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INTEGRATION OF DATA FOR INVENTORY AND ASSESSMENT OF AUSTRALIAS NORTHERN RIVERS

John Lowry[1], Renee Bartolo[1] and Mirjam Alewijnse[2]

[1]Supervising Scientist Division, Department of Environment and Heritage

[2] Australian Centre for Tropical Freshwater Research, James Cook University

email Renee.Bartolo@deh.gov.au

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ABSTRACT

Australia's tropical rivers and wetlands face renewed interest and pressures from multiple sources. 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. An information base is being established for assessing change, undertaking ecological risk assessments of major pressures, supporting local and indigenous management, and strengthening holistic approaches for managing tropical rivers/wetlands at multiple scales eg regional, catchment or individual habitat.

In this paper, we describe the spatial component of a project being conducted under Land & Water Australia's Tropical Rivers Program, which aims to better inform natural resource managers and decision-makers about the status of rivers in northern Australia. The specific project under the Tropical Rivers Program we are addressing is 'Australia's tropical rivers- an integrated data assessment and analysis'. This paper outlines the approach used to address sub-project 1, an inventory of the biological, chemical and physical features of aquatic ecosystems. The method undertaken was to implement a multiple-scale inventory of the habitats and biota of the rivers, floodplains and estuaries of northern Australia using information from a variety of sources. This has been achieved through a framework that was developed within Australia and has been subject to international critique and acceptance. This primary source of information for populating the framework was the integration of remote sensing imagery and GIS datasets at different scales (e.g. biogeographical, catchment and site scales) for mapping purposes. This information will be used to make an initial assessment of the diversity, status and ecological value of aquatic ecosystems across the region. Using this approach, the inventory data we have collected will be used to illustrate known areas of biodiversity importance and importantly, gaps in information.

BIOGRAPHY

Renee Bartolo is the Communications Officer for the Department of the Environment and Heritage's Supervising Scientist Division located in Darwin. As part of her role, she does communications for the Tropical Rivers Inventory and Assessment Project. Renee is a spatial scientist, having recently submitted her PhD on remote sensing of paperbark trees on tropical floodplains. She is co-founder of GecOz, a start-up company specialising in Synthetic Aperture Radar applications and has over seven years experience in research using spatial science tools and developing spatial technology based solutions. Through her research, Renee has specialised in the use of spatial technologies for tropical wetland applications, both in Australia and in Indonesia and Papua New Guinea. Renee is currently a director of the Spatial Sciences Institute and a member of the SSI Young Professionals National Committee.

1. INTRODUCTION

The rivers and wetlands of northern Australia (figure 1) are, by Australian standards, relatively undisturbed with a high degree of biodiversity and endemism [Finlayson *et al* 1997., Finlayson *et al.,* 2005, Gehrke *et al.,* 2004]. However, these environments are increasingly subject to degradation, restrictions on access, and development pressure from activities and industries as diverse as mining, pastoralism, tourism, agriculture, fisheries and aboriginal enterprises [Land and Water Australia, 2004]. Consequently, there is a clear need for detailed, consistent information on the ecology, biology, geomorphology, hydrology and management opportunities across the region. Whilst some detailed environmental information does exist, primarily for those catchments where mining, industrial or intensive agricultural development are proposed or undertaken [eg Begg *et al.,* 2002, Faulks, 1998a], most of the information is fragmented, and insufficient for addressing the management needs of the future [National Land and Water Resources Audit, 2002]. Areas in which knowledge gaps exist include information on the:

- Ecological character of tropical rivers/wetlands – the biological, chemical and physical components, ecological processes, and ecosystem services provided by these habitats
- Opportunities and threats to tropical rivers/wetlands – the management options and pressures on the ecological character, in particular environmental flows and key species, of these habitats

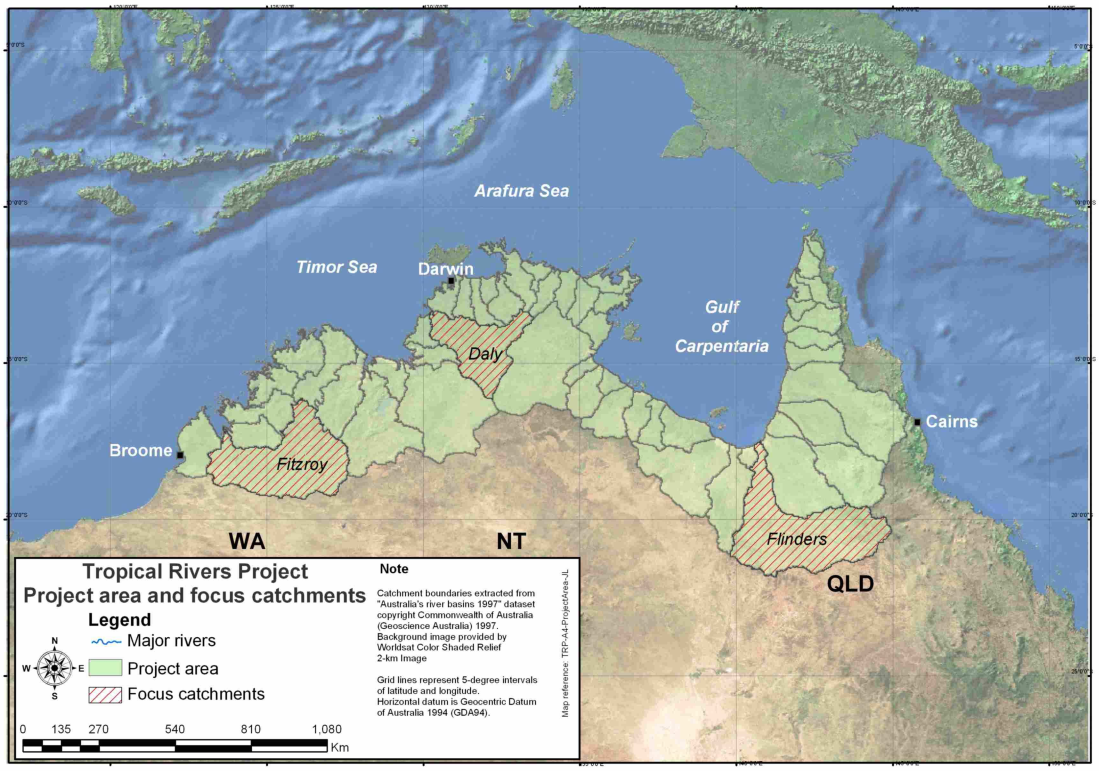

Figure 1 – Extent of project area

As part of a broader project funded by Land and Water Australia and the Natural Heritage Trust ("Australia's tropical rivers – an integrated data assessment and analysis"), a requirement has been identified for an information base which could be used to assess change, undertake ecological risk assessments of major pressures, and support and strengthen local and indigenous management of tropical rivers/wetlands.

We report here on the methods that we have developed to create an information base, and the steps used to develop base datasets which would be used to establish the ecological character of the rivers across the study area using an integrated and standardised spatial framework. It is intended that the information gathered in this project will be used to support future risk assessment activities, and support the development of management plans as part of the broader project objectives.

2. METHODS

2.1 Data integration and management

Due to the size of the study area (1,190,973 km^2) (Figure1), which extends across all catchments from the Kimberley in Western Australia, through the Top End of the Northern Territory, to the west side of Cape York in Queensland, a hierarchical, multi-scalar approach has been utilised to enable the collation and integration of information. The model has been adapted from that developed by Finlayson *et al* [2002] for the Asian Wetland Inventory (Figure 2), which enables the collation of data at a number of scales, with progressively more detailed information being collated as the scale of the data being collected progresses from continental (1:2,500,000) to focus catchment (1:100,000) to site specific (1:1,000).

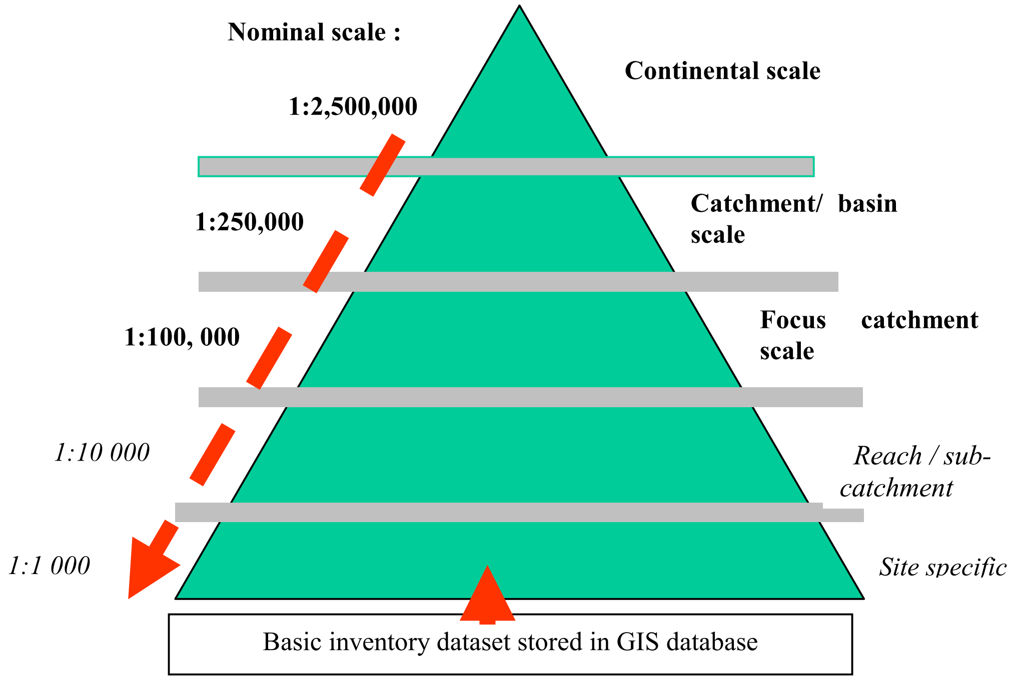

Figure 2 – Hierarchical approach used in the collation and integration of data.

For the purposes of this study, data is being collected across the study area at two scales:

- a broad, "continental" scale, with data collated to a nominal scale of 1:2,500,000
- a "catchment" scale, with data collated to a nominal scale of 1:250,000

In addition, data have been collated to a nominal scale of 1:100,000 for selected "focus" catchments. These catchments, listed in Table 1 with their corresponding catchment areas, were selected as being representative of those catchments which are experiencing increased pressures from multiple sources. It is intended that detailed ecological risk assessments will be undertaken in the next stage of this project for these catchments.

Catchment	Area (km^2)
Fitzroy	93,953
Daly	53,282
Flinders	109,714

Table 1: focus catchments of the Tropical Rivers Project

The data audit for Australia's Tropical Rivers [NGIS, 2004] provided a significant amount of information on the status, distribution and availability of data across the study area. However, in order to ensure that as many datasets were identified as possible, extensive searches of metadatabases maintained by the state and federal environmental and natural resource agencies across the study area was undertaken. In addition, liaison and consultation was undertaken with the respective data custodians to secure access to the data.

As data was identified, the suitability of the data for establishing the ecological character of the rivers was assessed by reviewing the available metadata. Key criteria included the spatial resolution (eg the scale to which it could be reliably applied) and distribution (eg its extent across the study area). For some data sets, such as hydrology, and faunal and floral observations, temporal resolution (how old the data was, and the frequency with which observations were made) was also a consideration. While broad-scale datasets that satisfied these criteria were integrated into the information base, datasets compiled to a scale of 1:100,000 or better were only selected if they fell into one or more of the focus catchments identified in Table 1.

Once the data was selected, it was integrated into a central database, using the eight step process shown in Figure 3. It is important to emphasise that the focus of this project was to utilise and integrate existing datasets wherever possible, rather than generating new datasets.

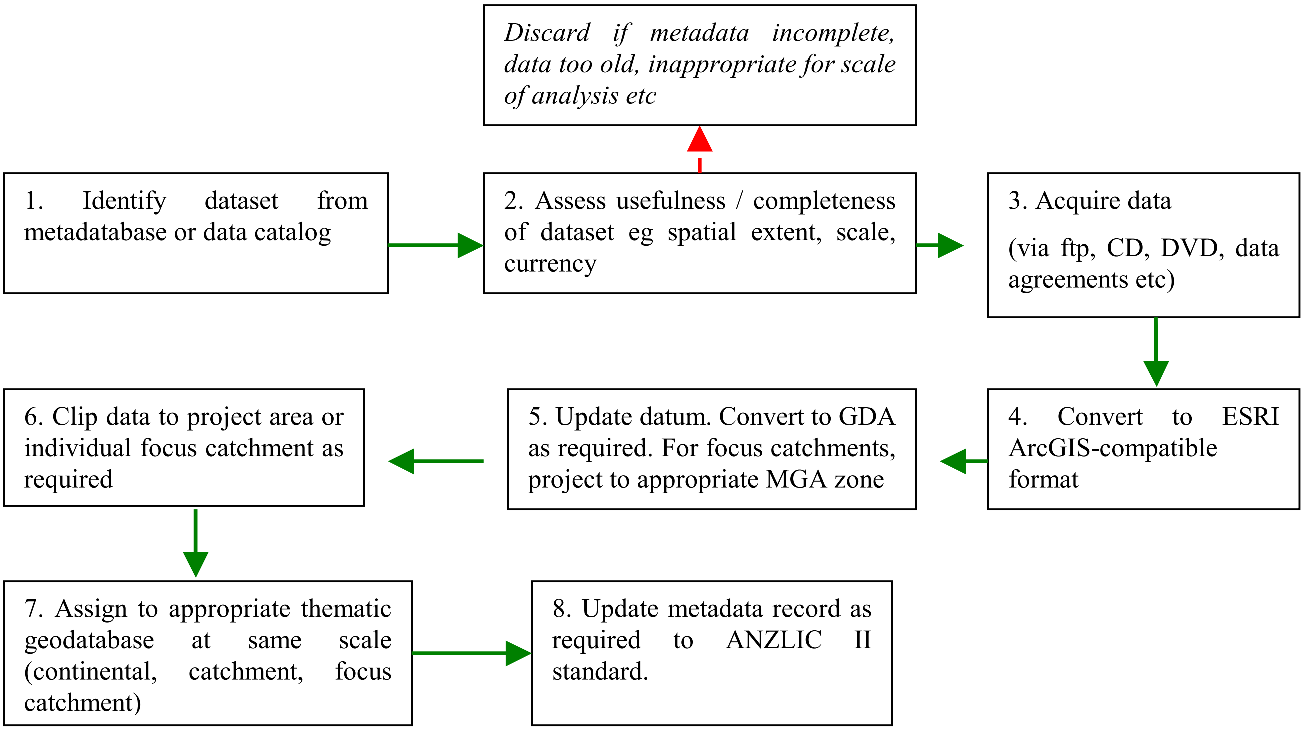

Figure 3 – Eight-steps of data integration

Datasets were managed using a hierarchical, multi-scalar structure, in which they were integrated into thematic geodatabases in the ArcGIS environment. Importantly, all datasets were converted to the Geocentric Datum of Australia (GDA94), and in the case of data collated for the focus catchments, projected into the relevant Map Grid of Australia (MGA) zones. In addition, all metadata records were created and updated using the ANZLIC II metadata standard.

To date, more than 50 different types of datasets (ranging from topographic to vegetation, faunal, landform and geological) have been collated, from a variety of state and federal agencies. Most of the data compiled to date have been at the broad continental and catchment scales. Over time we expect to focus on the collation of additional data for the specific focus catchments.

2.2 Creating base data - generating base hydrological layer

Fundamental to establishing the ecological character of the rivers in the project area was the creation of base datasets, which represented the range of geomorphic types or classes likely to be encountered along the major drainage features of the study area at both the broad catchment and focus catchment scales. The first requirement for these datasets was the delineation of the major drainage features at the respective

scales. As shown in Figure 4, the base drainage datasets were derived by cleaning, building and stream ordering existing topographic drainage datasets on a catchment-by-catchment basis.
As a starting point, the 1:250,000 drainage divisions produced by Geoscience Australia were used to delineate the individual catchments across the project area. For the broadscale dataset, encompassing the whole of the project area, drainage lines representing named drainage features were extracted from the 1:250,000 topographic data produced by Geoscience Australia for each catchment within the project area. Ancillary data, principally Landsat 7 imagery, were used to ensure the hydrological continuity of the drainage features. Polygon features representing a range of waterbody features (land subject to inundation, swamp etc) were also extracted from the 1:250,000 topographic data and used to compliment and aid in the identification of features representing the drainage lines.

For the three focus catchments, the base 1:250,000 topographic data generated for the broadscale drainage dataset was enhanced by combining it with Strahler 6th order drainage features extracted from the SRTM (Shuttle Radar Topographic Mapping) 3" digital elevation model (DEM). However, because the positional accuracy of the DEM-derived drainage features was noticeably reduced in areas of low relief, only those drainage features from high-relief areas of the DEM were integrated with the topographic data. Ancillary data, including Landsat 7 imagery, and aerial photographs where available, were also used to assess and validate the hydrological integrity of the drainage features.

When creating both base drainage datasets, it was necessary to 'clean' the topographic data to ensure that the linear features representing the major rivers were continuous, and then build them (removing dangling nodes/arcs), to ensure their topological integrity.

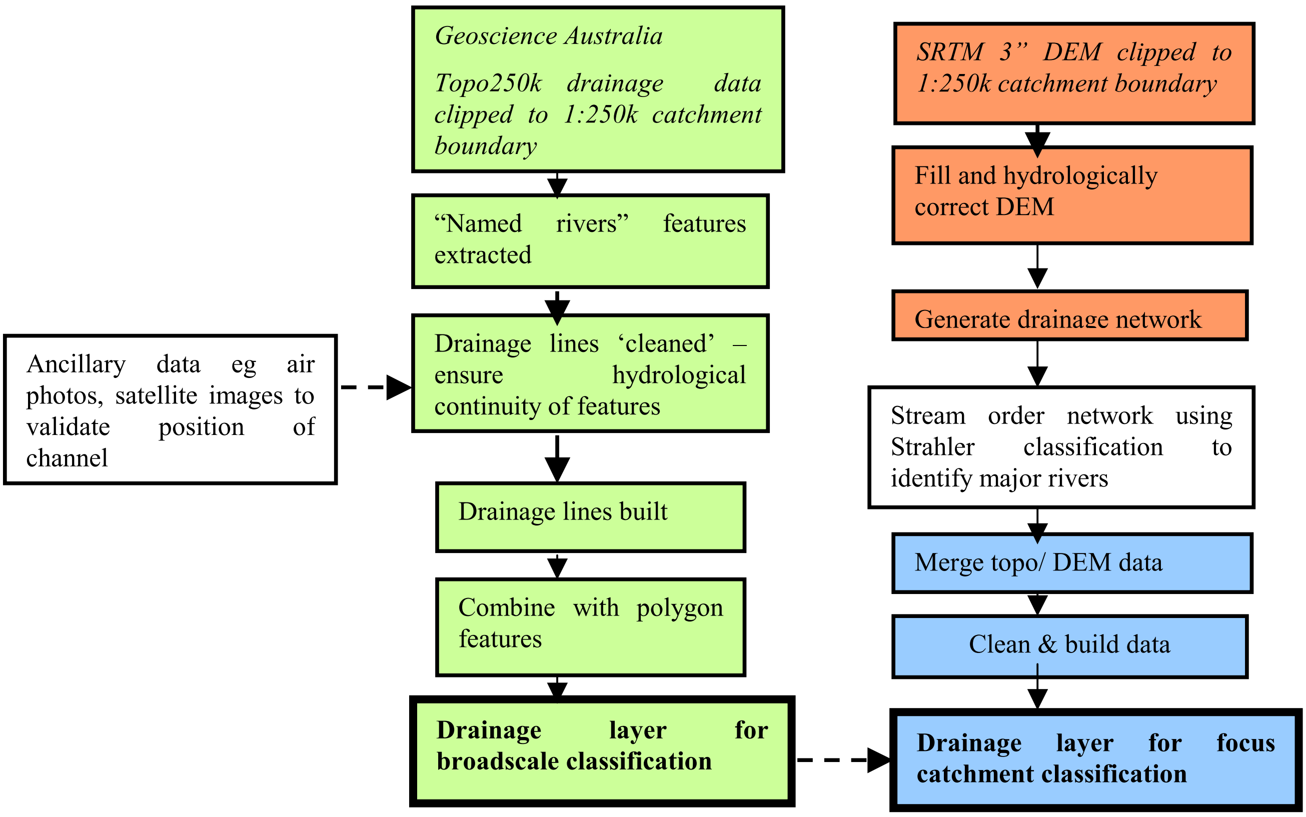

Figure 4 – Process for the creation of base drainage datasets.

2.3 Geomorphic classification and typology

The next stage of developing the base dataset used for establishing ecological character was to combine the base hydrological data with a geomorphic typology. Various methodologies/schemes/typologies have been used to describe the geomorphology of the rivers and catchments in the tropical parts of northern

Australia. These range from the CSIRO land system studies [Speck *et al.,* 1965; Story *et al.,* 1969, 1976; Twidale, 1966] to more general geomorphic studies on the Roper River [Faulks, 2001] and the Daly River [Faulks, 1998a, b] catchments. In addition, a geomorphic study, which includes a comprehensive geomorphic reach classification system is being undertaken for many of the Queensland Rivers that debouche into the Gulf of Carpentaria [Brennan *et al*., 2004].

Because of the hierarchical nature of this project, a need for two types of geomorphic classification has been identified – one suitable to be applied at the focus catchment (1:100,000) scale, and one suitable to be applied to the drainage features compiled at the broader, catchment (1:250,000) scale.

Importantly, 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. Table 2 lists the geomorphic classes which have been developed for the broad and focus catchment scales.

Broad scale classification	**Focus-catchment scale classification**
Bedrock channel	Bedrock channel
Bedrock confined	Bedrock-confined
Alluvial	Low sinuosity rivers
	Meandering rivers
	Floodouts
	Multiple channel rivers
	Wandering channel rivers
Lake / swamp	Non-channelised
	Swamp / waterbody dominated zone
Estuarine	Tidal

Table 2 – Broad scale and focus catchment geomorphic classes

By integrating elements of the report by Brennan *et al.,* [2004] , Erskine *et al.,* [2005] have developed a geomorphic typology which will be applied to the drainage features within each focus catchment. An important feature of this typology, as reflected in Table 2, is that classes applied at a focal catchment scale may be grouped within the framework of a broader classification. This broader and simpler classification will then be applied to the broad-scale drainage datasets produced for the whole project area.

The classifications will be applied to their respective broad scale and focus catchment datasets through the integration, querying and analysis of the geomorphic, geological, landform landsystem, vegetation and elevation datasets which had been previously collated at the different relevant spatial scales within a GIS environment. Elevation data derived from the 3" DEM has been used to distinguish channel slope and confinement, complimenting landsystem and geological data which identified the underlying lithology and structure of the substrate. The base drainage dataset identified the meandering and anabranching sections of the river, whilst land systems and topographic data identified potential areas of inundation and flooding. Using a process similar to that described in Begg *et al*., [2003], the waterlogging characteristics of the soil datasets will be queried to identify wetland areas. Table 3 illustrates some of the key spatial parameters which have been used to identify the different geomorphic types along a river.

An example of how the typology may be applied to the drainage features in a catchment is shown in Figure 5, with the Leichhardt as an example.

Importantly, the geomorphic typologies developed for this project will be compatible with those developed for the Murray Darling Basin, which focus on erosional, transport and depositional sections.

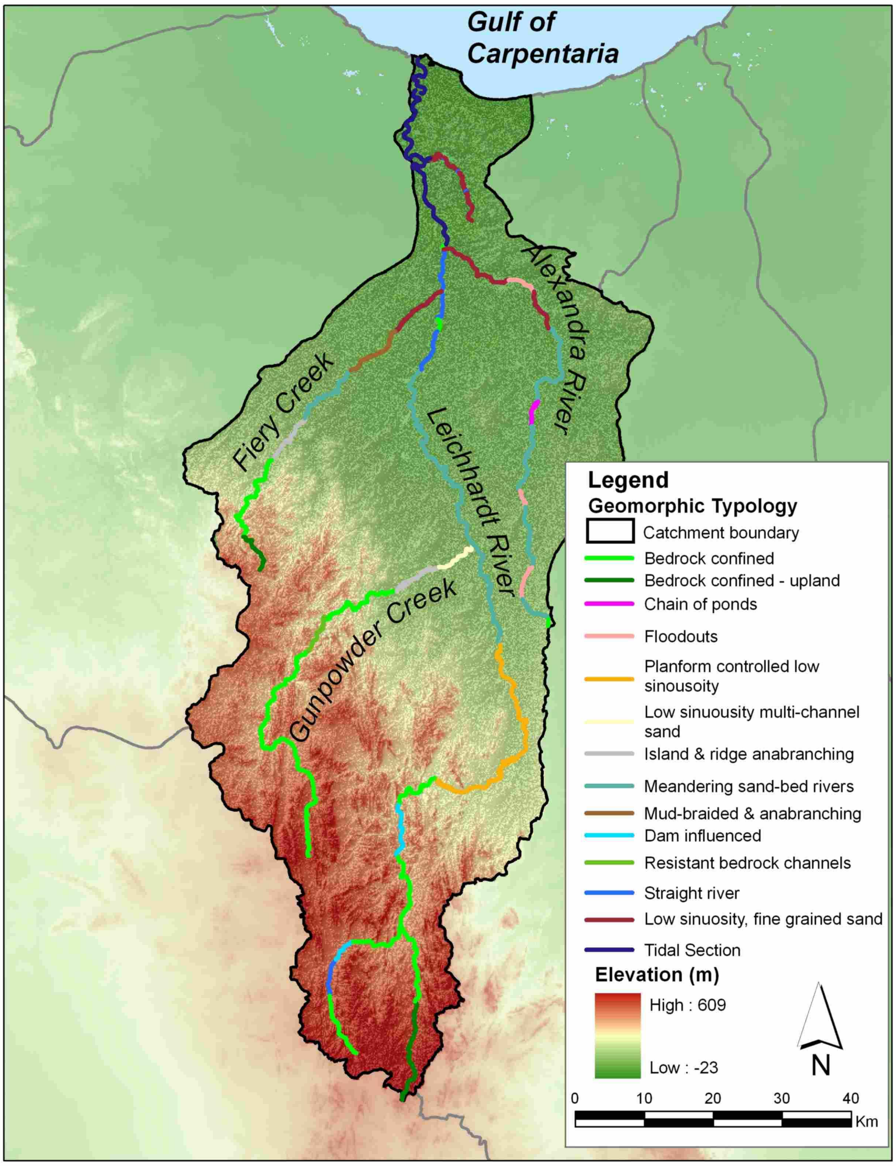

Figure 5 – geomorphic typology of the Leichhardt catchment

Geomorphic type	Features used for delineation
Bedrock channel (upland channels and gorges)	Elevation and slope from DEM , landform; optical imagery
Bedrock-confined rivers	Elevation, slope, contours from DEM; geology; optical imagery
Meandering rivers	Topographic data; drainage from DEM; optical imagery
Low-sinusity / straight rivers	Topographic data; drainage from DEM; optical imagery
Floodouts	Drainage data from DEM and topographic sources; optical imagery
Multiple channel rivers	Drainage data from topographic sources; optical imagery;
Wandering channel rivers (Mud braided and anabranching)	Drainage data from topographic sources; optical imagery
Freshwater wetlands, swamps, and non-channelised	Waterbody features from topographic data; waterlogging characteristics of land systems and soils data; vegetation data; optical imagery

Table 3 – Spatial parameters used to delineate geomorphic classes

2.4 Application of additional datasets to describe ecological character

With the geomorphic typology of the different reaches in the drainage datasets established, it is proposed that the ecological character of the rivers may be determined by overlaying the faunal and floral datasets collated earlier, that occur within a prescribed distance (eg 2 km) of the different geomorphic typologies represented along a watercourse. Figure 6 illustrates how the different datasets, such as vegetation may be overlayed, to identify the spatial distribution of key species relative to the different geomorphic types.

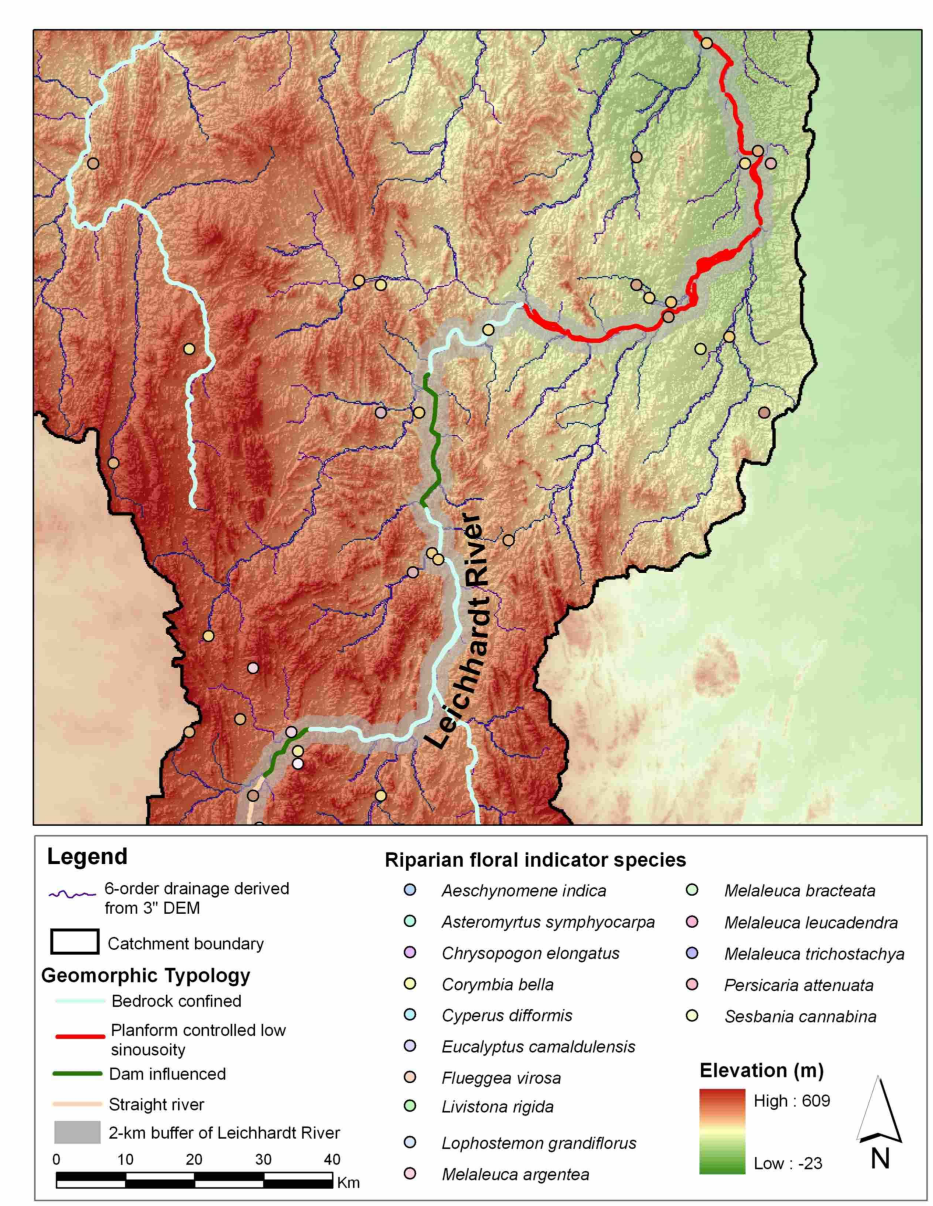

Figure 6 – integration of floral data with the base geomorphic typology

3. DISCUSSION

As noted at the outset, the objective of this work was to establish the methods for collating and integrating datasets which would be used to define the ecological character of rivers across northern Australia. These datasets are to be used to support risk assessment analyses and the development of management plans for the rivers.

We recognise that the collation of the data is an ongoing process, and will continue through the life of the project as additional datasets are created and/or acquired from other sources. We anticipate that much of the future collation will be for the specific focus catchments, as information required for risk assessments are identified. The selection of datasets is heavily dependant on the availability and completeness of metadata. We have found that a significant limitation has been the incomplete nature (or absence) of metadata for many datasets, and the periodicity with which metadatabases are updated and maintained. Consequently, a major task has been updating, and in some cases creating metadata records to ensure a consistent base for the project.

In addition to metadata quality, this project has identified that for many areas, the required data simply do not exist, particularly at the scale which could be applied to the focus catchments. Information which is not consistently available at this scale includes vegetation, soils, landuse, landform, faunal composition and distribution, and elevation. In the latter category for example, high resolution digital elevation data such as the 1" DEM is not available across the whole study area or for each of the focus catchments.

A further problem is the lack of consistency between dataset representing similar features. For example, while 1:250,000 geological information is widely available across the project area, the individual geological map sheets within the catchments use different terminology to represent the same features. This limits the ability to rapidly apply the geomorphic typology across the drainage features where the underlying geology is a determining characteristic.

It is important to emphasise that the development and application of the geomorphic classification is an iterative process. As additional datasets become available, they will be assessed to see if they can assist with the application of the geomorphic typology. Whilst we currently have only applied the typology to a selected catchment, once the typologies have been finalised at both the broad and focus catchment scales, we plan to apply them across the study area and focus catchments as appropriate.

We recognise the importance and value of field work and ground truthing interpreted data when preparing and cleaning base datasets, and in assigning the geomorphic classes to sections of the drainage lines. A significant element of planned future activities is the development and implementation of a field survey program to validate the results of the classification. However, through the integration and analysis of spatial data, we hope to be able to strategically plan and organise field work campaigns to identify priority areas requiring validation, thereby minimising the field work required.

Significantly, a standardised geomorphic classification has not been yet been applied to rivers across the breadth of the study area of this project – hence the information generated by this project will provide a significant resource to assist with reporting requirements at a broad scale across the region. Importantly, through the adoption of a hierarchical approach to the collation and integration of data, we will produce products that are suitable for use at specific scales – but which relate to products generated at multiple scales.

It is planned to continue collating and integrating data as it becomes available. A key goal in the short term is to complete the generation of base datasets, and the application of the geomorphic typology to rivers at both the broad and focus-catchment scale. Through the spatial framework established for this project, this information will be able to be used to establish the ecological character of the rivers, support risk assessments to the rivers, and extend analyses being done through other initiatives in tropical Australia.

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