INTEGRATION OF DATA FOR INVENTORY AND ASSESSMENT OF AUSTRALIAS NORTHERN RIVERS

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Abstract

Australia's tropical rivers and wetlands face renewed interest and pressures from multiple sources. As part of a broader program that's developing an integrated information base for the assessment of the ecological character of rivers in northern Australia, we have undertaken 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 information will be used to make an initial assessment of the diversity, status and ecological value of aquatic ecosystems across the region. Our approach utilises the multiple-scale model for inventory supported by the Ramsar Wetlands Convention. This approach integrates remotely sensed imagery and GIS datasets at different scales (e.g. biogeographical, catchment and site scales) for mapping purposes. Core and interlinked data sets necessary for describing the biological, chemical and physical characteristics of an aquatic ecosystem were compiled for each scale, and suitable habitat typologies developed. These typologies will provide a framework for predicting the possible occurrence of specific biota and habitats within previously unsurveyed areas. However, we recognize the need for further field sampling, particularly in those areas where biogeographical information for many aquatic species is not available. The inventory information collected in this study will provide information for policy and management implementation at multiple-scales eg regional, catchment, or individual habitat. Using this approach, the inventory data we have collected will be used to illustrate known areas of biodiversity importance and crucially, gaps in information.

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 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

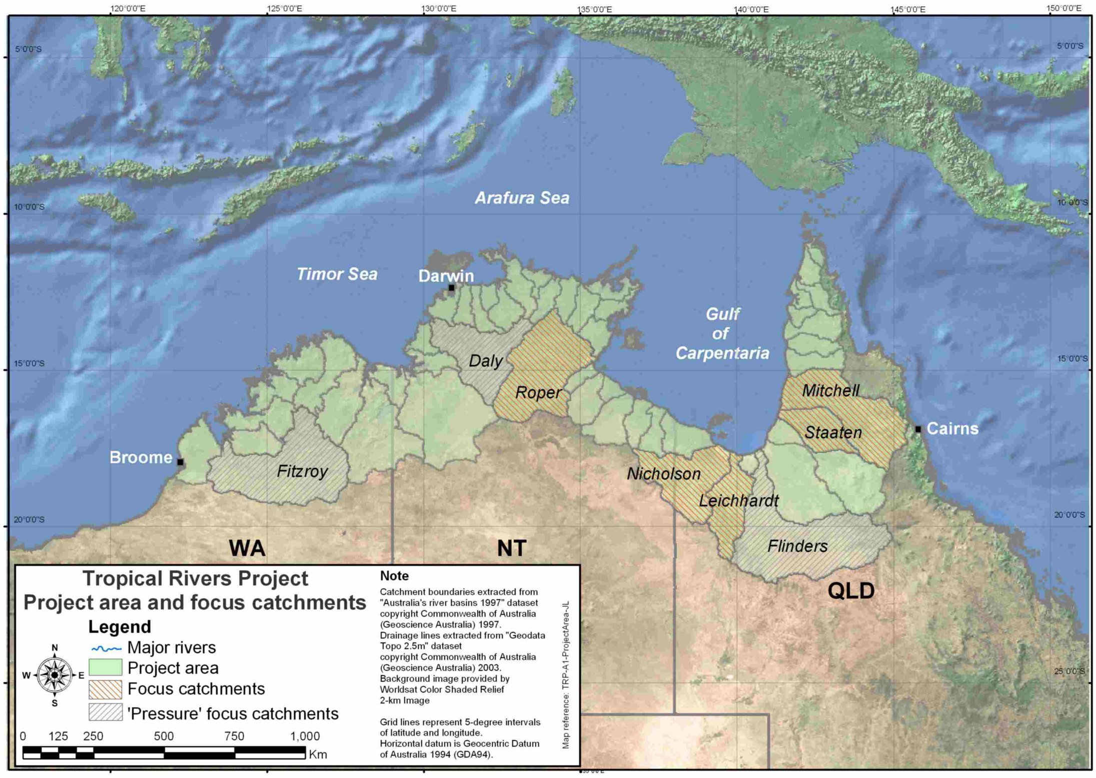

Figure 1 – Extent of project area

As part of a broader program 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 program objectives.

Methods

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 increases.

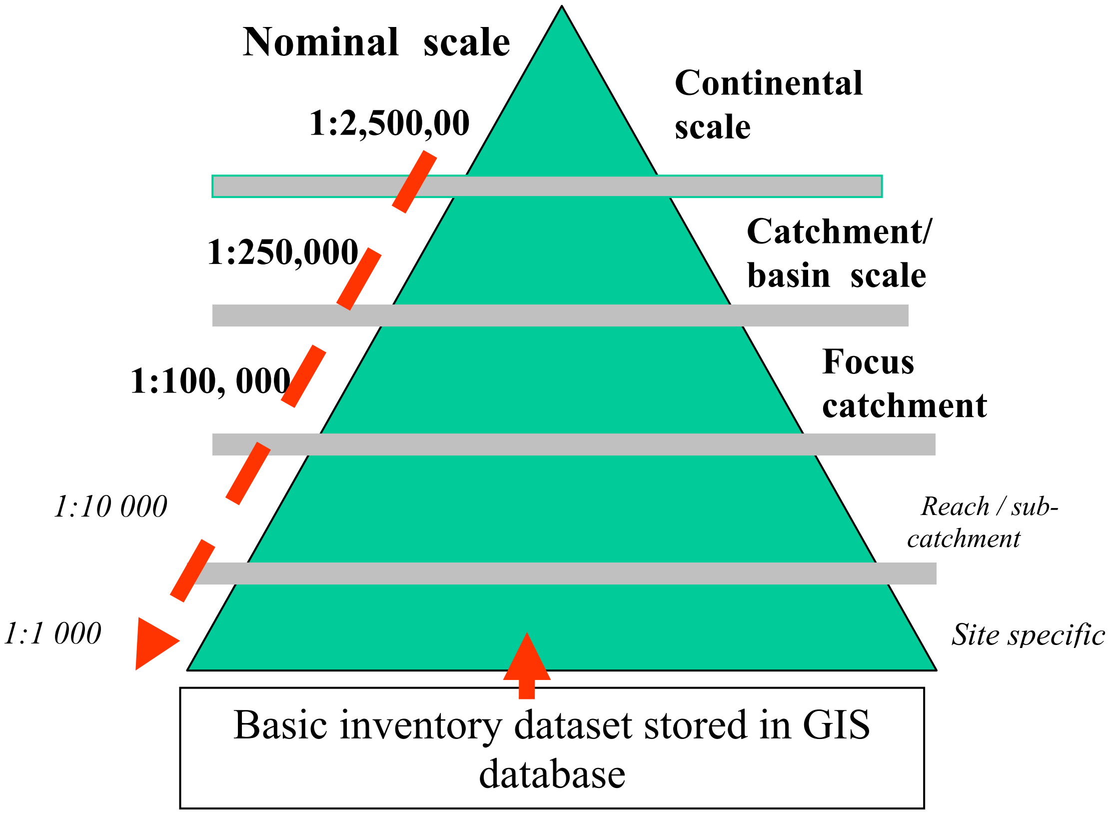

Figure 2 – Hierarchical approach used in the collation and integration of data.

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 which are experiencing increased pressures from multiple sources. Some of the “focus” catchments have been further categorised as “pressure catchments”, in which detailed ecological risk assessments will be undertaken in the later stages of this project.

Table 1: focus catchments of the Tropical Rivers Project

Catchment	Area (km^2)
Fitzroy*	93,953
Daly*	53,282
Roper	79,599
Nicholson	51,696
Leichhardt	33,287
Flinders*	109,714
Staaten	25,838
Mitchell	71,630

*Denotes a ‘pressure’ catchment

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.

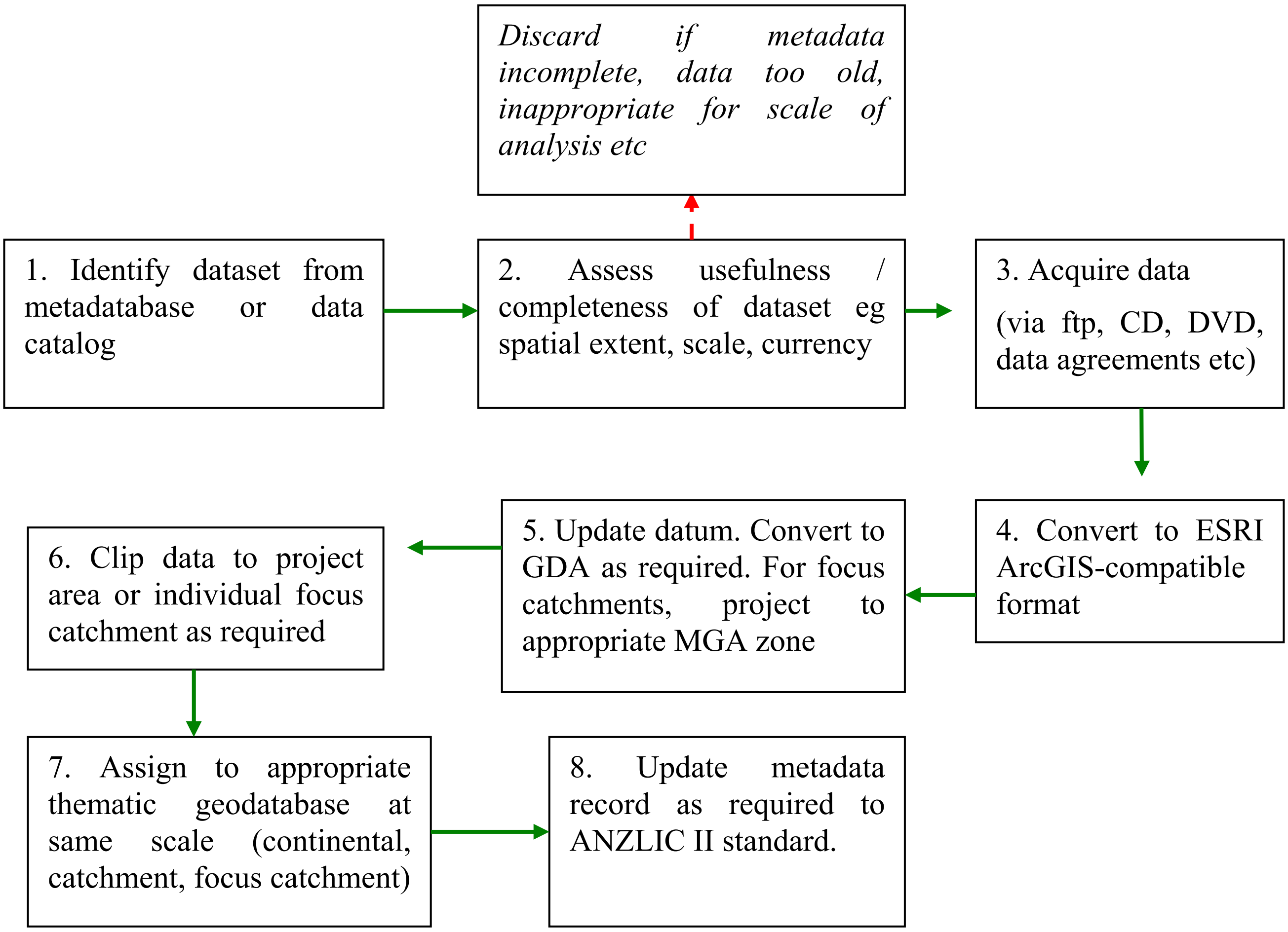

Figure 3 – Eight-steps of data integration

Datasets were managed using a hierarchical, multi-scalar structure, in which they were integrated into thematic geodatabases in the ArcGIS environment (figure 4). 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. The key datasets which have been utilized to identify the broad geological , landform, biological, floral and anthropogenic features of the project area are listed in Appendix 1.

Proposed directory structure - Tropical Rivers project

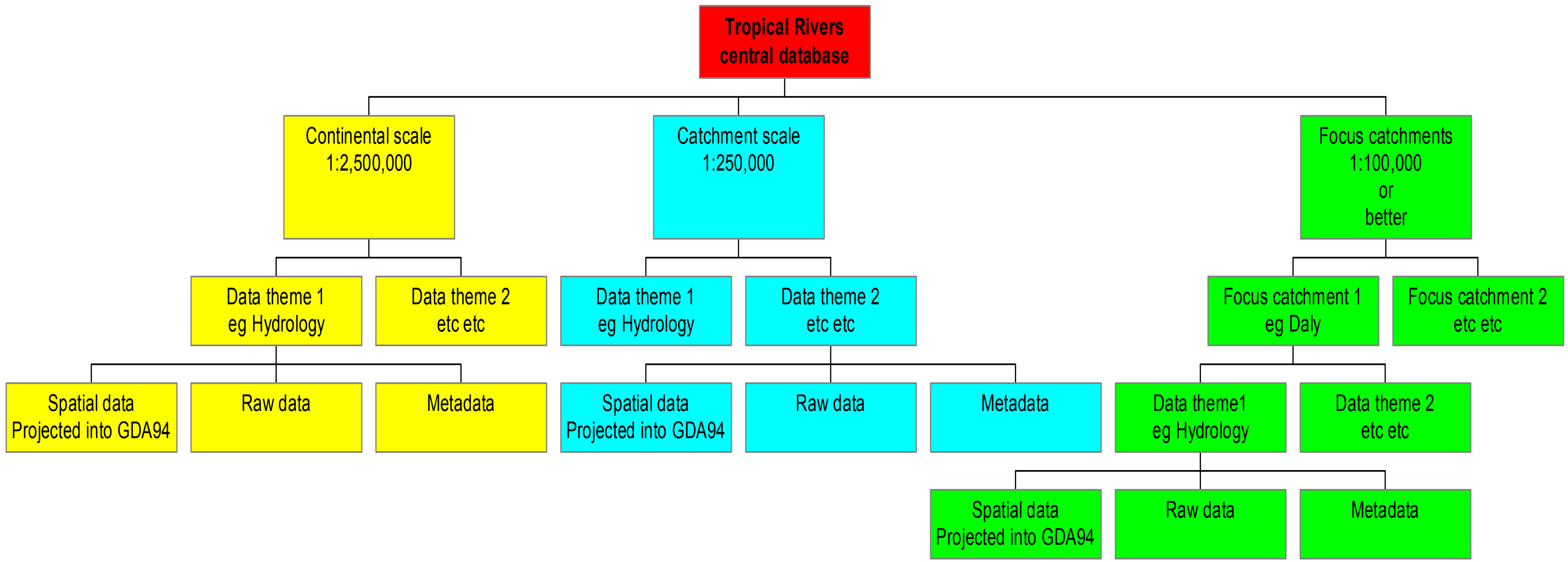

Figure 4 – directory structure

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 5, the base drainage datasets were derived by cleaning, building and stream ordering existing topographic drainage datasets on a catchment-by-catchment basis. For the broadscale dataset, drainage lines were extracted from the 1:250,000 topographic data produced by Geoscience Australia and used to delineate the key drainage features at the catchment scale, using the 1:250,000 drainage divisions dataset produced by Geoscience Australia . The 1:250,000 topographic data, complimented by drainage extracted from the SRTM (Shuttle Radar Topographic Mapping) 3" digital elevation model (DEM) of Australia was used to define the drainage features of the focus catchments. In both instances, 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.

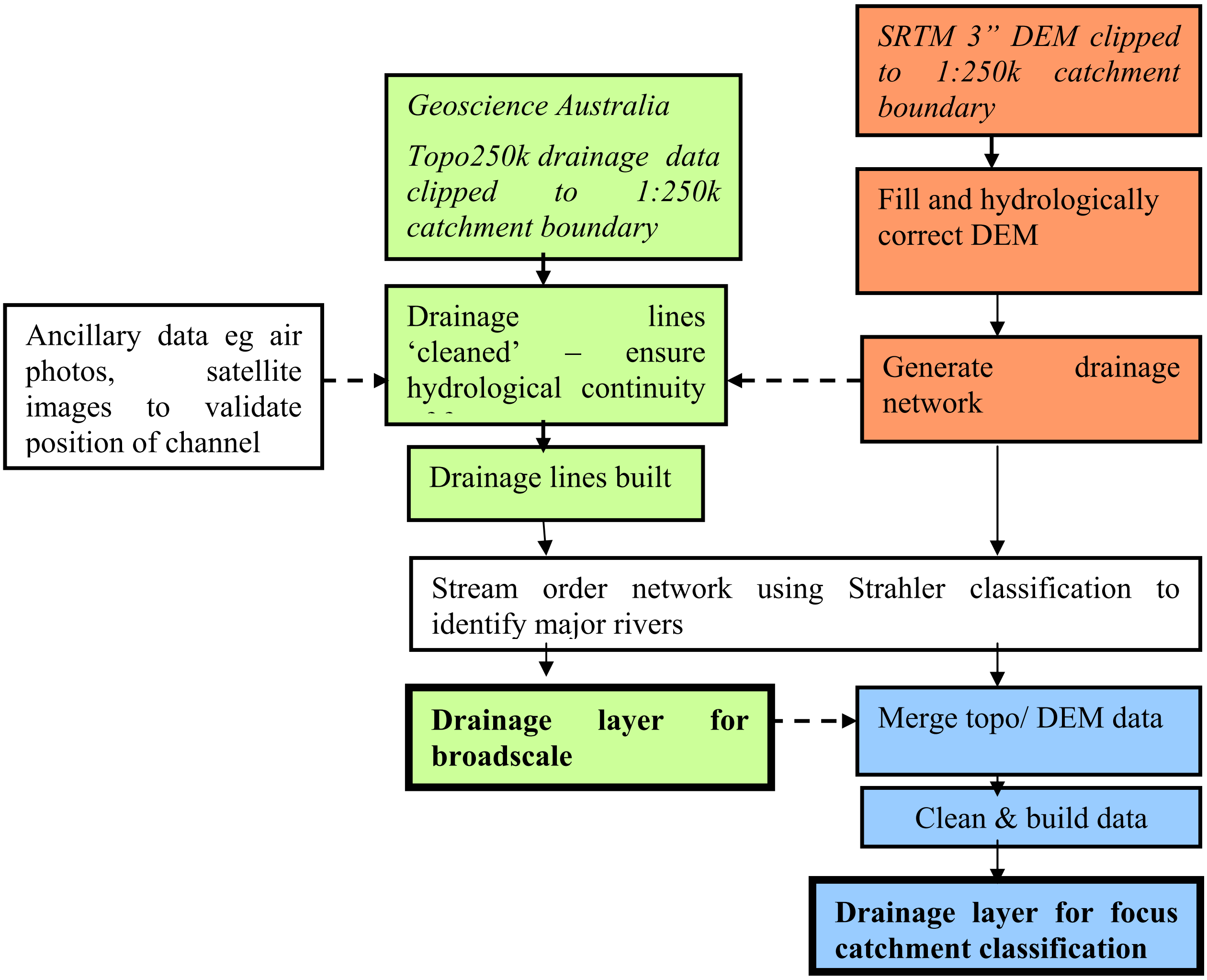

Figure 5 – Process for the creation of base drainage datasets.

Drainage generated from the 3”DEM was used along with aerial photographs and satellite imagery (where available) to complete the drainage features as required. In the case of the focus catchments, the drainage detail provided by the DEM was merged with the topographic data to provide enhanced drainage information in the areas with significant relief.

The drainage lines that were built for both the broadscale and focus catchment classification were stream ordered and classified using the Strahler classification system. Because of the complexity of the drainage patterns in the individual catchments, only drainage features with a high stream order eg >6 were extracted to form the base drainage layer for classification.

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 & Gardiner 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.

Integrating elements of the GAR report, Erskine et al 2005 have developed a geomorphic typology which will be applied to the drainage features within each focus catchment. By integrating, querying and analyzing the geomorphic, geological, landform landsystem, vegetation and elevation datasets which had been previously collated for the focus catchments within a GIS, it was possible to extract and delineate features which could be used to identify the different reaches within a focus catchment. Elevation data were 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. Table 2 illustrates the key spatial parameters used to identify the different geomorphic types along a river.

Excluding estuaries, the typology recognizes eight different river types, ranging from upland channels and gorges, to bedrock confined, to meandering rivers, straight rivers, floodouts, island and ridge anabranching rivers, mud-braided and anabranching, to extensive freshwater wetlands and billabongs. An example of how the typology may be applied to the drainage features in a catchment is shown in Figure 6, with the Leichhardt as an example. A similar, albeit simpler typology, is in the process of being developed for the broader scale drainage classification. Importantly, both typology classes will be compatible with those developed for the Murray Darling Basin, which focuses on erosional, transport and depositional sections.

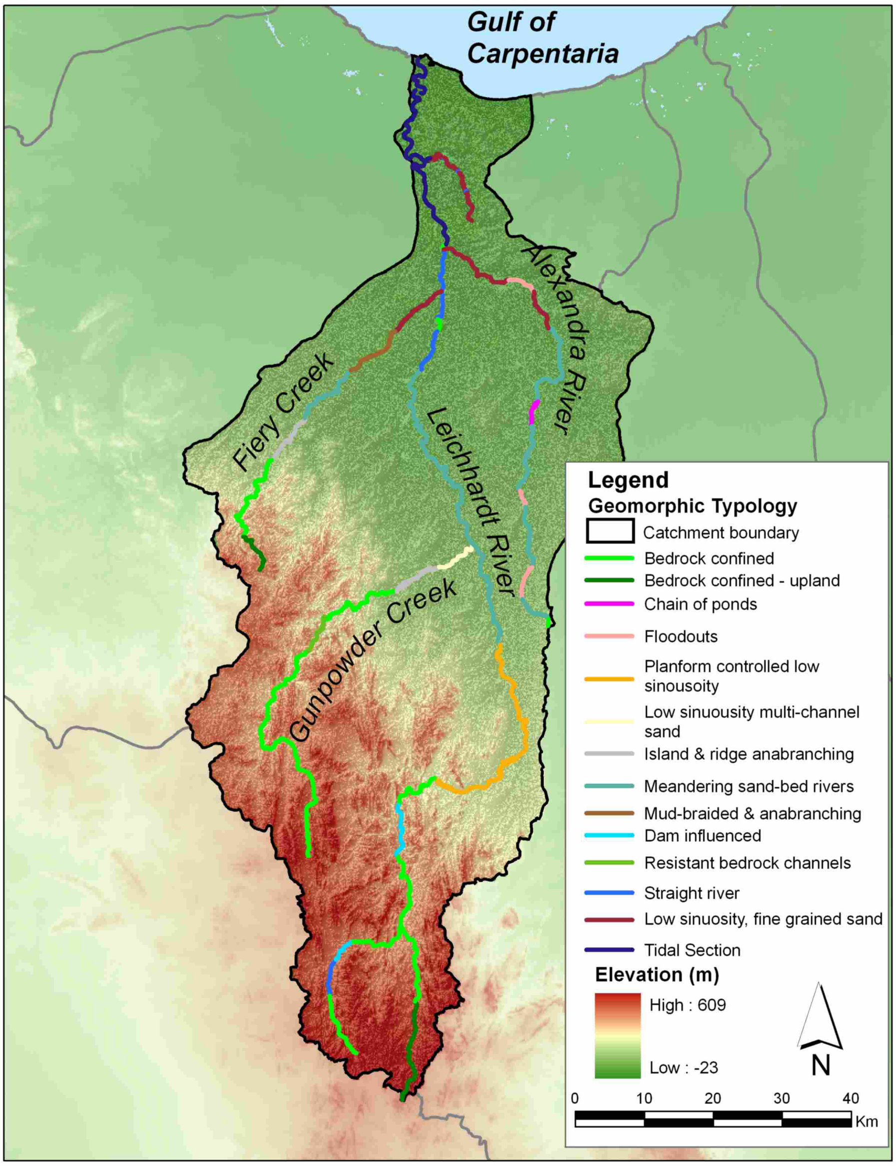

Figure 6 – geomorphic typology of the Leichhardt catchment

Table 2 – Spatial parameters used to delineate geomorphic classes

Geomorphic type	Features used for delineation
Bedrock rivers (upland channels and gorges)	Elevation and slope from DEM , landform
Bedrock-confined rivers	Elevation, slope, contours from DEM; geology
Meandering rivers	Topographic data; drainage from DEM
Straight rivers	Topographic data; drainage from DEM
Floodouts	Drainage data from DEM and topographic sources
Island and anabranching rivers	Drainage data from topographic sources;
Mud-braided and anabranching rivers	Drainage data from topographic sources;
Freshwater wetlands and billabongs	Waterbody features from topographic data; waterlogging characteristics of land systems; vegetation data

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 7 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.

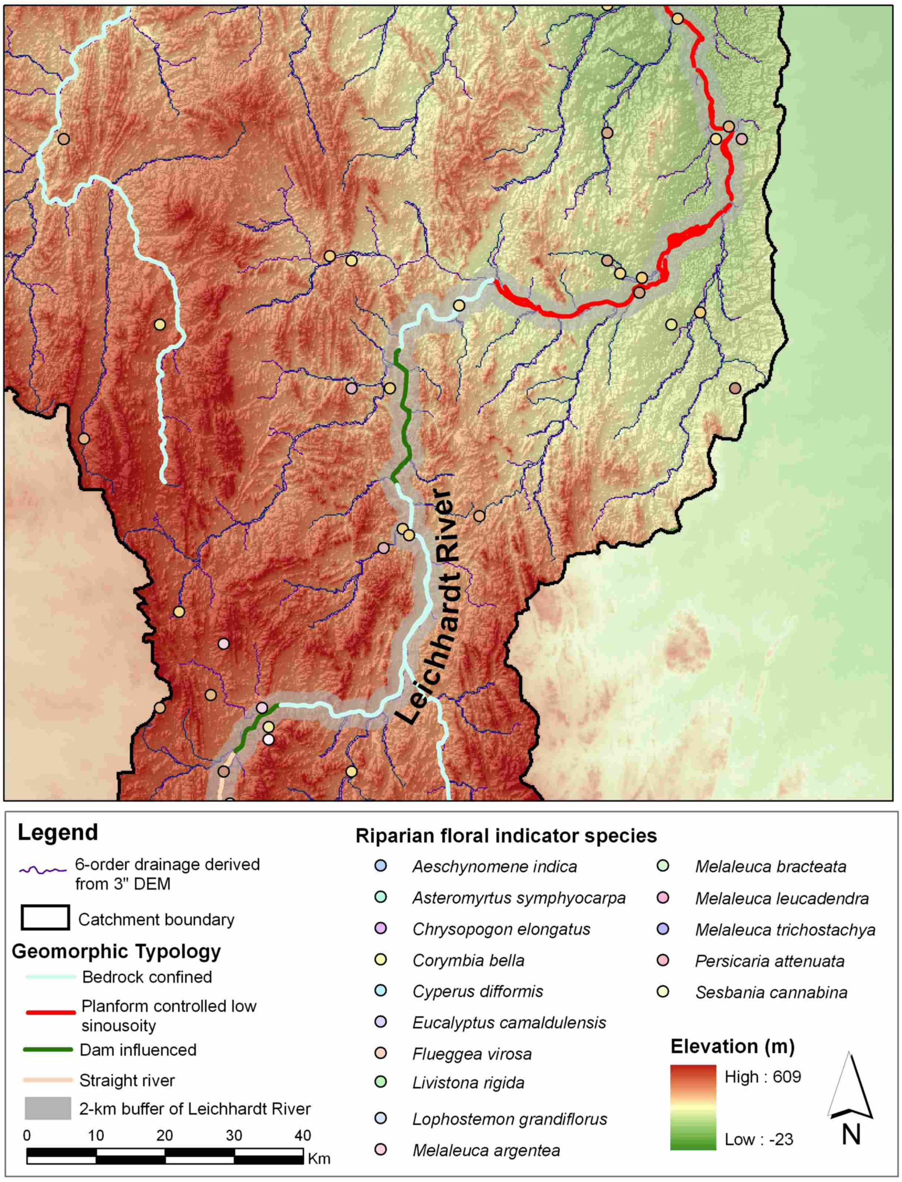

Figure 7 – integration of floral data with the base geomorphic typology

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, and thence 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.

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 (figure 8). This limits the ability to rapidly apply the geomorphic typology across the drainage features where the underlying geology is a determining characteristic.

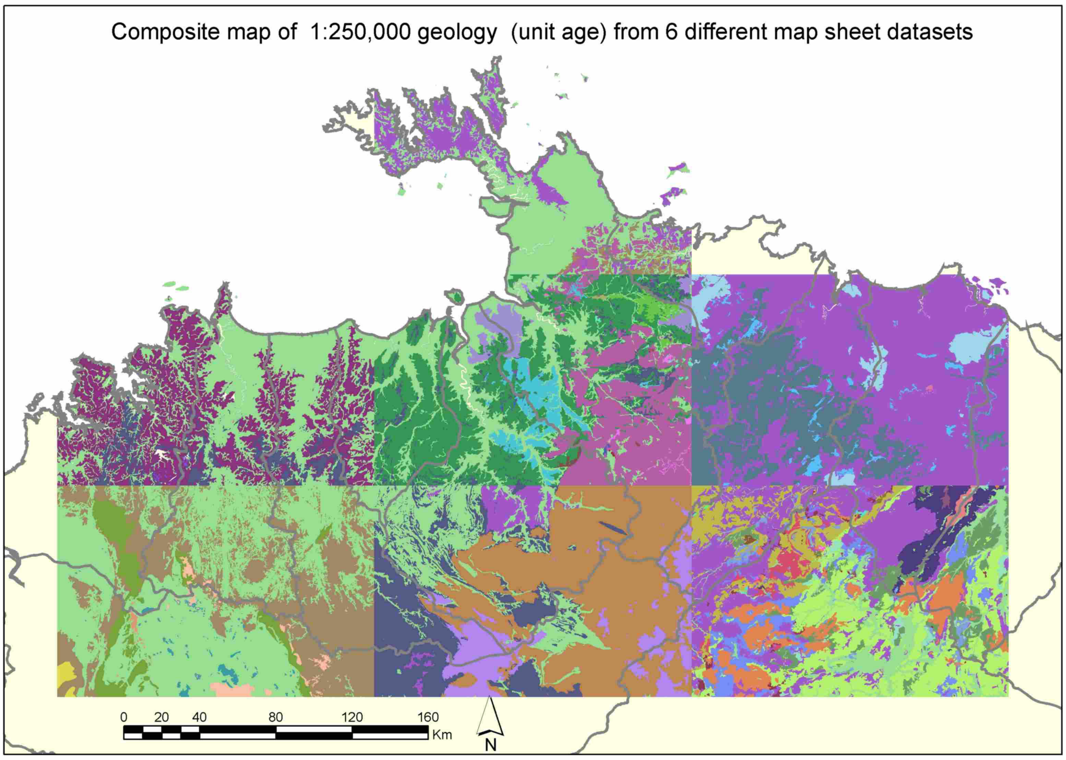

Figure 8 –representations of similar geological formations on different map sheets.

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 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.

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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Appendix 1 - List of key datasets*used to generate base datasets (as at 23/3/05).

* full list of datasets not shown. Data collation is ongoing and subject to change.

Theme	Dataset name	Published scale	Year published	Extent of study area for which data available	Custodian	Data format	Notes
Infrastructure	Geodata Topo 250,00	1:250,000	2003	Whole (100%)	Geoscience Australia	ArcInfo point and linear features coverages/ shapefiles	Includes roads, tracks, railways and localities
Drainage	Geodata Topo 250,000	1:250,000	2003	Whole (100%)	Geoscience Australia	ArcInfo linear features coverages/ shapefiles	
Climate	Gridded mean annual and monthly rainfall for Australia (30 year period)	-	2004	Whole (100%)	Bureau of Meteorogy	ArcInfo GRID format	
Vegetation	CRC Savannas Vegetation map	1:1,000,000	2001	Whole (100%)	Queensland Herbarium	ArcInfo coverage/ shapefile	

	National Vegetation Information System (NVIS) - Pre-European and Present Native Vegetation (Published Data - Stage 1, Version 2) National Land & Water Res Audit	1:1,000,000	2003	Whole (100%)	DEH	ArcInfo polygon coverage	
	National Vegetation Information System (NVIS) - Major Vegetation Groups - version 1.0		2001	Whole	DEH	Arc/Info GRID coverage	
Geology	Geology of Australia	1:250,000	Varies	Whole (100%)	Geoscience Australia	ArcInfo coverage / shapefile	
Geomorphology / landform	A relative relief and landform description map of Australia	1:2,500,000	2000	Whole (100%)	DEH	ArcInfo coverage / shapefile	
Catchment boundaries	Drainage basins and boundaries	1:250,000		Whole (100%)	Geoscience Australia	ArcInfo polygon coverage	Same as used in the land and Water Audit

	(Australia WRC drainage divisions and boundaries)						
Wetlands	Directory of Important Wetlands in Australia	1:250,000	2001	Whole (100%)	DEH	ArcInfo coverage / shapefile	
Hydrology	Directory of river gauging and rainfall stations across Australia	-	2004	Whole (100%)	Bureau of Meteorology with contributions from state agencies	Database files (*.dbf), able to be imported into ArcInfo or databases	
Fauna	AusRivas Macroinvertebrate database	-	2004	Whole (100%)	DEH	Access Database	Includes information on taxa, collecter, dates, location
	Atlas of Australian Birds	-	2004	Whole (100%)	DEH	Access Database	Includes information on taxa, collecter, dates, location
	OzCAM (Australian Museums on-line faunal database	-	2005	Whole (100%)	Various state museums	Database files (*.dbf) imported to ArcView shapefile format	Includes information on taxa, collecter, dates, location
Flora	IBIS (Integrated Botanical Information System	-	2005	Whole (100%)	DEH (Australian National Botanic Gardens)	Database files (*.dbf) imported to ArcView shapefile format	Includes information on taxa, collecter, dates, location

	Australian Virtual Herbarium	-	2005	Whole (100%)	Various state herbaria – Council of the heads of Australian Herbaria	Database files (*.dbf) imported to ArcView shapefile format	
	Remnant vegetation	1:100,000	2004	QLD regions only	Qld EPA (Queensland Herbarium)	ArcInfo polygon coverages	
Elevation	3” Digital Elevation Model of Australia`	3 arc-seconds (90m resolution)	2004	Whole (100%)	Geoscience Australia	ArcInfo GRID	
	1” Digital Elevation Model	1 arc-second (30m resolution)	2002	66%	DIGO	DTED Level 2	
	Geodata Topo250K	1:250,000	2001	Whole	Geoscience Australia	ArcInfo coverage (point files)	
Misc	Australia - Assessment of River Condition (Reach and Basin)	1:250,000	2001	Whole	DEH	.dbf file for reaches and basins. ArcView shapefile for reaches and basins	

	Northern Territory Land Systems survey	Variable 1:250,000 – 1:500,000	2002	60% of NT area only	NT DIPE	ArcInfo polygon coverage	
	Australia - Landscape Health Database 2001	1:250,000	2001	Whole	DEH	Arc/Info polygon coverage	