

2 Environmental assets

Information layers representative of the environmental assets being monitored in the ARR are presented with a focus on freshwater wetland systems. From this perspective, wetlands of northern Australia, including the ARR, are considered far less disturbed relative to those elsewhere in Australia. These wetlands, and especially those in Kakadu National Park (KNP) and the surrounding ARR, have immense ecological, cultural and aesthetic significance. The high natural value of these ecosystems and diversity and abundance of waterbird species they support are some reasons why these wetlands have World Heritage³ (UNESCO 1972) status and are listed under the Ramsar⁴ convention (Bellio et al 2004a&b).

Spatial information relating to the quality and character of these environmental assets come from: a) aerial surveys that document the distribution and abundance of waterbirds; and b) maps of native vegetation communities of the freshwater floodplain and terrestrial environments. Potentially, vegetation mapping allows for the capacity of specific habitats to support native fauna to be measured. When used in conjunction with information relating to the extent and severity of degradation (such as weed distribution), the relative loss of particular habitats can be assessed. While this concept is useful for conservation management, it should be noted that the quantitative relationship between habitat surface area and population size is only known for a limited number of species (Leuven & Poudevigne 2002). Animals also often use different habitat patches across different stages in their lifecycle. Furthermore any mapping exercise should account for the seasonal dynamism and changes exhibited by wetland vegetation of the region. Some floodplain resources (eg *Oryza meridionalis*) are only available seasonally and this has implications for monitoring vegetation. That is, seasonal changes in vegetation distribution need to be accounted for in any vegetation monitoring exercise before change due to anthropogenic factors can be measured (Finlayson 2005). Map sampling effort should therefore include strategic timing of remote sensing captures and coincident ground validation surveys to characterise key vegetation community states.

2.1 Waterbirds

Floodplains of the ARR have both national and international conservation significance by providing seasonal refugia for large aggregations of native and migratory waterbirds (Bellio et al 2004b). Waterbirds are also highly valued by Aboriginal people as a traditional food source where hunting and gathering is still practiced in modern-day Aboriginal society. Additionally, the diversity and abundance of waterbirds is a major asset for Kakadu's tourism industry.

Considerable effort has been devoted to monitoring the distribution and abundance of waterbirds in the ARR and the Top End (eg Bamford 1988, 1990, Morton et al 1990a&b, 1991, 1993a&b, Bayliss & Yeomans 1990a&b, Saalfeld 1990, Chatto 2000, 2001, 2003, 2006 PWCNT 2003). Given the links between the distribution and abundance of waterbirds and habitat condition, waterbird population indices provide a basis to assess the health of wetland ecosystems.

³ UNESCO International Convention Concerning the Protection of the World Cultural and Natural Heritage (see also <http://whc.unesco.org/en/conventiontext/>)

⁴ Bureau of the Ramsar Convention on Wetlands. The Convention on Wetlands signed in Ramsar, Iran in 1971 is an intergovernmental treaty that provides the framework for national action and international cooperation for conservation and wise use of wetlands and their resources (see www.ramsar.org).

These datasets fall under the following categories:

- Standardised sample counts via systematic aerial surveys: predetermined, regularly spaced, transect lines sampled using fix-winged aircrafts for different seasons and years. Seasonal distribution and relative abundance of waterbirds are then determined. This includes an ongoing monitoring program to map colonial nesting areas of magpie geese and has enabled indices of habitat suitability to be determined for this species;
- Ground count surveys: total counts of birds observed at selected sites. Seasonal distribution and relative abundance of waterbirds are then determined; and
- Opportunistic counts via aerial surveys: surveys in which the main aim is to collect general information on wildlife (waterbirds, shorebirds, turtles, dugongs) distribution and occurrence across the Top End. All records are point records rather than records relating to an area. Estimates of densities or comparison across seasons or years are not possible with this data. Nevertheless, these surveys enable the identification of sites of high waterbird abundance and diversity.

Magpie geese are widely distributed across Top End wetlands. However the historical range of the magpie goose across Australia has contracted by about half its original distribution. For this reason this species has 'near threatened' listing under the EPBC Act (Garnett & Crowley 2000). Historical records of magpie goose abundance and distribution in the ARR were examined for current ecological risk assessment of the Magela Creek floodplain. Standardised aerial count data were used and surveys undertaken in 1982–83 (by Morton & Brennan) were compared with those conducted in 2001–2003 (by Bayliss & Saalfeld), providing a 20 year period to assess relative change. Across this period a distinct downward trend in abundance of magpie geese is apparent for the floodplain.

Because of the wide distribution of magpie geese, causal mechanisms for the observed decline on the Magela floodplain remain unclear. Population fluctuation in waterbird populations, similar to those reported above, also occurred at a broader scale across the Top End and have been linked to decadal variation in rainfall patterns (Bayliss et al 2006). Nevertheless, declines may also be due to either habitat loss operating at a local scale (eg from weed invasions) or from other broad-scale factors, possibly insidious decline in habitat operating across the Top End. The latter assertion is difficult to confirm. While benchmark vegetation mapping has been undertaken (Wilson et al 1991), there has been no systematic monitoring at a suitable scale to detect habitat loss across the Top End. On the other hand there are many observed anthropogenic-related changes in wetlands attributed to specific environmental pressures for local regions (Finlayson 2005). A general recommendation from The Action Plan for Australian Birds 2000 was that weed control programs be supported in magpie goose habitat (Garnett & Crowley 2000).

2.1.1 Aerial surveys of waterbirds conducted in the Top End of the Northern Territory (April 2000) and Kakadu National Park (November 2003)

Monitoring waterbird populations, including the magpie goose, has been undertaken by the PWCNT across the Top End since 1983. The key purpose of monitoring is to detect changing trends in distribution and abundance of major species. The seasonal timing of surveys is variable although most coincide with the magpie goose nesting period (late wet season to early dry season). The datasets reported here relate to two standardised aerial surveys conducted in 2000 during the late wet season and 2003 during the dry season. The 2000 survey includes records of the distribution and number of magpie goose nests, as this survey coincided with the annual nesting season in early April.

Both surveys cover the major wetlands of the Kakadu region. The 2003 survey targeted only the wetlands of KNP, but the 2000 survey provided complete coverage of Top End wetlands as defined by the PWCNT magpie goose monitoring program (PWCNT 2003), extending from KNP to include Top End wetlands as far west as the Moyle River catchment. The locations and extent of transects for each survey are shown in Figure 4. The distribution and numbers of magpie geese counted on the Magela floodplain for this survey are mapped in Figure 5.

Individual records are stored as point data rather than records relating to a specific area, with spatial coordinates derived from Garmin™ GPS tracking systems. A description of the attributes contained in original shapefiles is provided in Table A1.2. For selected common species counted in the 2003 survey and for nest counts of magpie geese, raster data files have also been derived from point records as a spatial subset for the Magela ecological risk assessment.

Information on related datasets (pre-2000) and survey methodology standards have been documented in various reports and publications (Bayliss & Yeomans 1990, Saalfeld 1990, Colley 1999, Chatto 2000, 2006, PWCNT 2003). Data can be sourced through PWCNT. Scientific comparison with other monitoring datasets should be limited to surveys using similar methodology.

The full metadata report for this dataset is provided in Appendix 1.1.

2.1.2 Aerial surveys of waterbirds conducted in the Alligator Rivers Region from 1981 to 1984 by Morton and Brennan

Data presented here relate to a monitoring study on waterbird populations of major wetlands in the Alligator Rivers Region conducted between June 1981 and August 1984 by Morton et al (1991). The study aimed to assess seasonal trends in abundance and distribution for all waterbird species and used a combination of aerial and ground surveys techniques to assess abundance, distribution, and habitat preference (including vegetation) for specific species, resulting in a number of scientific publications (see also Morton et al 1990a&b, 1991, 1993a&b).

Original data from aerial survey component, until recently, had never been incorporated into a GIS. In 2005 the complete original hardcopy transcripts of the aerial survey dataset was digitised to MS Excel. Selected data from this dataset have been migrated to the *eriss* GIS: for the Magela floodplain site only and for magpie geese and egrets only and for the sampling times October '81, '82, '83 and May '82 and '83 only. A map of magpie goose distribution and numbers for the Magela floodplain excerpted from these data is provided in Figure 6.

Despite some differences in survey methodology between these data and the PWCNT waterbird monitoring program (section 2.1.1), this dataset complements more recent surveys and will allow a meta analysis to examine long-term trends in distribution and abundance of waterbird species.

The full metadata report for this dataset is provided in Appendix 1.2.

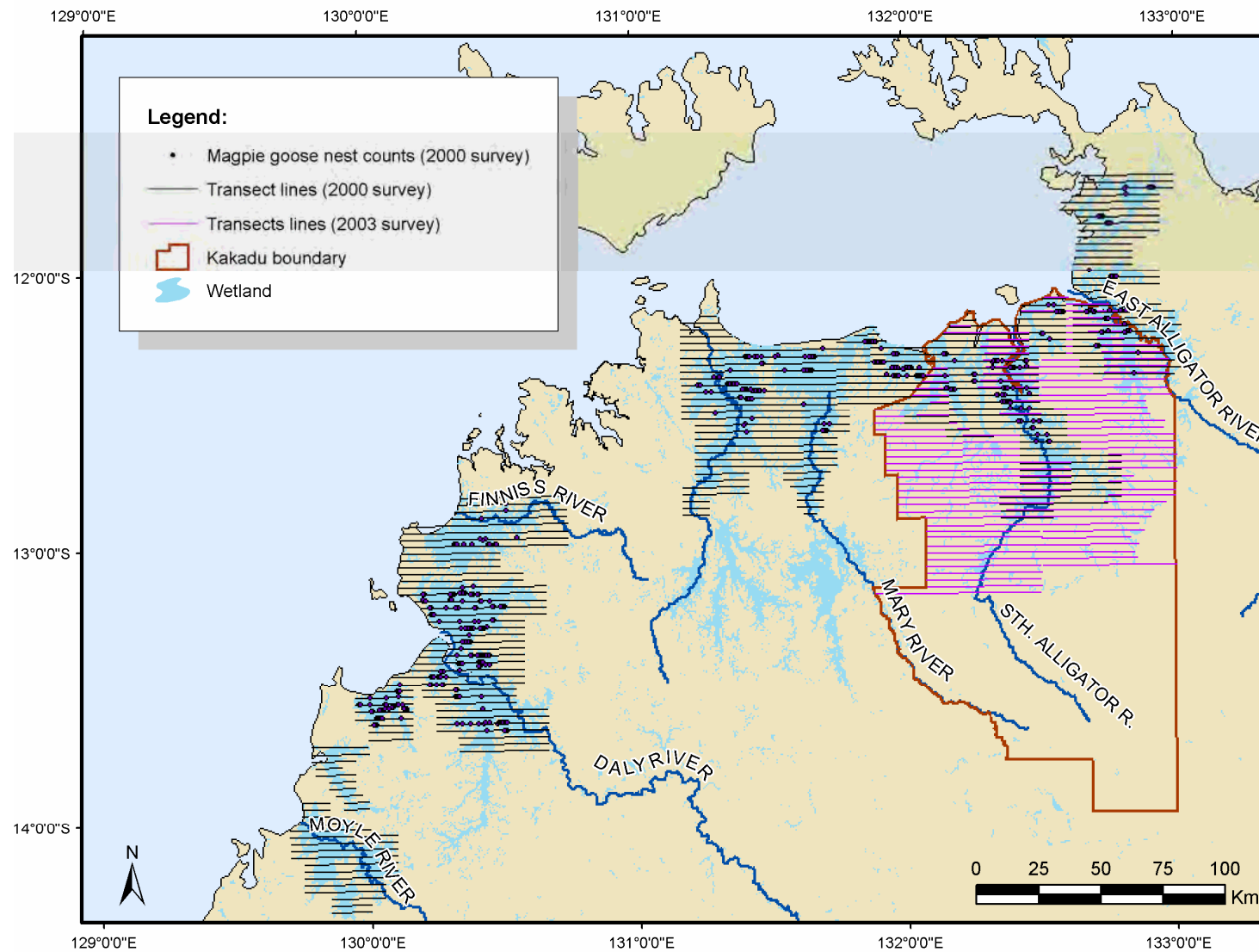


Figure 4 Distribution of magpie goose nests recorded by aerial survey in the wet season of 2000 by Keith Saalfeld. Transect lines indicate the extent & location of aerial surveys conducted in 2000 & 2003, where a common region is shared between both surveys within Kakadu National Park.

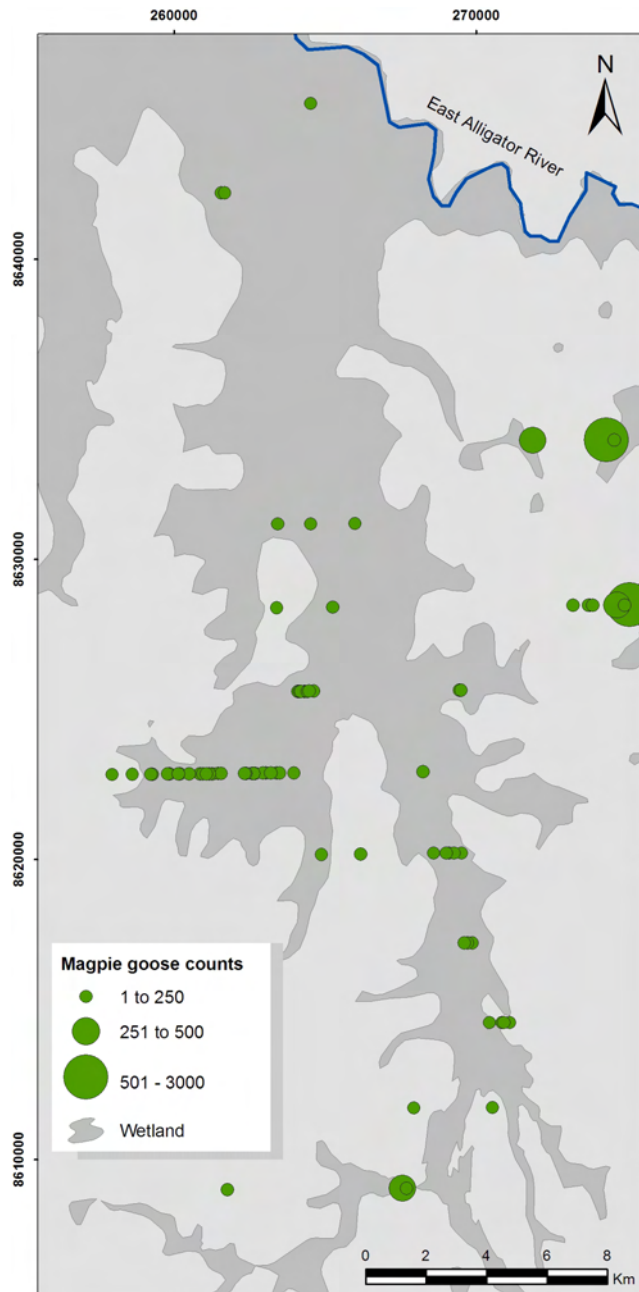
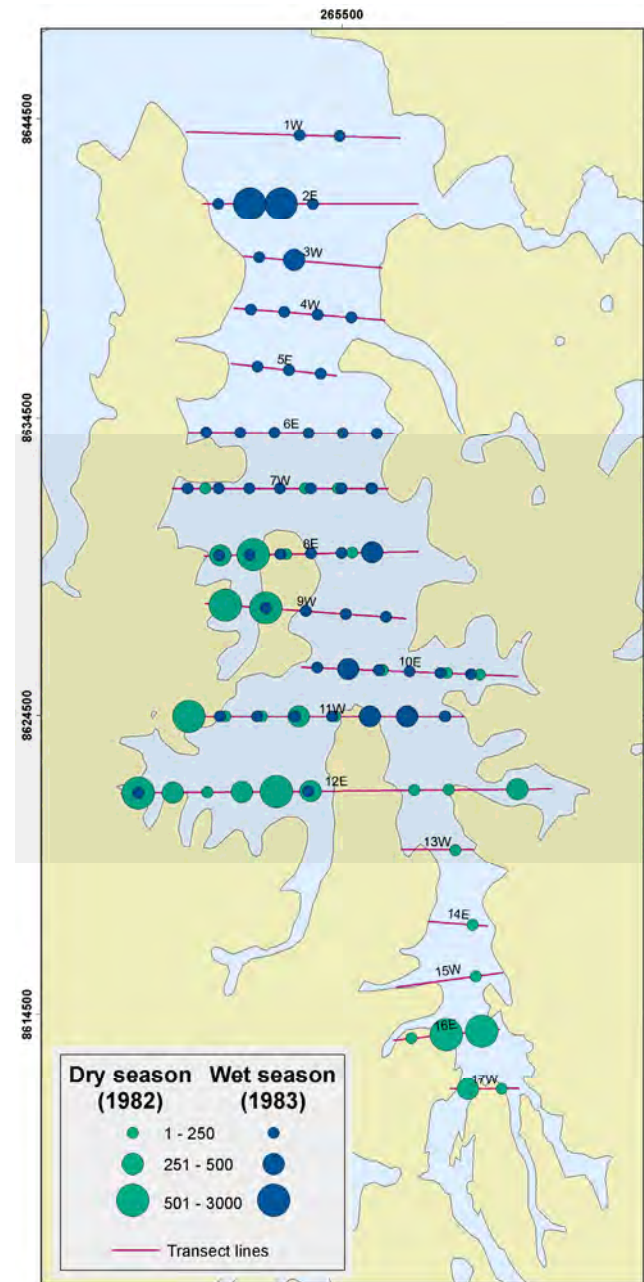


Figure 5 (left) Magpie goose numbers recorded by aerial survey during the late dry season of 2003 on the Magela Creek floodplain by Keith Saalfeld

Figure 6 (right) Total magpie goose numbers recorded by aerial survey on the Magela Creek floodplain during the late dry season of 1982 (green) and the late wet season of 1983 (blue) by Morton and Brennan



2.2 Native plant communities of wetlands

The patterns observed in the distribution and abundance of different plant types on wetlands are the result of interaction with local environment and disturbance history. That is, the spatial arrangement of vegetation while emulating some constancy due to typical conditions of the local environment (eg geology and topo-climatic patterns), is also dynamic over time. Change occurs in response to environmental variation (physical, chemical and biological), including that from predictable, cyclic and random disturbance events operating over a range of scales (eg hydro-dynamics, magpie goose foraging, and fire). Likewise, environmental pressures from identified threats to wetland systems, such as the encroachment of weeds, or ground disturbance by feral pigs can influence the distribution of vegetation communities. In regard to wetlands environments the substantial 'natural' variation among vegetation communities attributed to seasonality should first be characterised in any monitoring exercise aiming to detect change from potential threats (Finlayson 2005).

Because particular native vegetation assemblages are a result of the combined influence of multiple environmental factors they can act as natural resource assessment indicators. Large areas of native *Hymenachne* grassland (*H. acutigluma*), for example, can be perceived as undesirable by Aboriginal people for undertaking traditional hunting and gathering activities due to a reduced availability of resources (Christophersen, pers com) and can also indicate a 'climax' successional state in vegetation resulting from a prolonged absence of fire (Boyden et al 2003). Other native vegetation assemblages (eg *Oryza* grassland) are also representative of habitat availability for particular animals such as the magpie goose. For all these reasons vegetation distribution maps can be used as indices to assess environmental quality in spatially explicit models for natural resource management.

This section outlines available information on the distribution of native vegetation of wetlands in the ARR. Broad-scale mapping of vegetation assemblages on the Magela Creek catchment have been delineated in land system studies undertaken by Storey et al (1969, 1976) and by Schodde et al (1987) that extended to the whole of KNP. Vegetation of the Magela floodplain, specifically, has been surveyed, mapped and described by Finlayson et al (1989), following earlier analyses by Williams (1979), Morley (1981) and Sanderson et al (1983). More recently Riley and Lowry (2002) and Staben (2005) described changes in the distribution and density of *Melaleuca* communities on a section of the floodplain. In 2003 vegetation was again mapped in context to the Finlayson et al 1989 map classification by Lowry et al (in prep to assess major changes in distribution of different vegetation communities. This was done using new information acquired from both aerial and airboat surveys. Concurrent with this recent work, ongoing *eriss* studies have focused on developing remote sensing techniques for mapping vegetation communities, and in particular targeting the distribution of the environmental weed, para grass (Figures 10 & 11).

Change in vegetation distribution on the Magela floodplain between 1983 and 2003 was assessed using eight native vegetation classes, using the maps produced by Finlayson et al and Lowry et al, mentioned above. Selected classes represented dominant plant species that may be less influenced by classification bias: *Eleocharis* spp, *Oryza* spp, *Pseudoraphis spinescens*, *Hymenachne acutigluma*, *Melaleuca* spp, *Nelumbo nucifera*, *Nymphoides* spp and *Leersia hexandra*. Relative change in abundance was measured by change in percentage cover and distributional since 1983 (Figure 7). Most plant classes changed little except for the following: *Nymphoides* and *Leersia* were not recorded in 1983; *Eleocharis*, an important dry season food of magpie geese, decreased by 57%; *Melaleucas* decreased by 10%; and *Nelumbo* decreased by 85%. The 10% relative change in paperbark forest and woodland is significant because on an

absolute basis this corresponds to 5km² or 3% of the floodplain. This analysis did not include displacement of wetland vegetation communities due to weed invasions.

Landscape scale monitoring of wetland vegetation has also been undertaken for Boggy Plains (located in the South Alligator river catchment) since 2002 as part of a collaborative project between *eriss*, PAN and CSIRO and traditional land managers. As far as the authors are aware it is the only example where remote sensing in conjunction with ground validation has been used to monitor wetland vegetation change in response to traditional prescribed use of fire. It is also an example where traditional land management goals have been linked to a scientific monitoring and assessment program. Boggy Plains is also relatively un-impacted by weeds and is located in a catchment within KNP where mining does not occur. Preliminary unpublished findings are provided in Boyden et al (2003). Once this ongoing work is published, metadata reports for datasets used will be publicly available.

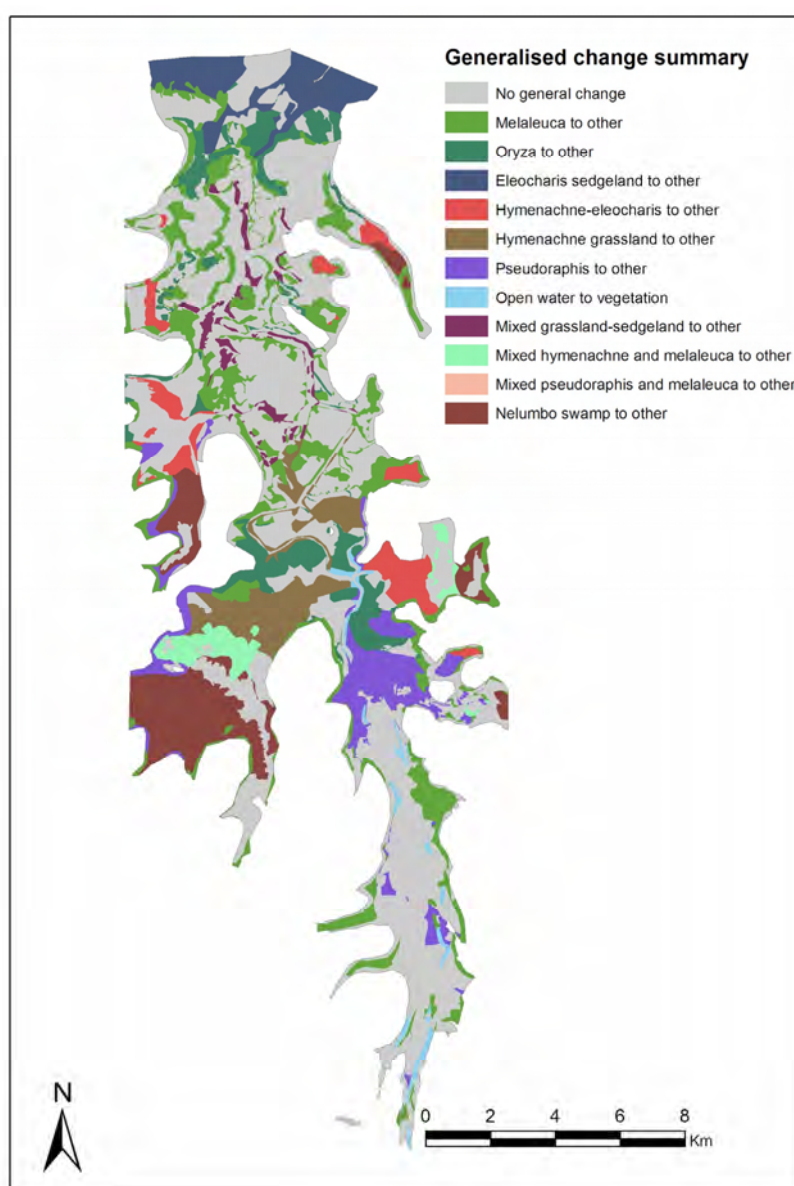


Figure 7 Generalised vegetation change classes for the Magela floodplain since 1983 derived by overlaying the Finlayson (1989) and Lowry (2004) vegetation maps. Note this assessment did not include most recent data on change due to para grass invasion.

2.2.1 Kakadu National Park vegetation (Schodde et al 1987)

The vegetation of Kakadu National Park is a structural classification of the upper-storey vegetation cover. The vegetation polygons were originally mapped as unique mapping units onto 1969 1:60 000 black and white aerial photos as part of the Alligator Rivers region ‘fact finding study’ which preceded gazettal of Kakadu National Park. After two unsuccessful attempts to produce a vegetation map for the region, a project was developed to transfer the line-work from the original air photos onto topographic compilation map sheets at the 1:100 000 scale to produce a planimetrically corrected vegetation coverage (Schodde et al 1987). Additional mapping was undertaken over the Mary River catchment since the original Alligator Rivers region study did not extend beyond that catchment. The project was funded under the Australian National Parks and Wildlife Service Research and Survey Program project 190/101/14.

The vegetation map has 31 different vegetation classes fully described in Schodde et al 1987. Each grid cell has a unique vegetation type, for example ‘Open forest’, ‘Paperbark forest’ and ‘Sandstone woodland’. The data includes various coverages of specific issues in paperbark distribution (eg mortality due to salinity). The map includes full attributing where available. A description of attribute fields for the shapefile version is provided in Table A6.1.

An excerpt from this map for the Magela floodplain ecological risk assessment is provided in Figure 8. Significant differences are observed between this map and other map productions for the Magela floodplain region. Specific reasons for the observed differences cannot be ascertained, although they probably relate to differences in survey scale, methodology and classification topology and not to real differences relating to vegetation change. Therefore caution should be exercised when making scientific comparison between the different maps.

The full metadata report for this dataset is provided in Appendix 1.3.

2.2.2 Land units of the Magela Creek catchment (Wells 1979)

The land unit classification of the Magela catchment was produced by Wells (1979) of the Land Conservation Unit of the Territory Parks and Wildlife Commission of the NT for the former Alligator Rivers Region Research Institute (now *eriss*). his work is a refinement of previous broader scale land system classifications conducted by Christian and Stewart (1953), Storey et al (1969) at scales of 1:1 000 000 and 1:250 000 respectively, and preliminary land unit classification work undertaken by the Land Conservation Unit by Schaeffer et al (1969) using 1:50 000 aerial photography. The land unit delineation at 1:50 000 was substantially revised by Wells (1979), after discovering a large number of inconsistencies and omissions in previous mapping, and including new information on soil and landform characteristics obtained for 320 field sites in the catchment, where vegetation information was also obtained for 137 of these sites. The most recent account of land systems within which land units can occur is provided by Storey et al (1976).

A conventional approach to land unit classification was applied to areas originally delineated from 1:50 000 aerial photos, with primary class differentiation occurring on the basis of landform and terrain type, secondary criteria on the basis of soil type and slope, and further breakdown based on vegetation, drainage, and rock outcrop differences (Wells 1979). Land units within regions identified as areas subject to major change due to development and therefore at higher risk of soil erosion, such as from mining (Ranger & Jabiluka projects) and the Jabiru regional township, were surveyed more intensively for soils to obtain a map at 1:10000 scale for land units within these areas. A detailed account of methodologies and description of land unit associations is provided in the Wells (1979) report. An excerpt map

from the dataset is provided in Figure 9 and a description of the land unit attributes is presented in Table A6.2. The full metadata report for this dataset is provided in Appendix 1.4.

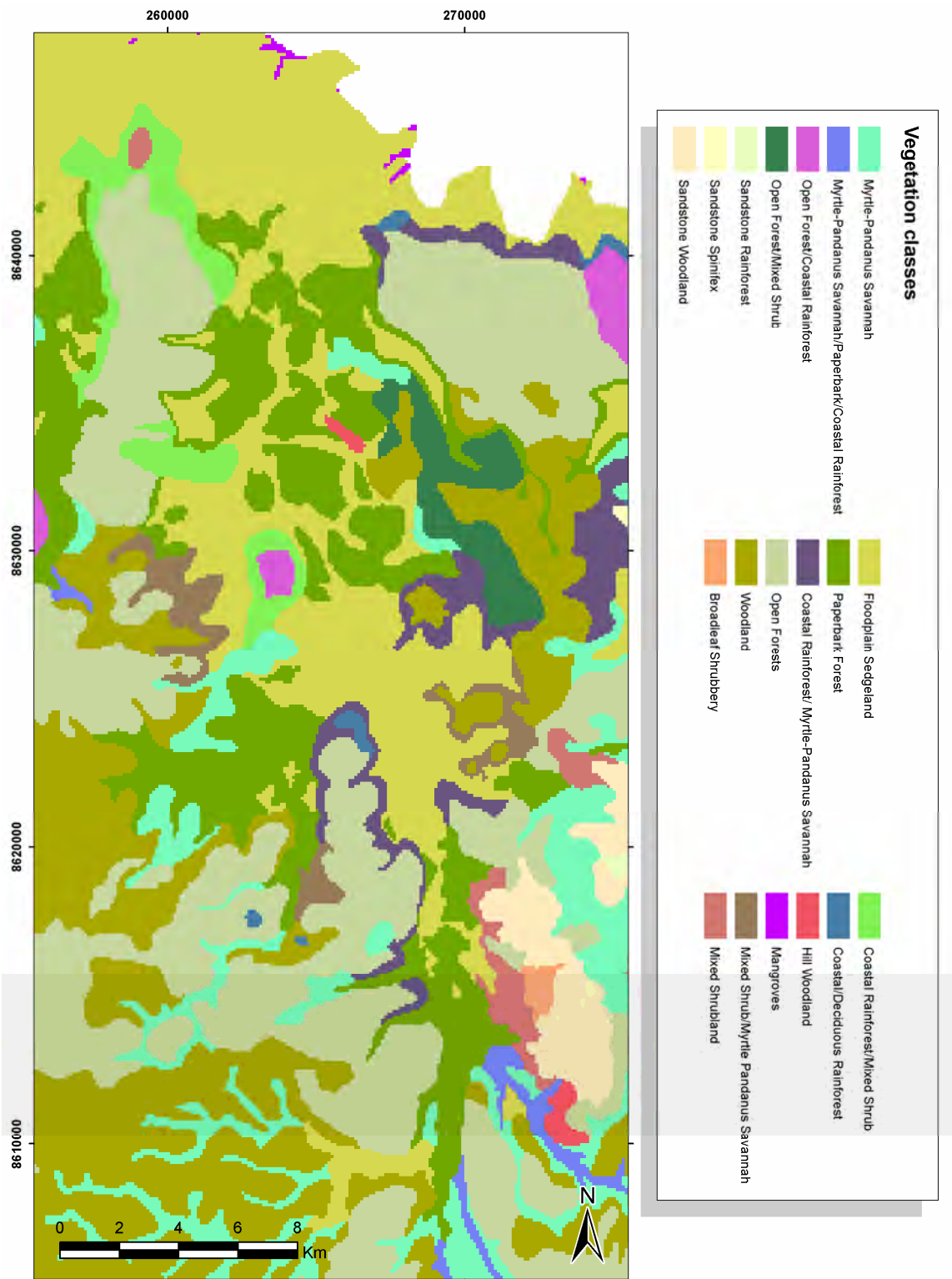


Figure 8 Vegetation assemblages of the Magela Creek floodplain and surrounding landscape produced from the Kakadu National Park Vegetation classification (Schodde et al 1987)

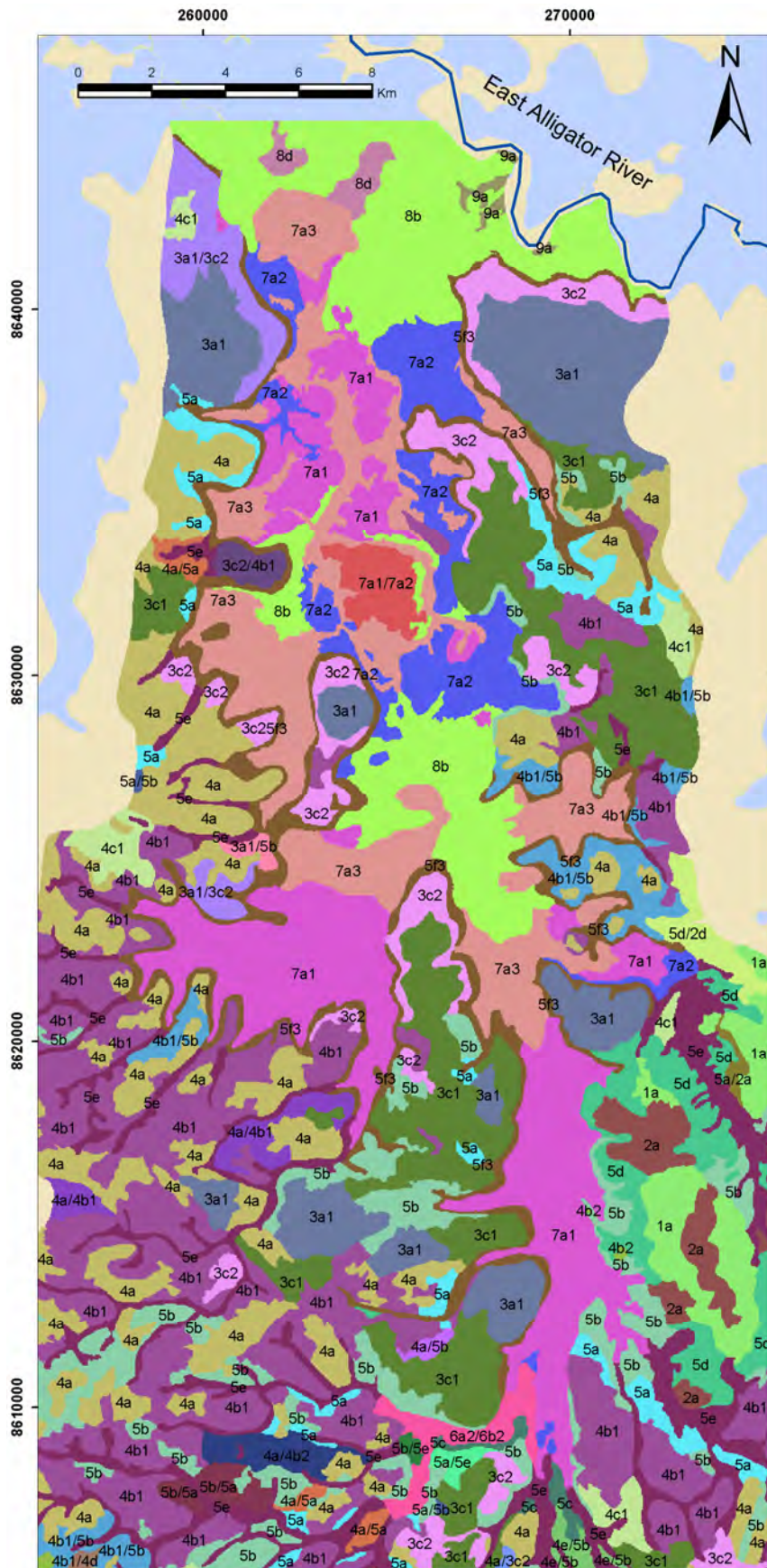


Figure 9 Land units of the Magela Creek catchment (Wells 1979). A full explanation of unit codes is provided in Table A6.2.

2.2.3 A macrophyte vegetation classification of the Magela Creek floodplain, Alligator Rivers Region (Finlayson et al 1989)

A generalised classification of vegetation was prepared from wet season vegetation maps and descriptions. Tree dominated communities were mapped using black and white photographs taken in September 1978 (non-stereoscopic), June 1975 and Oct 1982 (stereoscopic). Grass, sedge, and herb communities were mapped from a series of aerial colour photographs taken between 12 April 1984 and 4 June 1986, with a hand-held camera. Major plant communities were delineated on the basis of interpretation of patterns of colour and texture in the aerial photographs and from ground surveys. Details of species composition of communities, and of height of tree species were derived from field transects and field work incidental to the mapping over a period of 4 years (1983–1986). The resulting map is provided in Figure 10. See Finlayson et al (1989) for further details.

The full metadata report for this dataset is provided in Appendix 1.5.

2.2.4 A vegetation map of the Magela floodplain (Lowry et al, in prep)

The aim in producing a new vegetation map for the Magela floodplain was to assess change in vegetation communities in context to a previous vegetation mapping for the floodplain. In particular change was to be assessed over a 30-year timeframe in context to the vegetation classification produced by Finlayson et al (1989). Map assessment was undertaken by combining information from ground (airboat) and aerial surveys. The new map (Figure 11) by Lowry et al was produced from a systematic survey conducted between March and April 2003.

The full metadata report for this dataset is provided in Appendix 1.6.

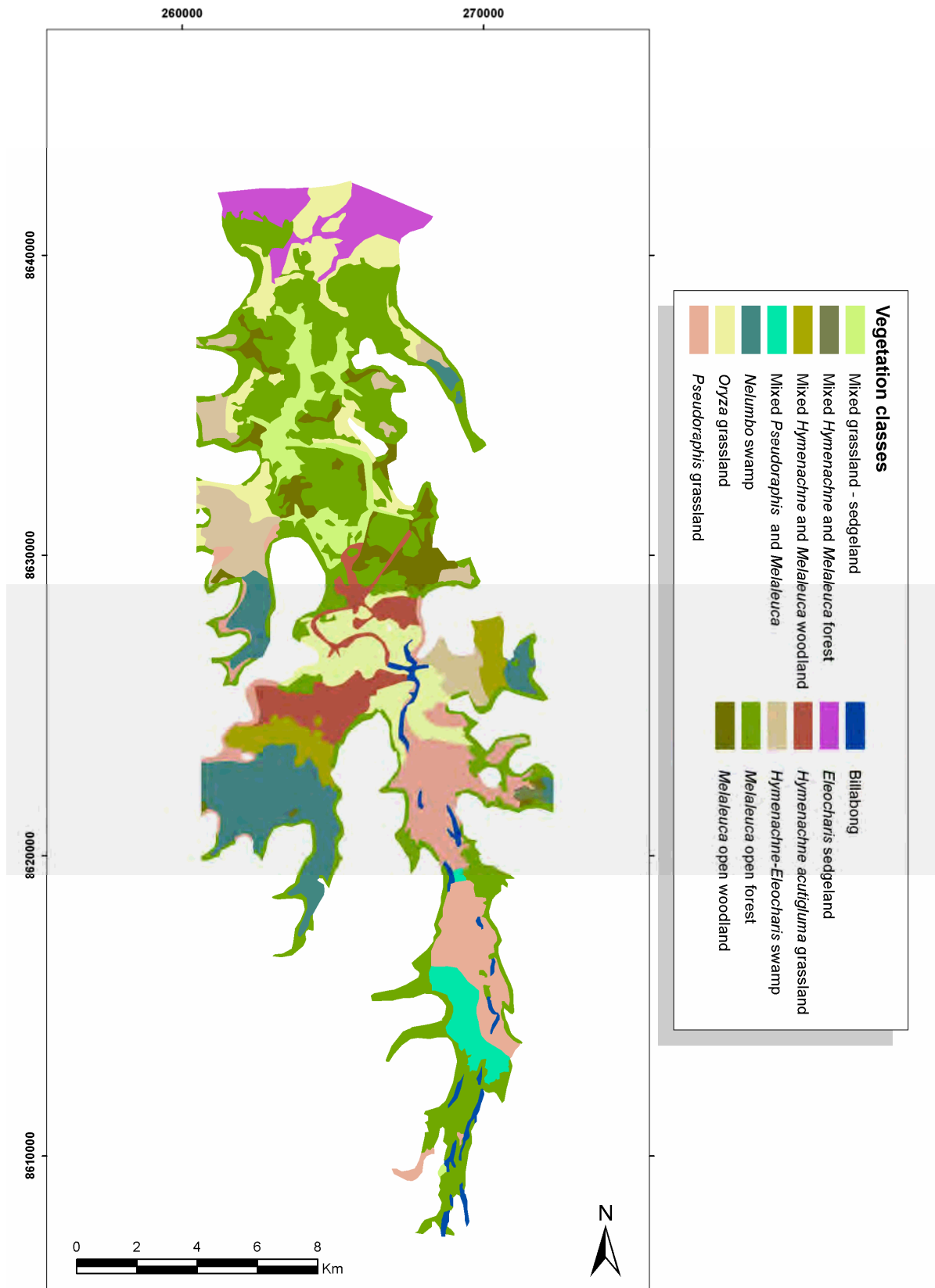


Figure 10 Vegetation assemblages of the Magela Creek floodplain produced by Finlayson et al 1989

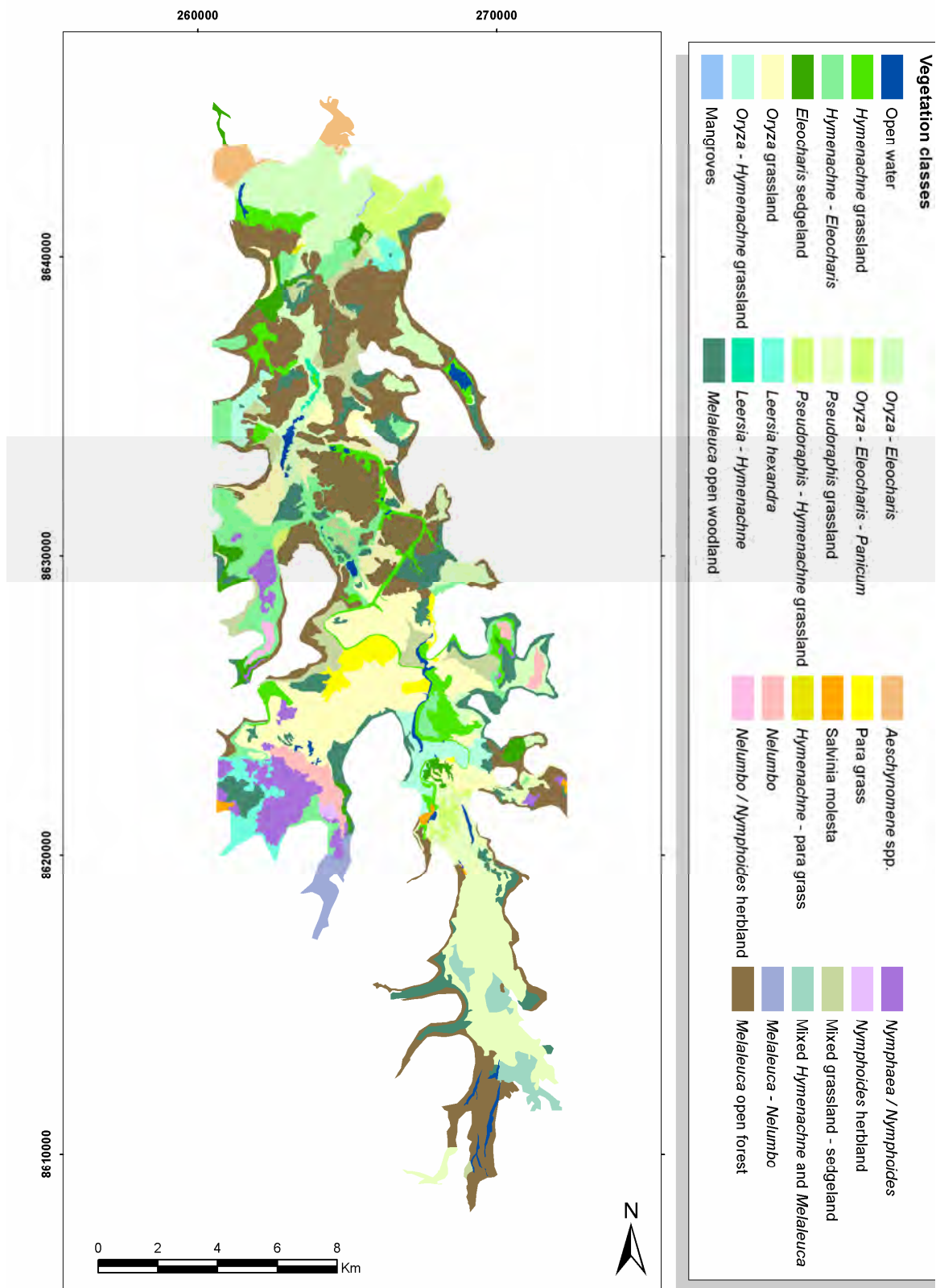


Figure 11 Biophysical features and vegetation assemblages of the Magela Creek floodplain produced by Lowry et al 2002