed framework and methodologies for ecological risk assessment of key threats to northern rivers document, is near completion. This contains a definition of terms used in the TRIAP risk assessment.

The conceptual models for the focus catchments have been discussed amongst the project team and are at varying degrees of being drafted. We are currently in the process of compiling a risk assessment GIS so that the spatial analysis can begin.

Project team meetings have been held regularly and will continue to be held. Documents will be made available on the TRIAP web site and stakeholders will be notified of their availability via email.

Sub-project 3: Development of a framework for the analysis of ecosystem services provided by aquatic ecosystems

Max Finlayson (International Water Management Institute) and Dolf deGroot (University of Wageninen) are currently making final amendments to the Final Draft Report of this sub-project that was submitted to LWA last October. When completed, it is anticipated the report will be made available on the TRIAP web site.

Meetings with other Stakeholders

Cross-Project Communication Regular Meetings

The cross-project communication meetings which are attended by researchers/staff of TRIAP, Northern Australian Irrigation Futures (NAIF), Charles Darwin University (TRACK) and the NT Department of Natural Resources, Environment and the Arts (NRETA) have continued with a meeting held in February and one in April. Meeting summaries are posted on the TRIAP web site.

Meeting with LWA

On Friday 24 February, TRIAP project leaders met with Brendan Edgar of LWA to discuss project progress and associated issues. Items discussed included the timeline for completion of sub-project 1 and options for an extension, the risk assessment methodology to be applied to the focus catchments and options for incorporating a northern Australian (ie. study area) overview of threats to aquatic ecosystems. Earlier in February, George Lukacs met with Nick Schofield of LWA, in Canberra.

Meetings with the Department of the Environment and Heritage (DEH)

Over the last few months, representatives of the TRIAP have met with the Coasts and Water Branch and Environmental Resources Information Network (ERIN) from DEH. The Coasts and Water Branch (one of the end users of the TRIAP products) provided advice on the form of the final product and what should be included. ERIN is the likely repository for the data generated from this project and has a useful technique to determine the length of forested rivers/streams from satellite data.