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A GIS compendium for landscape-scale risk assessment of the Magela Creek floodplain and broader Alligator Rivers Region, NT

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Executive summary

The Alligator Rivers Region (ARR), which includes Kakadu National Park (KNP), is one of Australia's most highly valued landscapes, with the Park having been declared a World Heritage area. It is also one of the most studied regions of Australia resulting in the accumulation of a very large body of knowledge. Despite this large knowledge base, natural resource managers of the region seldom have all the information they need to make informed decisions, and there remain uncertainties in data.

This report provides a compendium of spatial data currently available to assess ecological risks to the seasonally inundated floodplain of Magela Creek. The datasets represent the natural assets and character of these wetlands, and some of the regional threats to them arising from multiple and diffuse landscape-scale sources. Under these broad criteria, information has been collated specifically for the landscape-scale ecological risk assessment study of the floodplain conducted by the Environmental Research Institute of the Supervising Scientist (***eriss***), for which this is a supporting document. The identified data sources also provide a valuable resource for KNP and ARR land managers generally.

The ecological risk assessment project's aims were to quantify risks to the natural assets of the Magela wetlands arising from non-mining sources and from Ranger mine (based on measurement criteria to assess impacts to KNP World Heritage Values). This will enable risks from different sources to be assessed in context, with a broader objective to facilitate optimum decision making for managing risks to WHVs in Kakadu generally. In order to provide an objective assessment of risks, the analyst needs to communicate the relevant uncertainties in the information used for the assessment and, in this context, the assumptions, confidence in interpretation, and uncertainties of datasets used in these analyses.

This compendium provides an assessment of the state of knowledge for spatial risk assessment of the Magela Creek floodplain and, to a lesser extent, the ARR. Datasets are evaluated in context of their utility to provide suitable measurement endpoints for monitoring and ecological risk assessment. Evaluations are based on the ability of a dataset to provide repeatable measurements within acceptable levels of accuracy and precision, and at suitable scale(s), to measure both the risks to natural assets and the success of risk reduction strategies. Metadata reports for each dataset are provided in accordance with the Spatial Information Council of Australia and New Zealand.

It has also been an aim to prompt discussion as to how monitoring information for ecological risk assessment might be improved through contrasting the utility of existing data against identified limitations. While any monitoring endpoint will have intrinsic limitations, the quality (and utility) of the data can often be improved upon implementation of appropriate standards. Sometimes representative endpoint data do come from different sources where inconsistent collection methods are apparent and in these cases differences need to be accounted for and reconciled where possible.

Ongoing improvement of systems that support efficient management, retrieval, and analysis of information for risk-assessment reporting is considered critical to the long-term adoption of ecological risk assessment as a routine decision support tool for land managers in the region. Information access for participatory natural resource management under a GIS framework will be further enhanced through appropriate training at all levels in the data management and analysis cycle. Reporting is arranged under the headings: Environmental assets; Environmental threats; and Environmental characteristics – the basic framework developed for the ecological risk assessment. Datasets have also been arranged in a GIS under this framework and have been made available to KNP managers.

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Glossary and Abbreviations

AHD	Australian Height Datum (meters)
AOI	Area of interest
ANZLIC	The Spatial Information Council of Australia and New Zealand (formerly the Australia New Zealand Land Information Council)
ARR	Alligator Rivers Region
BFC	Bush Fire Council of the Northern Territory
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DEWHA	Australian Government Department of the Environment, Water, Heritage and the Arts
dGPS	Differential Global Positioning System
DIGO	Defence Imagery and Geospatial Organisation
EDS	Early dry season (period used by BFC, from May to July, inclusive, to define early dry season burning)
EPBC	*Environment Protection and Biodiversity Conservation Act 1999*
eriss	Environmental Research Institute of the Supervising Scientist
FCC	False colour composite image produced from viewing near-Infrared, red, and green spectral bands as visible RGB, respectively.
GDA94	Geodetic Datum of Australia 1994
GIS	Geographic information system
GPS	Global positioning system
KNP	Kakadu National Park
LDS	Late dry season (period used by BFC, from August to October inclusive, to define late dry season burning)
MG	magpie geese
MGA	Map Grid of Australia
MS	multi-spectral imagery
NRETA	Northern Territory Government Department of Natural Resources, Environment and the Arts
PAN	Parks Australia North
PWCNT	Parks and Wildlife Commission of the Northern Territory
QA/QC	Quality assurance and control
Ramsar	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[1] (see www.ramsar.org).
RGB	Visible red, green, and blue spectral bands used in remote sensing
RMS	Root mean squared error statistic used as an indicator of map registration accuracy
TCC	True-colour composite image produced from visible (RGB) spectral bands
WHVs	World Heritage Values

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[1] Extract from http://www.murrumbidgee.cma.nsw.gov.au/index.php?id=570

Glossary of terms for key metadata elements[2]

Quantitative data quality elements

Completeness — Refers to the completeness of coverage extent, classification and accuracy. Also the presence and absence of features, their attributes and relationships. *Negative Example: missing road data in a remote part of the province.*

Logical consistency — degree of adherence to logical rules of data structure, attributes and relationships. *Example: The dataset is topologically checked. All polygons closed etc.*

Positional Accuracy — The accuracy of the position of features. *Example: The date of data compilation was August 1990. Example:a dGPS was used. As such, it is expected that data features have a positional error of +/- 1 metre.*

Attribute Accuracy — An assessment of the reliability of values assigned to features in a dataset in relation to their 'real-world' values.

Temporal accuracy — Accuracy of the temporal attributes and temporal relationships of features. *Example: The date of data compilation was August 1990.*

Thematic accuracy — Accuracy of the quantitative attributes and the correctness of non-quantitative attributes, as well as the classification of features and their relationships. *Example: Areas have been classified according to remotely sensed imagery as green land, although in reality, they were swamps.*

Non-quantitative quality information

Purpose — Describes the rationale for creating the dataset and contains information about its intended use

Usage — Describes the application for which a dataset has been used

Lineage — Describes the history of a dataset and, in as much as it is known, recounts the life cycle of a dataset from collection and acquisition through compilation and derivation to its current form.

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[2] Sourced from Kresse W & Fadaie K (eds) 2004. *International Standards Organisation Standards for Geographic Information*. Springer-Verlag, Berlin Heidelberg.

1 Background

The Alligator Rivers Region Technical Committee (ARRTC) identified as a key goal the need to continue developing knowledge management systems for effective communication and decision support for regional natural resource management and environmental assessments. Supporting this development, the Environmental Research Institute of the Supervising Scientist (***eriss***) has adopted an ecological risk assessment framework to underpin the organisation of environmental information.

In order to achieve this aim, and to assess ecological impacts from mining in the ARR in context with other potential stressors, the Independent Science Panel (ISP) of the International Council of Scientific Unions, and the World Conservation Union, acting on behalf of the World Heritage Committee, recommended that it was necessary to:

- first conduct an assessment and collation of existing information at a landscape-catchment scale in order to identify gaps in knowledge and to establish and prioritise research needs; and
- conduct a more comprehensive risk assessment of both freshwater and terrestrial ecosystems at a landscape scale, because the region is subject to change and variability due to influences not immediate to mining activity, such as other land use practises, climate, and the introduction of invasive species (Bellio et al 2004a).

In response to these recommendations, ***eriss*** initiated a program of landscape-wide projects aiming to link environmental threats and pressures (mining, invasive species, climate change, and salt-water intrusion) to selected ecosystems in the ARR, particularly freshwater wetlands. The ecological risk assessment program aims to identify the potential likelihood, extent and severity of mining impacts in the ARR and to separate effects of such impacts from those caused by other potential (non-mining) environmental stressors. In addition the program aims to place these potential impacts in context for land managers by quantifying the risks.

This report aims to document available spatial data useful for conducting ecological risk assessment of the Magela Creek floodplain. Essential to this exercise has been the identification and collation of spatial datasets indicative of environmental threats and assets in the ARR and the incorporation of these data into a standardised form for spatial risk modelling purposes. It is hoped that this document will assist in the development of an effective knowledge management system for stakeholders in the region through: 1) providing a compendium of currently available spatial information for the ARR, and specifically the Magela floodplain; and 2) outlining a framework to facilitate routine landscape-scale ecological risk assessment analyses;

To provide an objective risk assessment it is incumbent upon the analyst to effectively communicate uncertainties in information used for the assessment (Burgman 2005). Identification of gaps and uncertainties of data, and effective communication of this information to stakeholders, therefore, underpins any ongoing risk assessment exercise, and helps to direct further research and monitoring. Consequently data quality assessments were also conducted for each dataset in accordance with accepted international standards, including an assessment of gaps and uncertainties in available information.

In summary, this spatial data compendium is provided for the exercise of ecological risk assessment in the ARR. Abstract reports of the data layers are arranged under three headings: 1) Environmental assets (including data on waterbirds and native wetland vegetation in the ARR); 2) Environmental threats (including data layers for feral animals, and weeds); and

3) Environmental character (physical drivers independent of assets and threats that nevertheless can interact with them or influence ecosystem processes such as fire history, hydrology and infrastructure). Complete metadata reports are contained within the appendices.

While the aim has been to provide summaries of all spatial data relevant to the ARR, their inclusion in this report does not necessarily mean that they will be applied in the final risk assessment process. As has already been stated, the primary aim was to summarise 'existing information at a landscape-catchment scale in order to identify gaps in knowledge and to establish and prioritise research needs'. Therefore the applicability of specific data layers to the formulation of an ecological risk assessment model will need to be reviewed after initial model development.

This GIS compendium provides an information resource to land managers in the region, summarising spatial data currently available to assess potential ecological risks to the natural environment of the ARR, and in particular the Magela Creek floodplain. While considered relatively complete with respect to data available at the time of publication, a number of information gaps are also apparent. It is hoped that this document will promote debate towards the development of a more comprehensive spatial database for ecological risk assessment and land management planning in the ARR.

1.1 Measurement endpoints used for risk assessment

This section outlines the spatial information sources used for the non-mining component of the landscape-scale ecological risk assessment project as they relate to available measurement endpoints (MEs) for the assessment. In order to describe MEs in context it is first useful to outline the process of ecological risk assessment.

Essentially ecological risk assessment is a framework and decision support tool for assessing and managing multiple ecological risks at multiple scales. The term is ascribed to the method(s) for determining risk posed by a stressor (contaminant or perceived threat) to the survival and health of ecosystems (natural assets). The general steps for performing ecological risk assessment, as applied to an identified 'stressor', are outlined in Figure 1. Under these procedures ***risk*** is defined as the probability that an adverse effect will occur as a result of ecosystem exposure to a particular concentration of the stressor. Hence ***risk*** is determined by measuring two components:

1 the ***consequences*** (also measured as effects/extent) of an adverse event, and

2 the ***likelihood*** or *probability* of the event occurring (exposure).

Using these criteria, risk is calculated as the probability of an adverse event, or the likelihood of exposure multiplied by the consequences or effects of that exposure ($P_{risk} = P_{exposure} \times P_{effects}$). In turn, risk level can be measured for each identified 'stressor', separately, and then comparisons of the relative risk contribution from multiple stressors can be made.

A general outline for the ecological risk assessment of the Magela Creek floodplain is shown in Figure 2 (Bayliss, van Dam & Humphrey 2006). Broad assessment endpoints chosen to evaluate risks (from mining and non-mining stressors) are:

- the conservation of the biological diversity of the ARR based on World Heritage Values of KNP for which the Australian government is under international obligation to protect, and
- the protection of the health of people of the ARR.

Measurement of the risks to these values from diffuse landscape threats relate to exposure of specific threats (eg spatial extent of weeds or feral animals) to key natural assets (such as significant habitat for magpie goose). The distribution and extent of threats measured in relation to the displacement of natural habitat form the measurement endpoints in the assessment. Implicit is the need for benchmarking of natural assets (eg definable habitats), where relatively homogeneous vegetation communities (or habitats) form the basic landscape unit for assessment and management planning.

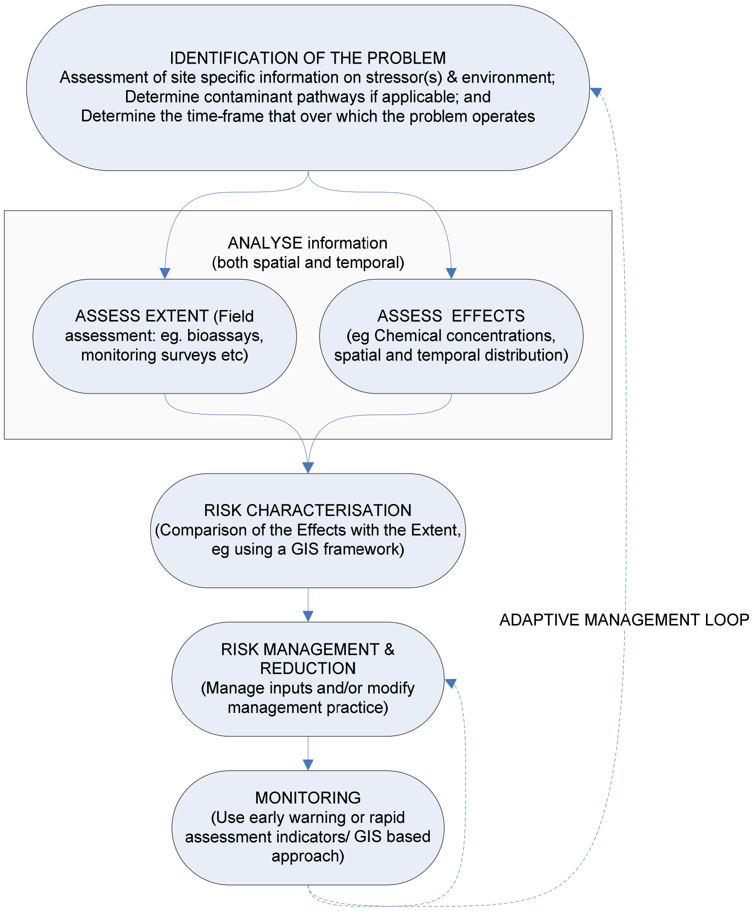

Figure 1 A basic framework for conducting Ecological Risk Assessment (adapted from US EPA 1998)

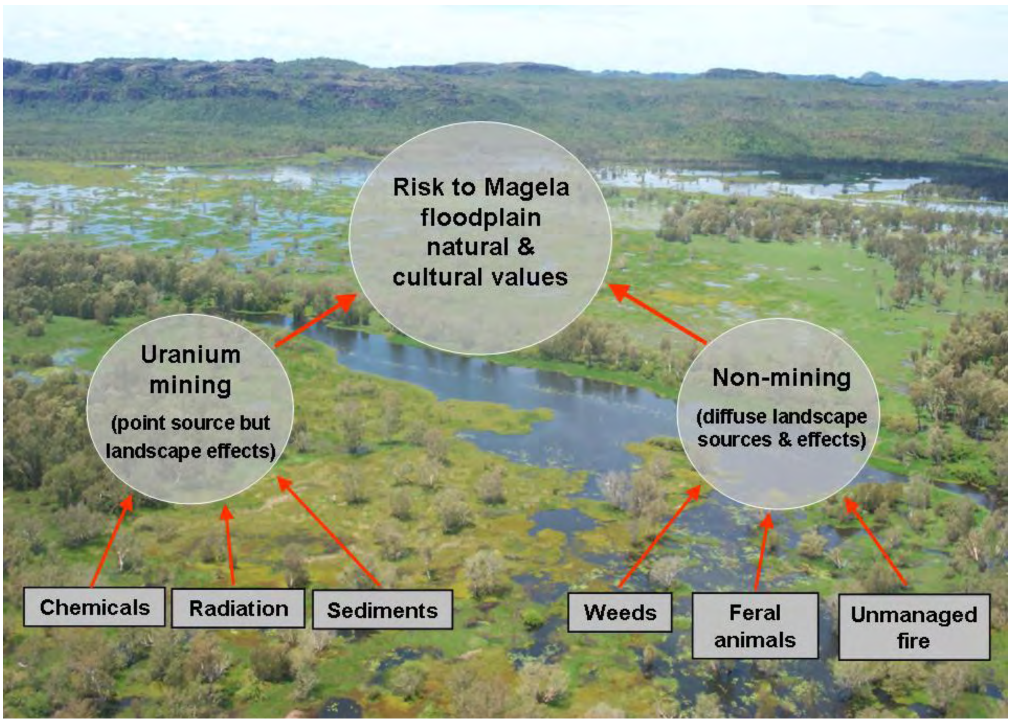

Figure 2 Ecological stressors considered in the relative risk model for the Magela floodplain (source: Bayliss et al 2006a)

Hence, aspects of the datasets reported here that need be understood in relation to the ecological risk assessment of the Magela floodplain are:

- a recognition of the measurement endpoints indicative of ecological change over different scales (as they relate to measuring both the status of World Heritage Values of wetlands and the health of the local community in the ARR);
- the limitations, assumptions and context-dependence of *measurement* endpoints, as they relate to *assessment* endpoints; and on this basis
- issues of data interpretation, accuracy and reliability of information being used to derive endpoints.

These factors are also relevant to planning future monitoring programs, and for improving rigour and precision of risk assessments. Measurement endpoints used in the ecological risk assessment, and potential quality control and assurance issues are summarised in Table 1. Available data are identified for each measurement endpoint.

More thorough description of endpoints as they relate to the assessment of wetland assets, and the potential threats to them are found in sections 2 and 3 (assets and threats), respectively. Section 4 outlines datasets used to define the physical attributes of the Magela floodplain and surrounding landscape, including topography, fire regime, and infrastructure (tracks and roads). The latter two are intrinsically related to land management and the history of human occupation. These attributes may also be considered as 'threats' under some circumstances. For example, where fire is a natural part of the environment in Kakadu, an 'unmanaged' fire regime can contribute to reduction in local biophysical heterogeneity of the landscape, thus impacting on biodiversity.

1.2 Spatial data reporting

Spatial data associated with the Magela floodplain risk assessment project have been incorporated into a GIS maintained at ***eriss***. In general, all datasets are publicly available by application through the data custodian, on condition that original ownership and data lineage are appropriately acknowledged. A summary of all datasets is provided in Table 2.

For each data layer a brief abstract is provided in sections 2 to 4 (cross-referenced to a complete metadata report in the Appendices). Metadata descriptions follow the Spatial Information Council of Australia and New Zealand (SICANZ) reporting standard for spatial metadata (ANZLIC 2001). The SICANZ metadata thesauri were used to derive keyword and qualifier search terms for each report and the ISO metadata topic category thesauri were also used for selection of broader classification terms.

Spatial data have been projected to the Australian standard, Geodectic Datum of Australia 1994 (GDA94), and using the appropriate map zone (Map Grid of Australia 1994) such that analyses can be conducted using the metric scale. When the dataset extent encompassed more than one map grid zone the dataset is projected using the geographic coordinate system. With respect to the ecological risk assessment of the Magela floodplain, spatial data subsets delineating this region (Figure 3) were derived from each original data layer and projected to GDA94, MGA zone 53. Wetland areas depicted on maps are derived from AUSLIG 1:250000 map series where they are classed as 'swamps and land subject to seasonal inundation'.

Table 1 Datasets used to characterise risk to World Heritage Values of Magela floodplain, the measurement endpoints used, and potential limitations of data sources

Measurement endpoint		Indicator	Links/interactions	Potential confounding influences for Magela floodplain assessment
Assets	Distribution and abundance of waterbirds (aerial surveys data)	• indicative of 'health' of waterbird populations for iconic species	• Waterbirds are partly dependent on high-energy native vegetation resources (eg *Oryza* spp & *Eleocharis dulcis*)	• Population home-range extends over local and regional scales
Assets	Distribution and spatial extent of native macrophyte habitats (from various floodplain mapping studies)	• Indicative of the 'health' of native vegetation habitats critical for waterbird conservation • Potential indicator of the quality of environment for Indigenous land use (hunting and gathering)	• Relates to the quality of habitat for waterbirds (magpie geese & egrets) • Can be used to monitor success of invasive species control programs at a habitat-specific scale • Potential indicator of climate change and/or salt-water intrusion into freshwater wetlands • Fire regime can influence successional state of vegetation on floodplains (eg Boyden et al 2003)	• Although they relate specifically to the Magela floodplain, multi-temporal datasets are not standardised: Different sampling methodology and scales are used between datasets.
Threats	Distribution and abundance of feral animals and estimates of habitat damage (aerial surveys)	• Semi-quantitative indicator of the spatial extent and relative 'severity' of visible damage by feral pigs in floodplain and terrestrial habitats • Indicates relative abundance of species counted	• Relates to the exposure of natural assets on floodplains to feral animal activity and hence the potential for change/displacement of these resources • May be used to monitor success of feral animal control programs	• Relative abundance estimates potentially unreliable for some species (pigs) • Visual estimates of 'damage' while indicative of presence of pigs, may not directly relate to measurable ecological impact;
Threats	Weed mapping (various sources)	• Distribution and density of para grass & other weeds derived from field surveys and remote sensing	• Relates to the exposure and displacement of native vegetative habitats to weeds (esp para grass) • Can be used to monitor success of weed control programs • Possible interactions with fire regime (by increased fuel loads & fire intensity) • Possible reduction of nutrients to aquatic food webs (Bunn et al 1997) • Possible changes in floodplain channel morphology and hydrodynamics (Bunn et al 1998)	• Techniques for monitoring para grass using remote sensing are under development; • and comprehensive accuracy assessment has not been undertaken. Preliminary map classifications have been used.
Threats	Seasonal (early vs. late dry season) fire scar history from BFC (derived from remote sensing)	• Fire regime. While fire is a natural part of the landscape, 'unmanaged' fire may be considered a potential threat to conservation of habitat diversity. • Late dry season fires contribute more CO_2 emissions than early season fires (ratio of EDS:LDS may be a useful indicator, weighted by total extent)	• Fire regime (frequency & timing of burns) can alter availability of specific wetland vegetation resources ; • A 'low' frequency burning regime has been implicated in reduction of both floodplain habitat diversity and the quality of wetlands for indigenous landuse (Boyden et al 2003, Christophersen et al 2003). • Fire can influence runoff input of nutrients and sediments into aquatic systems (Townsend, Douglas & Setterfield 2004). This may influence the magnitude of seasonal plant production pulses on floodplains • CO_2 emissions contribute to global warming	• While accuracy of fire-scar mapping is considered high for terrestrial environments (>80%), accuracy assessments data for floodplain environments are limited.

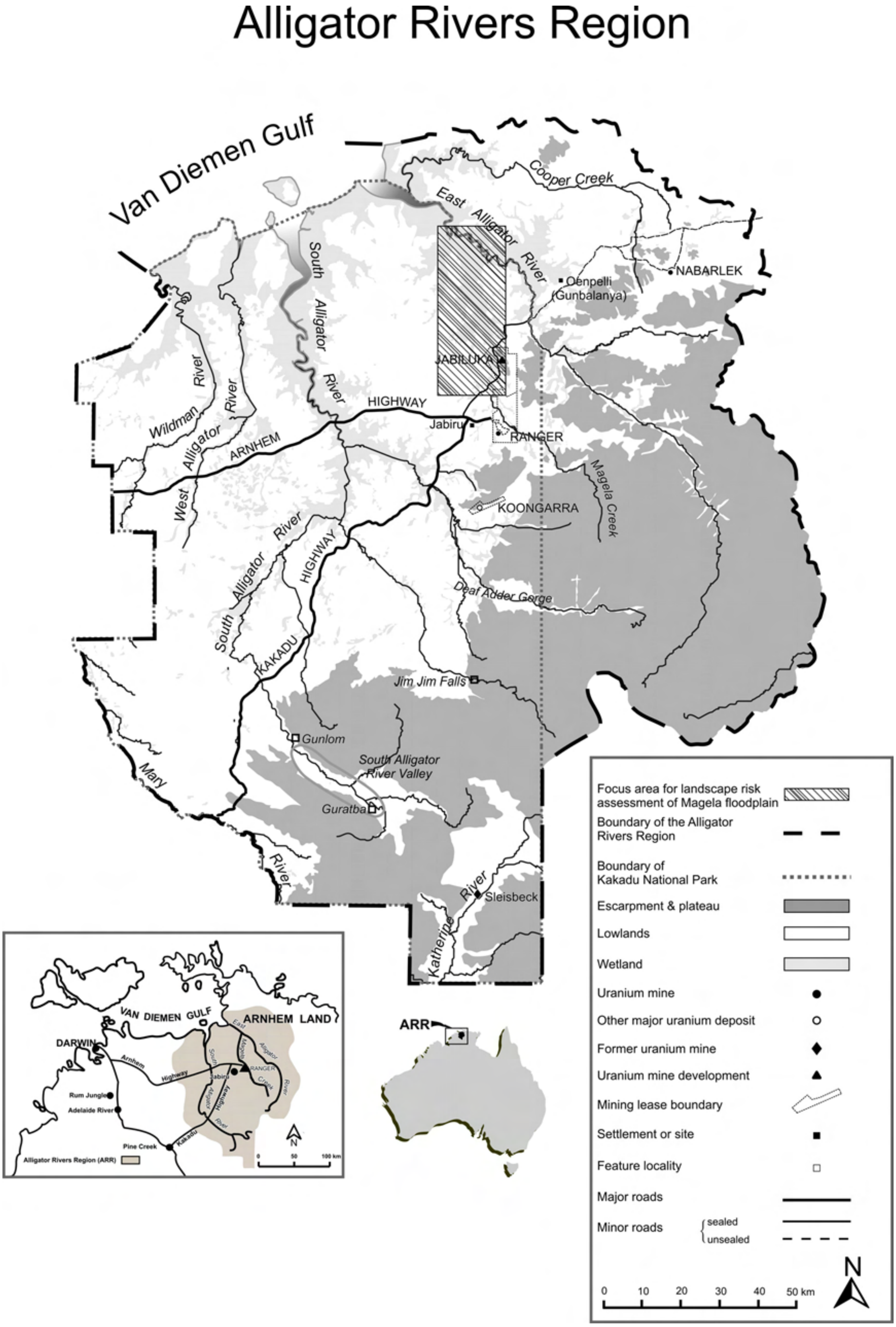

Figure 3 The Alligator Rivers Region in Australia's Northern Territory showing the area for landscape scale risk assessment of the Magela floodplain (hatched area). The boundary of Kakadu National Park, within the Region, is indicated.

Table 2 Summary of spatial data layers available for the ARR with potential use in ecological risk assessment grouped by assets, threats, environmental character and management zones

Category	Layer Description	Custodian	Source(s)	Format(s)	General coverage of datasets within Kakadu NP (see tables for coordinates)
Assets	Waterbirds	PWCNT	Aerial surveys of waterbirds in 2001 & 2003	Point shapefile data and derived raster grids	Complete coverage of major wetlands within Kakadu NP
	Native Vegetation Communities	DEWHA	Schodde et al 1987 & Storey et al 1969 &1976	Vector polygon shapefile and derived raster grids	Complete coverage of Kakadu NP
		DEWHA	Boyden et al 2003	Raster grids & derived vector polygon shapefiles	Covers Boggy Plains, Sth Alligator River only
		DEWHA	Finlayson et al 1989	Vector polygon shapefile and derived raster grids	Complete coverage of Magela floodplain
		DEWHA	Lowry et al 2005	Vector polygon shapefile and derived raster grids	Complete coverage of Magela floodplain
	Land units	PWCNT	Wells 1979	Vector polygon shapefiles	Complete coverage of Magela catchment
Threats	Feral Animals	PWCNT/ ***eriss***	Aerial surveys of feral animals in 2001 & 2003	Point shapefile data and derived raster grids	Complete coverage of lowland landscapes, including wetlands within Kakadu NP
	Weeds	***eriss***	Satellite remote sensing	Point shapefile data for field surveys and 2.7m pixel image data	Partial coverage of Magela floodplain
		PAN	PAN central weeds database	Point shapefile data	Point data from opportunistic field surveys within Kakadu National Park
		eriss	*eriss* field surveys	Point shapefile data and derived raster grids	Point data from opportunistic field surveys within Magela floodplain
		DPIFM	NT government data	Point shapefile data	Point data from opportunistic field surveys within Kakadu National Park
		PAN	Cowie & Werner 1987/88	Point shapefile data	Point data from opportunistic field surveys within Kakadu National Park
		eriss	Knerr 1998	Point shapefile data	Point data from opportunistic field surveys within Kakadu National Park

PAN = Parks Australia North, DEWHA = Department of the Environment, Water, Heritage and the Arts; DIGO = Defence Imagery & Geospatial Organisation; BFC = Bushfires Council of the NT; ARR= Alligator Rivers Region

Table 2 (continued)

Category	Layer Description	Custodian	Source(s)	Format(s)	General coverage of datasets within Kakadu NP (see tables for coordinates)
Environmental characteristics	Infrastructure	***eriss*** & Geoscience Australia	1:50 000 DIGO Geoscience Australia & QuickBird™)	Vector polygon shapefiles and derived raster grids 1:250k Geodata & 1:50k DIGO*	Entire ARR region, including KNP (1:50 000 data) including updated information from QuickBird™ data (for partial coverage of the Magela Ck. Catchment)
	Distance to water	Geoscience Australia	1:250 000 Geoscience Australia	Interpolated raster grids from vector polygon shapefiles	General coverage of datasets within KNP (see tables for coordinates)
	Wetland areas	Geoscience Australia	1:250 000 Geoscience Australia	Vector polygon shapefiles and derived raster grids	Complete coverage of KNP
	Fire scar history	BFC	BFC Landsat	Vector polygon shapefiles	Complete coverage of KNP
	Digital elevation model for the Magela floodplain (uses available high-resolution data with gaps substituted by low-resolution data)	DEWHA	Combination of data from DIGO (low-resolution) & NRETA (high-resolution)	Raster	Complete KNP region (low-resolution data) and including partial high-resolution coverage of Magela floodplain by data component.
Management zones	Feral animal management zones	PAN/***eriss***	Boundaries digitised from PAN NRM hardcopy maps by ***eriss***	Vector polygon shapefiles	For selected management districts of KNP
	KNP Boundary	PAN/DEWHA	DEWHA	Vector polygon shapefiles	Delineates the KNP region
	Mining Leases of the ARR	DEWHA	DEWHA	Vector polygon shapefiles	Delineates mineral leases within KNP

PAN = Parks Australia North, DEWHA = Department of the Environment, Water, Heritage and the Arts; DIGO = Defence Imagery & Geospatial Organisation; BFC = Bushfires Council of the NT; ARR= Alligator Rivers Region

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 Heritage[3] (UNESCO 1972) status and are listed under the Ramsar[4] 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 there 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.

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[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 (Finalyson 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.

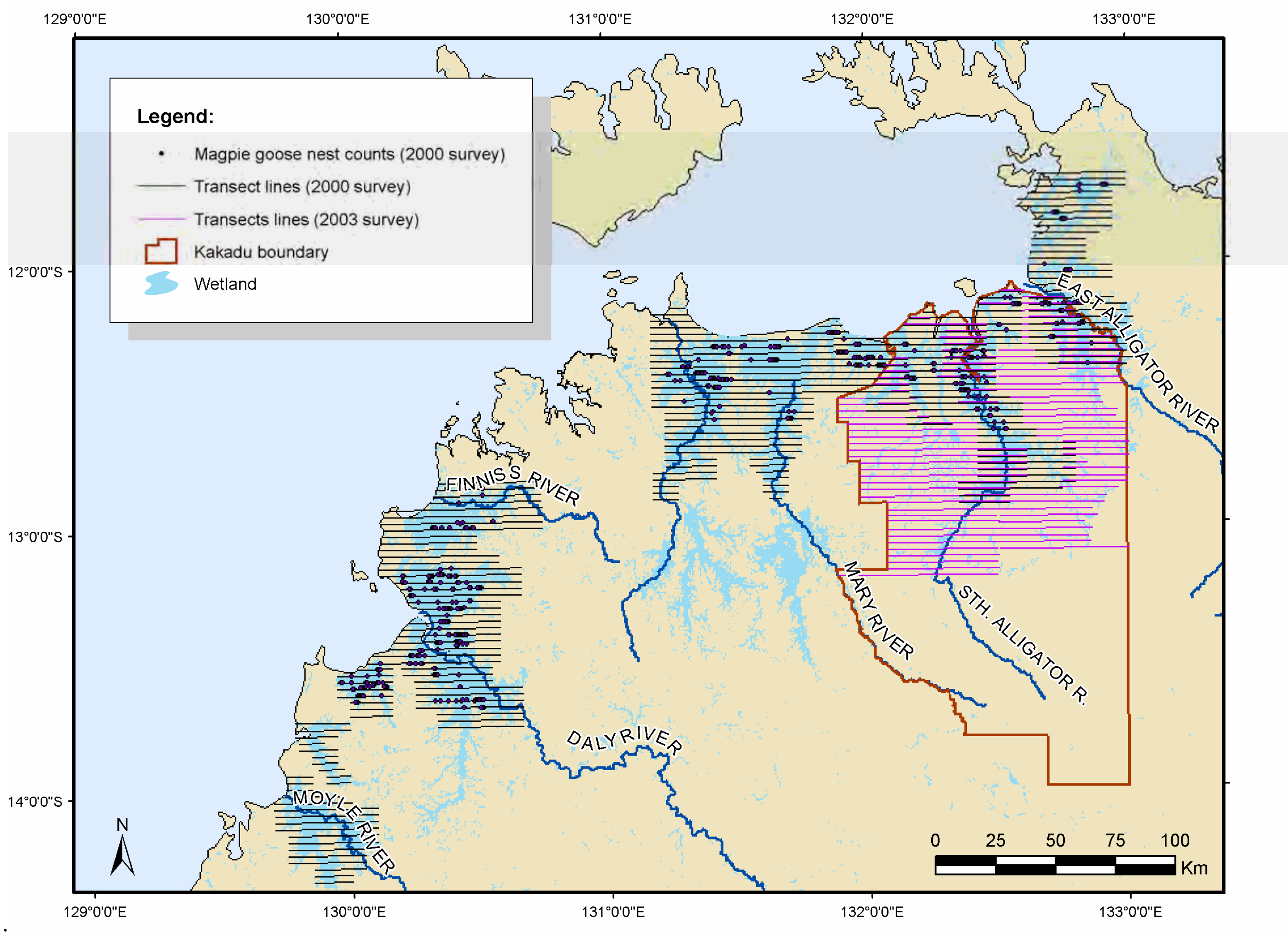
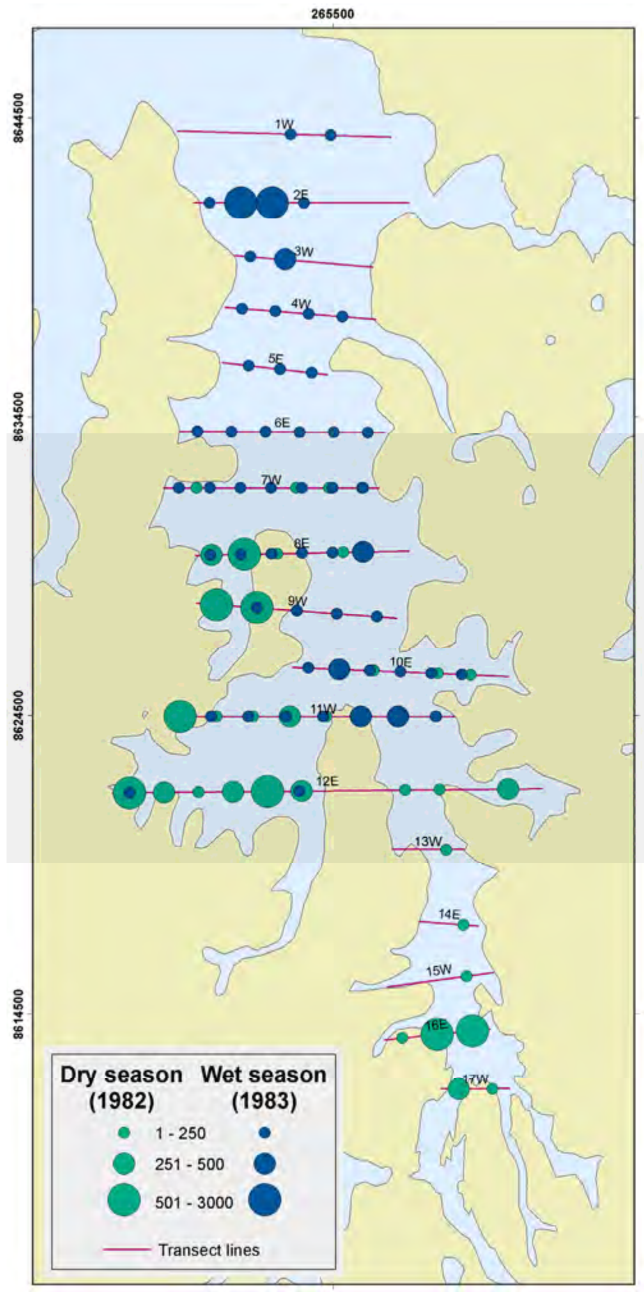


Figure 4 Distribution of magpie goose nests recorded by aerial survey in the wet season of 2000 by Keith Saalfeld. Transect lines indicate the extent & location of aerial surveys conducted in 2000 & 2003, where a common region is shared between both surveys within Kakadu National Park.

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 Finalyson 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 Finalyson 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 5km^2 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.

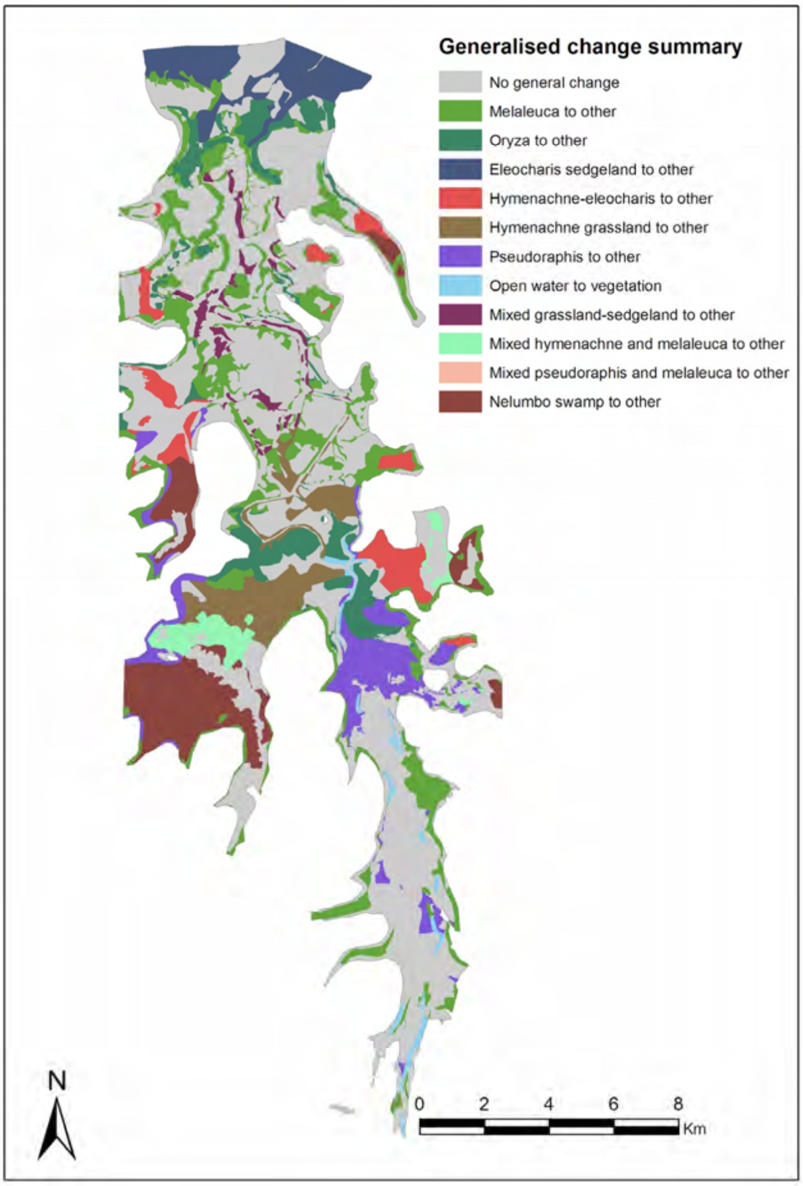


Figure 7 Generalised vegetation change classes for the Magela floodplain since 1983 derived by overlaying the Finlayson (1989) and Lowry (2004) vegetation maps. Note this assessment did not include most recent data on change due to para grass invasion.

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 a 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.

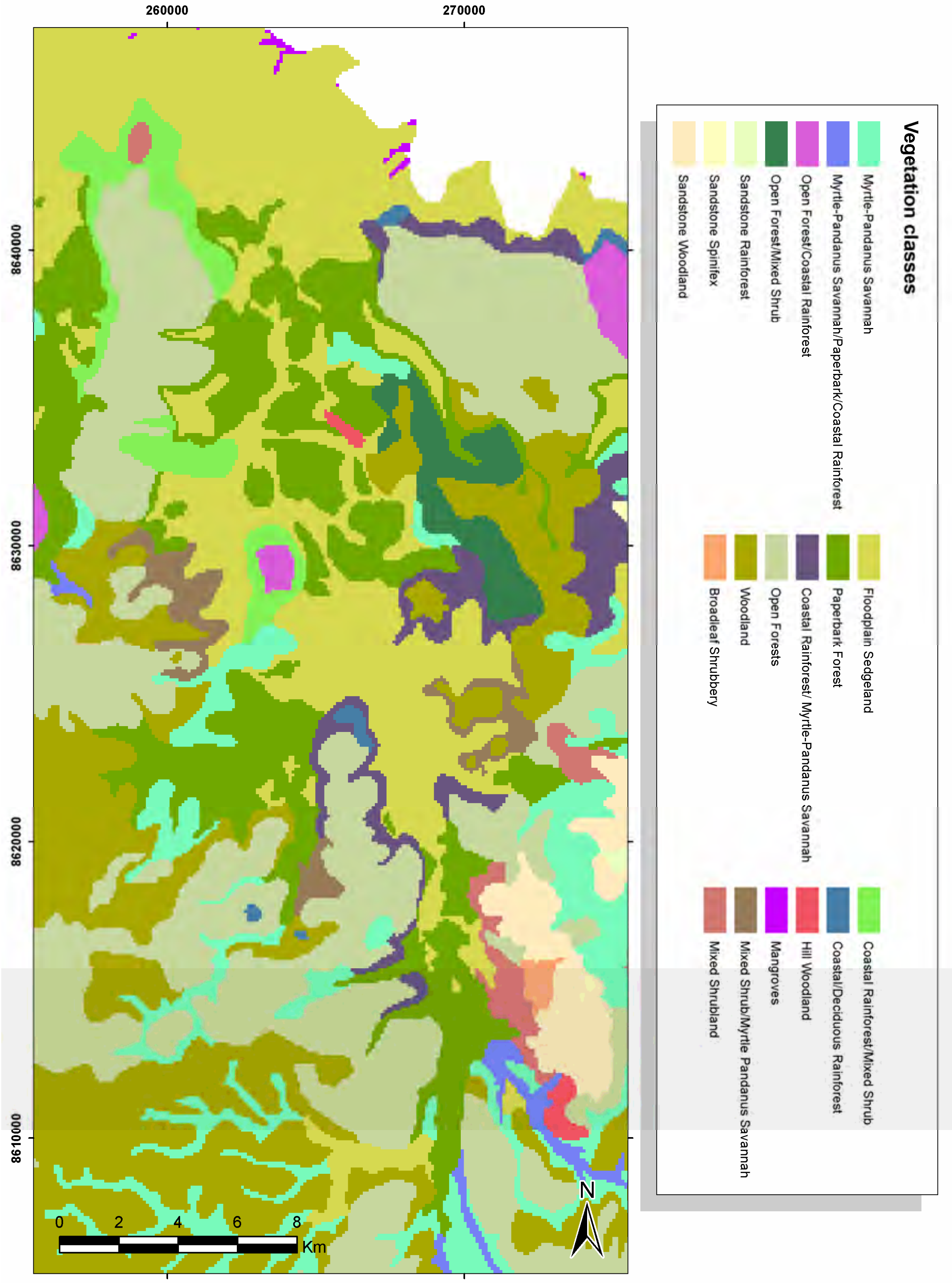


Figure 8 Vegetation assemblages of the Magela Creek floodplain and surrounding landscape produced from the Kakadu National Park Vegetation classification (Schodde et al 1987)

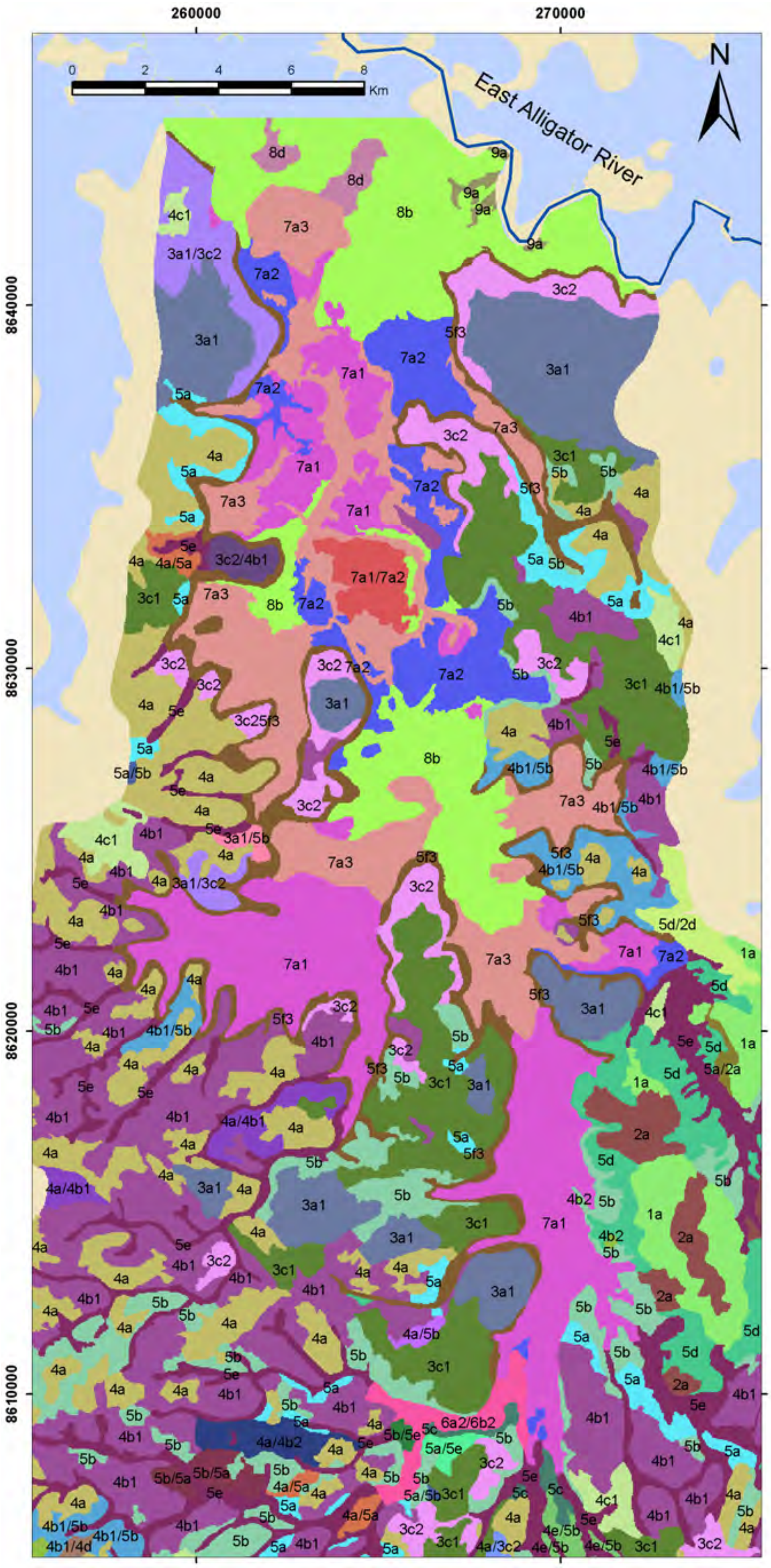


Figure 9 Land units of the Magela Creek catchment (Wells 1979). A full explanation of unit codes is provided in Table A6.2.

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 Finalyson 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.

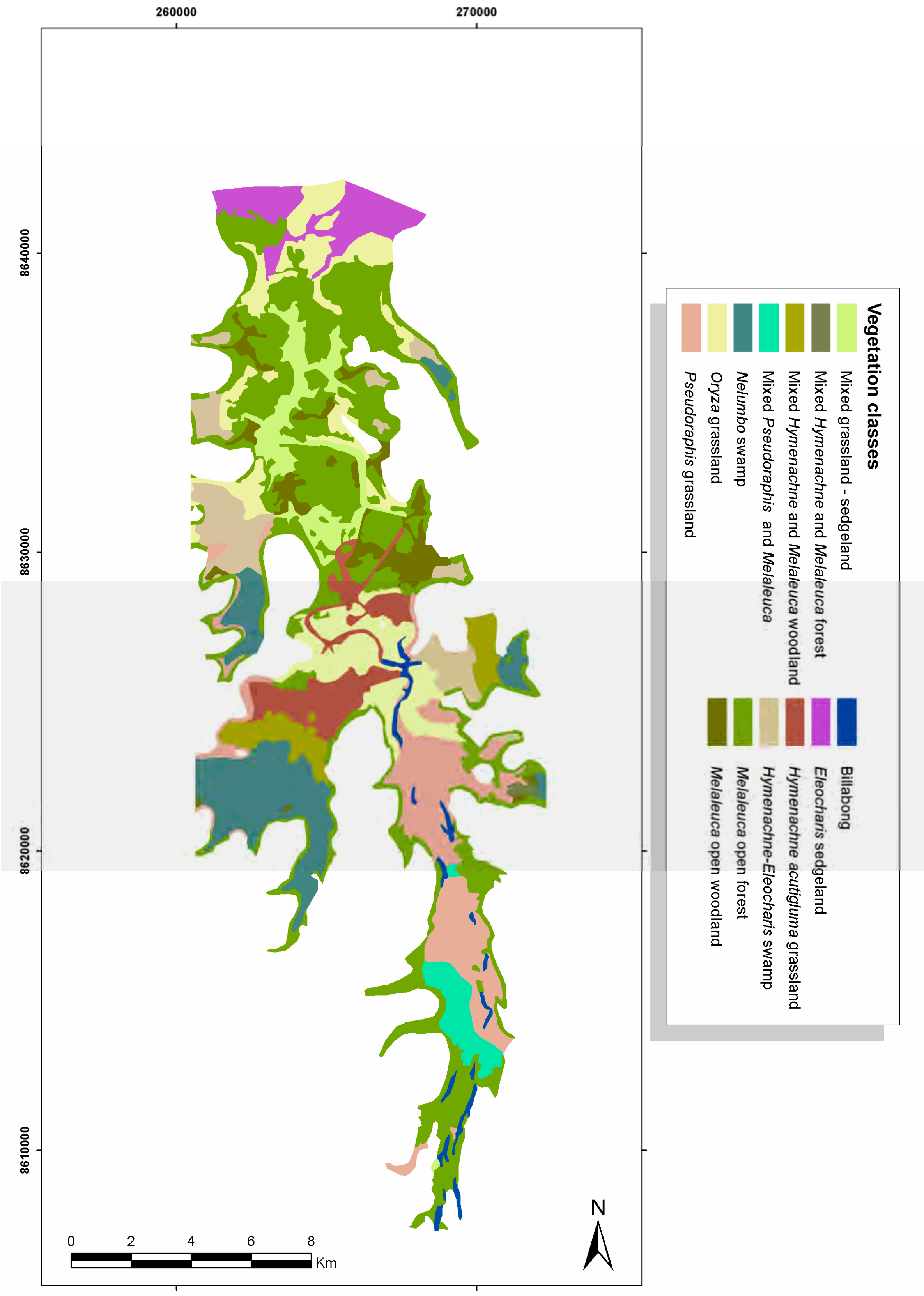


Figure 10 Vegetation assemblages of the Magela Creek floodplain produced by Finlayson et al 1989

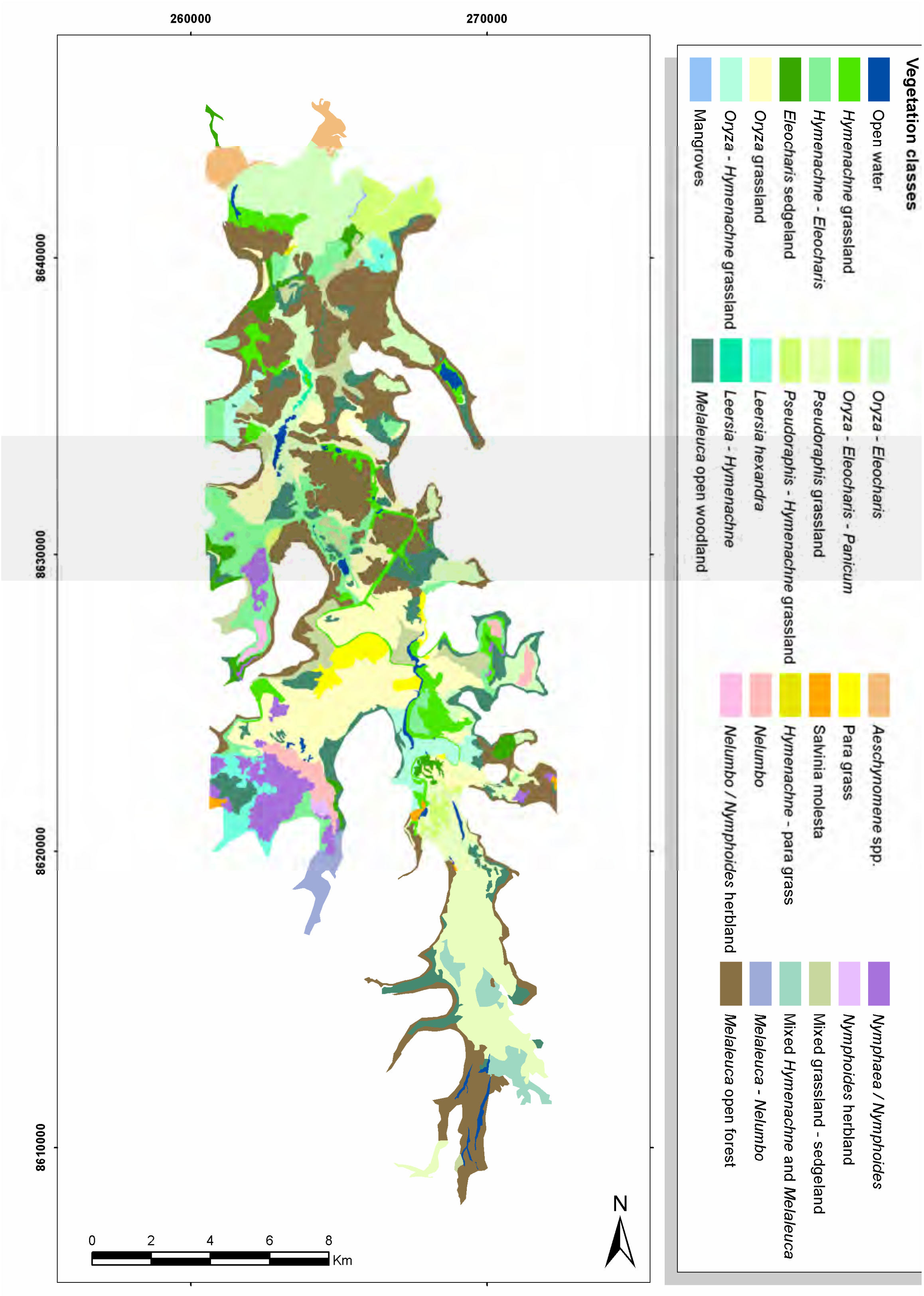


Figure 11 Biophysical features and vegetation assemblages of the Magela Creek floodplain produced by Lowry et al 2002

3 Environmental threats

A number of general reviews and analyses have identified a suite of stressors operating at a landscape scale, other than mining related pressures, that currently, or will eventually, affect the ecological condition of ARR wetlands and the biodiversity that they support (Bayliss B et al 1997). In particular exotic species invasions and the subsequent effects of climate change are considered the most significant biophysical pressures effecting wetlands, and associated waterbird habitats (Finlayson, Storrs et al 1997). Specifically the identified threats are:

- loss in extent and diversity of habitats due to weed invasions from Mimosa (*M. pigra*), Olive hymenachne (*H. amplexicaulis*), Salvinia (*S. molesta*) and para grass (*Urochloa mutica*);
- damage to both micro- and macro- scale habitats caused by feral animals such as pigs and buffalo;
- loss of freshwater habitat due to salt-water intrusion caused by sea-level rise from climate change.

The information layers described in this section provide a basis for the assessment of the extent of key threats identified for the Magela Creek floodplain. Gaps in knowledge, where further research is necessary to evaluate risk to wetland habitats, can also be identified. Projected habitat loss due to climate change was not considered in this assessment.

3.1 Weeds

Like many tropical wetlands, the Magela floodplain is threatened by invasive weed species. Mimosa (*Mimosa pigra*), Salvinia (*Salvinia molesta*) and para grass (*Urochloa mutica*) are the most immediate weed threats. A dedicated risk assessment of these weeds on the Magela floodplain is being undertaken concurrently with other ecological risk assessment programs at ***eriss*** (Walden et al, in prep). The ability of these weeds to dominate and completely alter ecosystems and to drastically reduce floral and faunal diversity throughout the tropics has been well documented (Walden et al 2004, Storrs 1996, Knerr 1998, Douglas et al 2001, Whitehead & Dawson 2000). Fortunately, the Magela floodplain remains free of mimosa due to an active 'search and destroy' program by Kakadu National Park management, and the impact of the floating fern Salvinia has been greatly reduced by biological control using the weevil *Cyrtobagous salviniae*. Thus the primary focus of the ecological risk assessment was the impact and current and potential distribution of para grass.

Para grass was first discovered on the Magela floodplain during the 1950s, having been introduced to the Alligator Rivers Region decades earlier as a pasture grass. A study in the mid 1990s by Knerr (1998) revealed that, in the vicinity of the largest infestation on the Magela floodplain, para grass spread from 132 to 422 ha in the five years between 1991 and 1996 (Figure 12). This study used aerial photographs and a nested quadrat technique on the ground to determine the distribution of para grass and the change in distribution between 1991 and 1996 in the most heavily infested area. A total of 30 quadrats were sampled in each of four dominant grassland communities during the dry (November) and wet (April) seasons of 1995–96. The increase in the area of para grass was coupled with a corresponding decrease in area of a community of wild rice (*Oryza meridionalis*) (Knerr 1998).

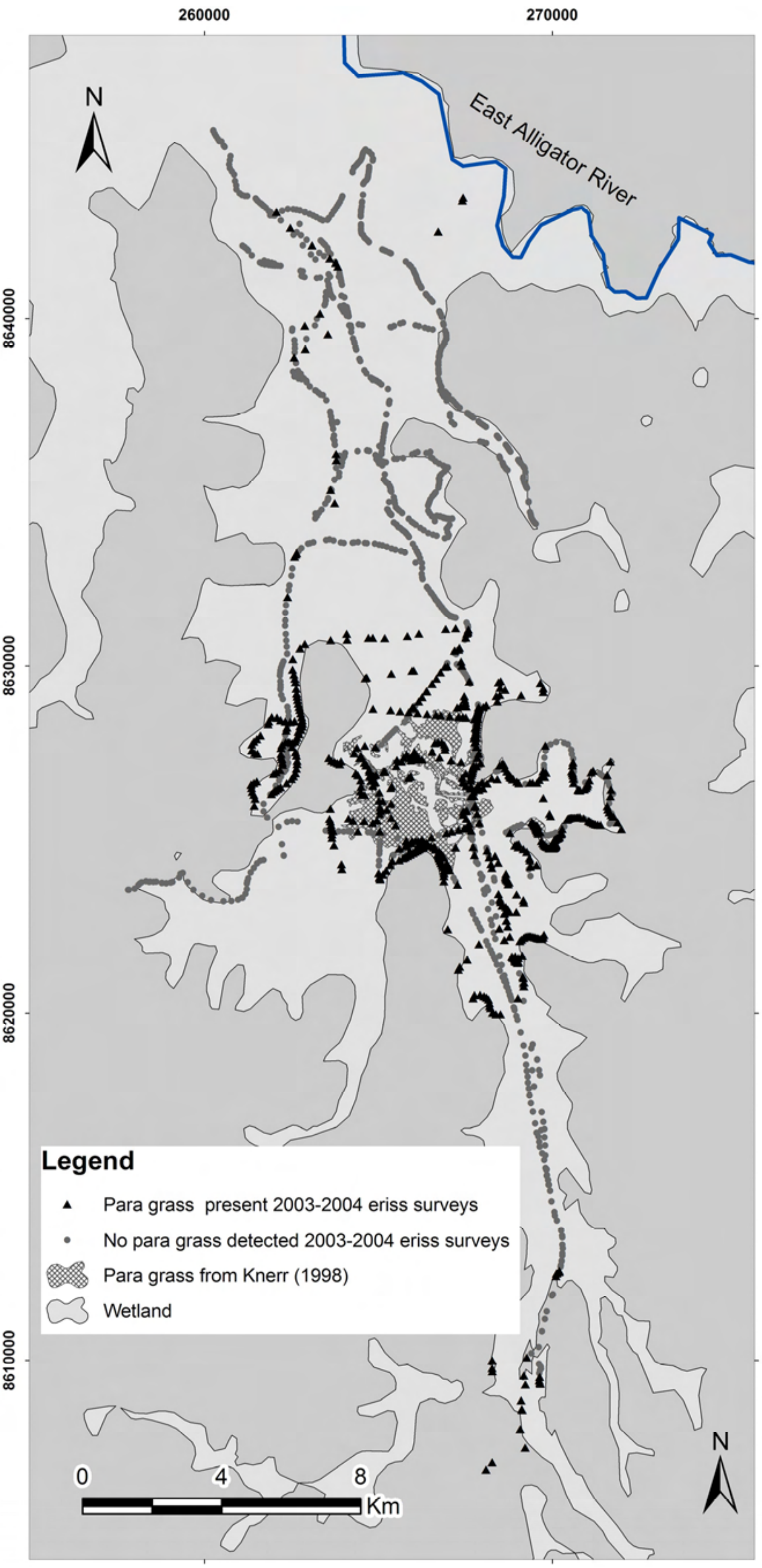


Figure 12 Para grass distribution on the Magela Creek floodplain from Knerr 1998 and point observation records by helicopter and airboat between 2003–2004 from ***eriss*** surveys and records from NT Government

Surveys conducted from 2003–2006 in conjunction with QuickBird™ remote sensing data revealed that this area has continued to expand rapidly, with para grass spreading to many other areas of the floodplain. Preliminary results of this survey work are shown in Figure 13. Prior to the ***eriss*** surveys in 2003–2004, the only other spatial investigation of para grass distribution on the Magela floodplain was by Knerr (1998).

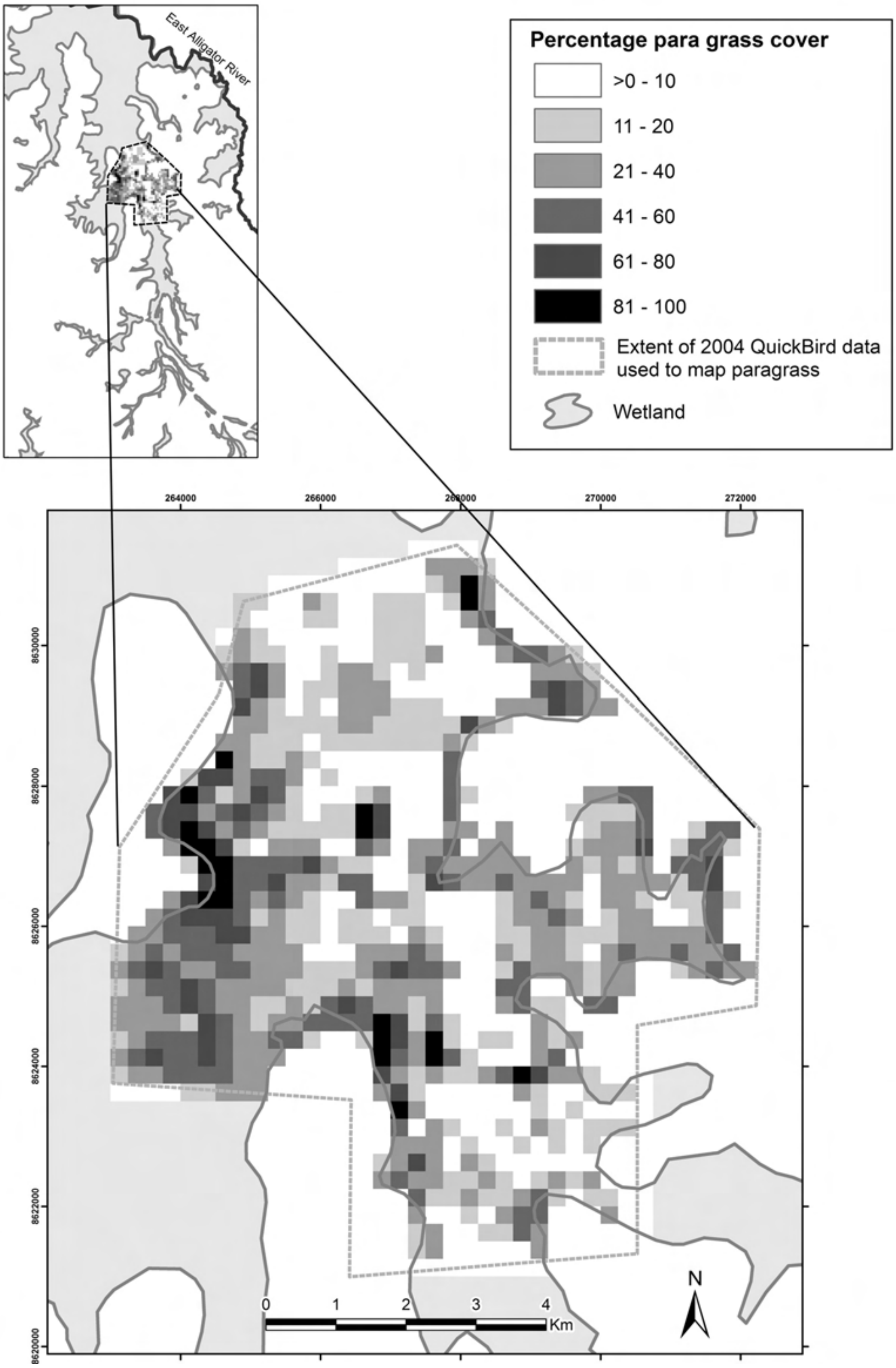


Figure 13 Estimates of para grass cover (represented as a percentage at 250 m grid cell resolution) derived from supervised classification of remotely sensed data collected in 2004

Wetlands of the ARR continue to be threatened by new weed introductions. In this regard Olive Hymenachne (*Hymenachne amplexicaulis*), currently established in Top End wetlands west of KNP, is the most likely new incursion to Park wetlands. Several outbreaks of this weed within the park have already occurred. Its successful suppression has only been due to vigilance, timely intervention, and follow up control by land managers (Ferguson, pers com 2005). Nevertheless the potential for Olive Hymenachne to invade wetlands of the ARR has been well demonstrated (Csurhes et al 1999). Remote sensing is also likely to be a useful tool for monitoring its distribution on wetlands.

3.1.1 Para grass distribution at 1991 and 1996 for a selected area of the Magela floodplain (Knerr 1998)

As part of a university honours project, a vegetation survey and mapping study was conducted by Nunzio Knerr to estimate the change in distribution of para grass (*Urochloa mutica*, or formerly *Brachiaria mutica*) from 1991 to 1996 for a selected area of the Magela. floodplain (Knerr 1998). Four vegetation communities were examined (dominated by either *Urochloa mutica*, *Oryza meriondalis*, *Hymenachne acutigluma*, and *Pseudoraphis spinecens*). The plant communities used for mapping units follow Finalyson et al (1989), with the addition of para grass, which was described as 'growing in dense clumps and dominates…throughout the year'. Knerr (1998) concluded that the Oryza grassland was the primary native community displaced by para grass invasion, based on comparisons with historical records (Finalyson et al 1989). Mapping was undertaken using georefereced ground data in conjunction with aerial photo interpretation at a scale of 1:25 000.

Positional anomalies in the projection of the original GIS dataset were identified and have been rectified for the 1996 dataset to an acceptable accuracy level (by re-registering to a standard QuickBird™ satellite image using the RST procedure in ENVI™). Resulting map is shown in Figure 12. To date, projection anomalies have not been resolved for the 1991 distribution map, and this will need to be reregistered if it is to be of any value.

The full metadata report for this dataset is provided in Appendix 1.7.

3.1.2 Airboat and helicopter surveys of para grass on the Magela floodplain conducted by *eriss* from 2003–2004

With limited resources it was not possible to conduct a systematic survey of para grass for the entire Magela floodplain. However, in March 2003, as part of a broader floodplain vegetation mapping program (Sections 2.2.4 & A1.6, Figure 11), two rapid-assessment, mobile-airboat surveys were conducted by a trained observer/recorder, where vegetation types, including para grass, were ranked in order of cover dominance for about 1200 locations spanning the length of the floodplain. Using this information and historical information on para grass distribution (Knerr 1998), it was decided to focus further para grass-specific survey efforts within the region of the largest infestation located near the centre of the Magela floodplain where the aim was to obtain more detailed information on environmental and native plant associations of para grass across its range. Therefore in June 2004, another airboat survey of this region was completed, followed by a low level helicopter survey. For this airboat survey, the percentage cover of dominant plant species and open water were recorded in detail for some 80 sites located along four transverse (east-west orientated) transects (each approximately 3.5 km in length and spaced at about 1km intervals) and two longitudinal adjoining transects. Sites observations were made at approximately 250 m intervals along the transect where each was taken in a 20 m radius of the bow from the standing airboat. Water depth measurements (with coincident measurement at the Jabiluka gauging station) and photographs were also taken at most 2004 sites. The main purpose of the accompanying helicopter survey was to delineate larger, homogeneous patches of para grass across a broader extent than could be achieved using the airboat alone. Larger patches of homogeneous vegetation were later used as training (and validation sites) for classification of a coincident remote sensing image capture (Sections 3.1.3 & A1.9, Figure 13).

Surveys of dominant floodplain vegetation types in the Magela floodplain were conducted using airboats on 05/03/03 – 06/03/03 & 18/03/03 – 19/03/03 & 16/06/04. The helicopter survey was conducted on 18/06/04. The locations of all observation points for all surveys were recorded using a handheld Garmin eTrex™ GPS unit. Point data records for para grass are illustrated in Figure 12.

The full metadata report for this dataset is provided in Appendix 1.8.

3.1.3 A preliminary classification of para grass distribution on a selected region of the Magela floodplain derived from high resolution multi-spectral Quickbird™ satellite imagery captured on 25 June 2004

This map production shows the distribution and density of the environmental weed, para grass (*Urochloa mutica*) over a central 64 km^2 area of the Magela Creek floodplain. It was produced using supervised classification of multispectral QuickBird™ satellite imagery (captured on 25 June 2004), in conjunction with spatially referenced ground and helicopter survey data. The quality of the base QuickBird™ image is excellent. Image capture timing occurred when fire was has not occurred and spectral discrimination of para grass from other major floodplain plant communities was considered most pronounced. Classification accuracy assessment indicated an overall accuracy of 86% and a producer accuracy for para grass ranging from 90 to 97%, across three visibly distinct ‘states’ of para grass indicating that there is potential to monitor para grass using QuickBird™ imagery (Boyden et al 2007).

The satellite image captures an Area of Interest (AOI) considered to be the centre of the largest para grass infestation of the floodplain located in the Nankeen billabong area. The AOI also incorporates native vegetation communities that are potentially threatened by this infestation (Oryza, Eleocharis and Hymenachne spp), in addition to floodplain margin areas that already have para grass infestations or have the potential to become infested. Full coverage of the floodplain was not possible at the time of image capture due to the relatively high cost of this type of imagery. The map assists monitoring and weed control targeting, and the layer may be overlayed with other spatial data such as bathymetry and native vegetation to facilitate predictive modelling.

Percentage cover of para grass was derived from original classification within 250 m^2 grid cells using zone statistics in Spatial Analyst™ (Figure 13).

The full metadata report for this dataset is provided in Appendix 1.9.

3.2 Feral animals

There is little doubt that feral animal activity particularly from pigs and buffalo can physically modify wetlands and floodplain environments. Buffalo reached peak populations in the 1960s, and have since been reduced to manageable numbers within KNP with the implementation of a dedicated eradication campaign. Despite their removal, Buffalo have undoubtedly influenced development of floodplain systems in the ARR, and have been implicated as a cause of salt-water intrusion into freshwater systems (Finlayson et al 1997).

Disturbance by pigs has been listed as a threatening process under the EPBC act. Pig numbers, despite an annual reduction campaign, may have increased in KNP since reduction in the buffalo population (Bayliss pers com). Evidence suggests that there has also been a concomitant increase in widespread pig disturbance on floodplain regions of KNP (Finlayson et al 1997). Disturbance activity probably facilitates the establishment of weeds in floodplain areas, and selective foraging by pigs may also limit availability of high-energy foods (such as the water chestnut, *Eleocharis dulcis*), important to many native animals, including the magpie goose (Whitehead & Darwson 2000). However, no quantitative studies have been undertaken to determine the relative impact on such resources across Top-End wetlands and at different pig population densities.

An adaptive management philosophy has been adopted by KNP board of management for the control of feral animals (Field et al 2006). However its implementation requires effective use of information through the development of decision-support tools that complement informed and skilful management. This requires gathering appropriate quantitative data where monitoring indices are both practical and measurable. In this context indices ideally need to be cost-effective and represented at an appropriate management scale. They should also be capable of measuring feral animal populations and their impacts, as well as the effectiveness of targeted control strategies.

For species of concern, there is a need to review available information. Three types of data were available when writing this report:

- systematic aerial counts of feral animals, including buffalo, pigs, horses, cattle and donkeys;
- associated visual estimates of ground disturbance by feral animals (pigs, buffalo, horses);
- as an adjunct to above data, management zones for monitoring and control of feral animals within KNP have been produced.

Aerial surveys of feral animals have been conducted periodically in the Top End of the Northern Territory since the 1980s. The survey technique has been standardised and populations of the larger species (buffalo, horses, cattle, and donkeys) can be estimated with reasonable precision at a landscape scale using these methods (Bayliss 1989). Monitoring of feral animal population density is invaluable for planning of control programs and underpins successful, targeted feral animals control. In conjunction with 'cost of control' modelling population information can be used to optimise control programs given limited economic resources.

Feral pig numbers generally can not be estimated accurately by aerial survey (Bayliss & Yeomans 1989). As an alternative, aerial survey estimates of ground disturbance (pig rooting activity) may provide a surrogate to measure pig abundance, and possibly also the success of population reduction programs (Figures 14–15). Site-specific (and context-dependent) 'damage-density' relationships, still need to be developed for pigs, however. No published works exist that outline quantitative relationships between the extent of ground disturbance and local population size in different environments (eg floodplain vs. forest). In this regard a 'ground-disturbance' surrogate may be too insensitive for monitoring population change at the scales required for population control and, as Hone (2002) found, a very large reduction in feral pig population is required to get a significant reduction in ground digging extent. There is also some doubt as to the ability to separate between disturbance caused by pigs from that caused by buffalo (or horses) by aerial observation. Nevertheless, since the successful control and reduction of the buffalo population within KNP, it is believed that the vast majority of ground damage observed in contemporary surveys on wetland & floodplain environments is the result of pigs. Further, aerial ground disturbance assessment may be the only way to estimate pig populations in a cost effective way and at the scale necessary for monitoring control strategies.

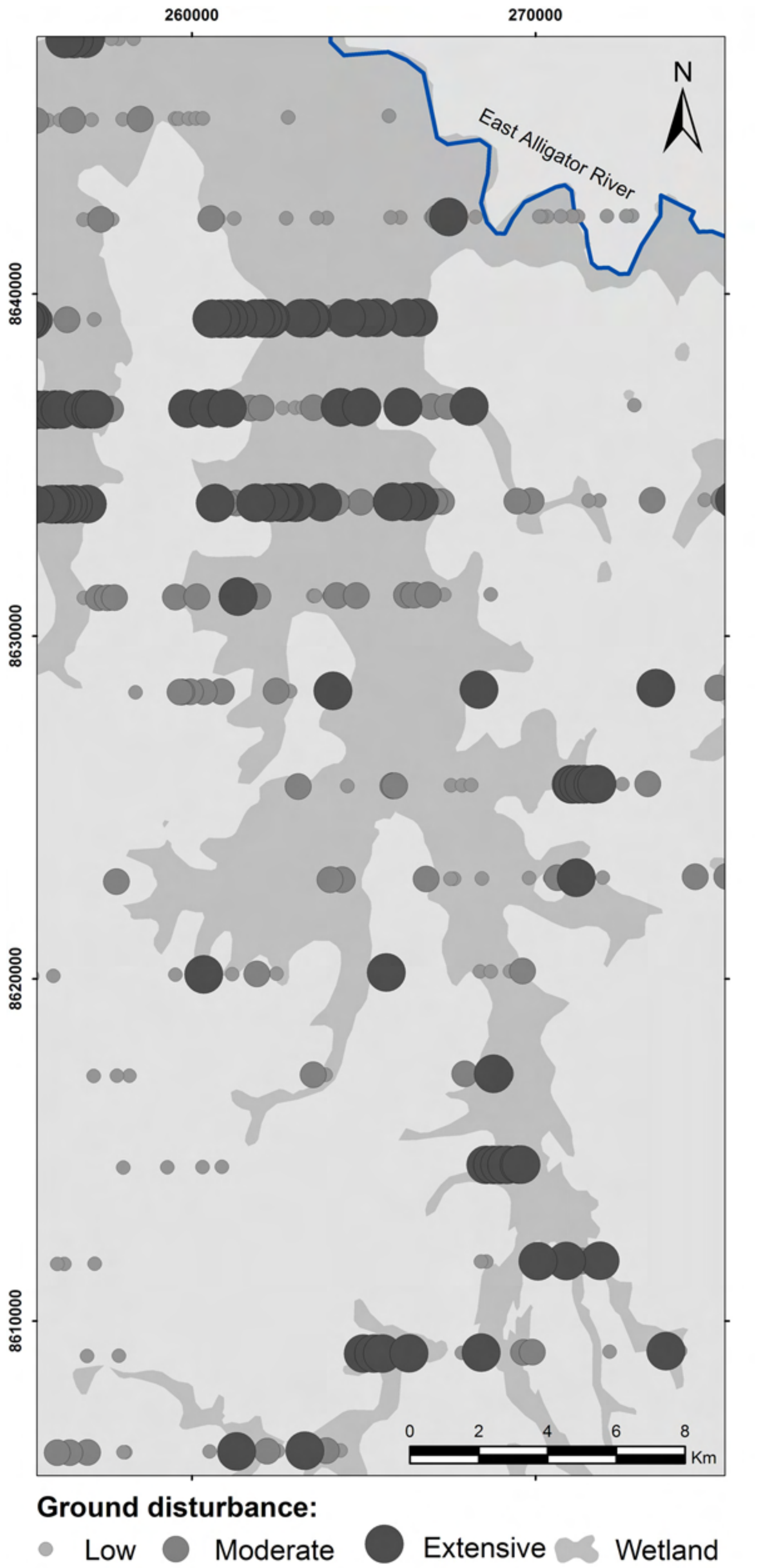


Figure 14 Estimates of ground disturbance by pigs and buffalo for the Magela floodplain region of KNP as recorded in the aerial survey conducted in November 2003

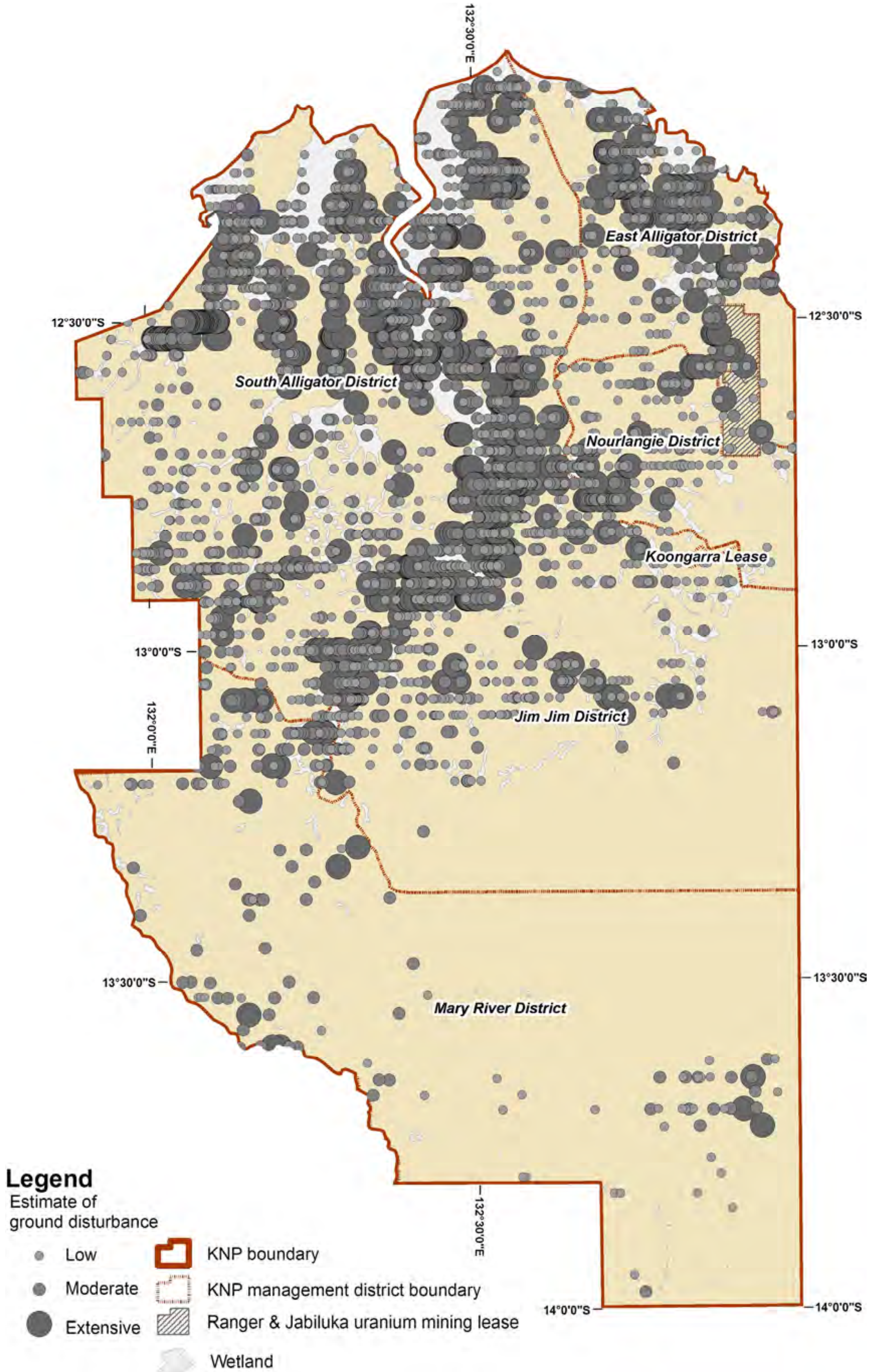


Figure 15 Estimates of ground disturbance by pigs and buffalo in KNP as recorded in the aerial survey conducted in November 2001 and November 2003

3.2.1 Aerial surveys of feral animals conducted in Kakadu National Park in November 2001 (south KNP) and November 2003 (north KNP)

The dataset provides information on the distribution and abundance of feral animals (pigs, buffalo, cattle, horses and donkeys) and visual estimates of ground surface damage by pigs and buffalo within KNP from aerial survey conducted in 2001 and 2003. Combined data offers complete coverage of the lowland landscapes within KNP.

Data originated from two systematic aerial surveys involving standardised sample counts and using pre-determined transect lines spaced at regular intervals and flown using fixed-wing aircraft. The aircraft flew at a height of 72.6 m (250 ft) at an average speed of 186 km/hr along each transect. Observer counts were made from both the port and starboard side by trained observers within a 200 m swath along each transect (using marks on the aircraft wings as guides). Transects were 2.5 km apart over the coverage area. The same general methods were applied to both surveys.

Observations were made of feral animal abundances (Figures 16–20), as well as a visual assessment of feral animal damage, where areas of low, medium, or extensive ground disturbance were recorded. Feral animal ground damage was distinguished, where possible, as being caused by either Pigs or by Buffalo, as listed by 'species' attribute as either ‘Pig rooting’ or ‘Buffalo damage'. However observers have expressed some doubt as to the ability to consistently and accurately separate between the specific types of ground damage (Bayliss per com 2005). Nevertheless the vast majority of damage observed in the 2001 & 2003 surveys was attributed to feral pigs. The level of observed damage is classified by the 'Number' attribute by the values of 1, 2 and 3, representing either low, medium, or extensive damage, respectively (Figures 14–15).

Damage estimate data are complementary to abundance data and are considered a more robust method of estimating actual population levels for pigs, in comparison to aerial counts methods. However there remains a paucity of quantitative data linking damage extent to actual population levels, and relationships are likely to be site-specific.

Each record has spatial coordinates and is stored as a point, rather than records relating to a specific area. However, raster data files have also been derived from point records, for each animal species counted in the survey. In these cases Spatial Analyst™ was used to calculate the sum of point-data counts for within grid cells that intersected transect lines at 250, 500 m and 1 km grid scales.

All attribute fields for the shapefile are described in Table A3.1a. A map showing the location and extent of the transects covered in both surveys is shown in Figure A2.1. All records are point records rather than records relating to a specific area.

Scientific comparison with other datasets should be limited to surveys using similar methodology. NRETA have been conducting similar surveys (eg ‘Top End Feral 1985’, ANZLIC identity code ANZNT0002002015).

The full metadata report for this dataset is provided in Appendix 1.10.

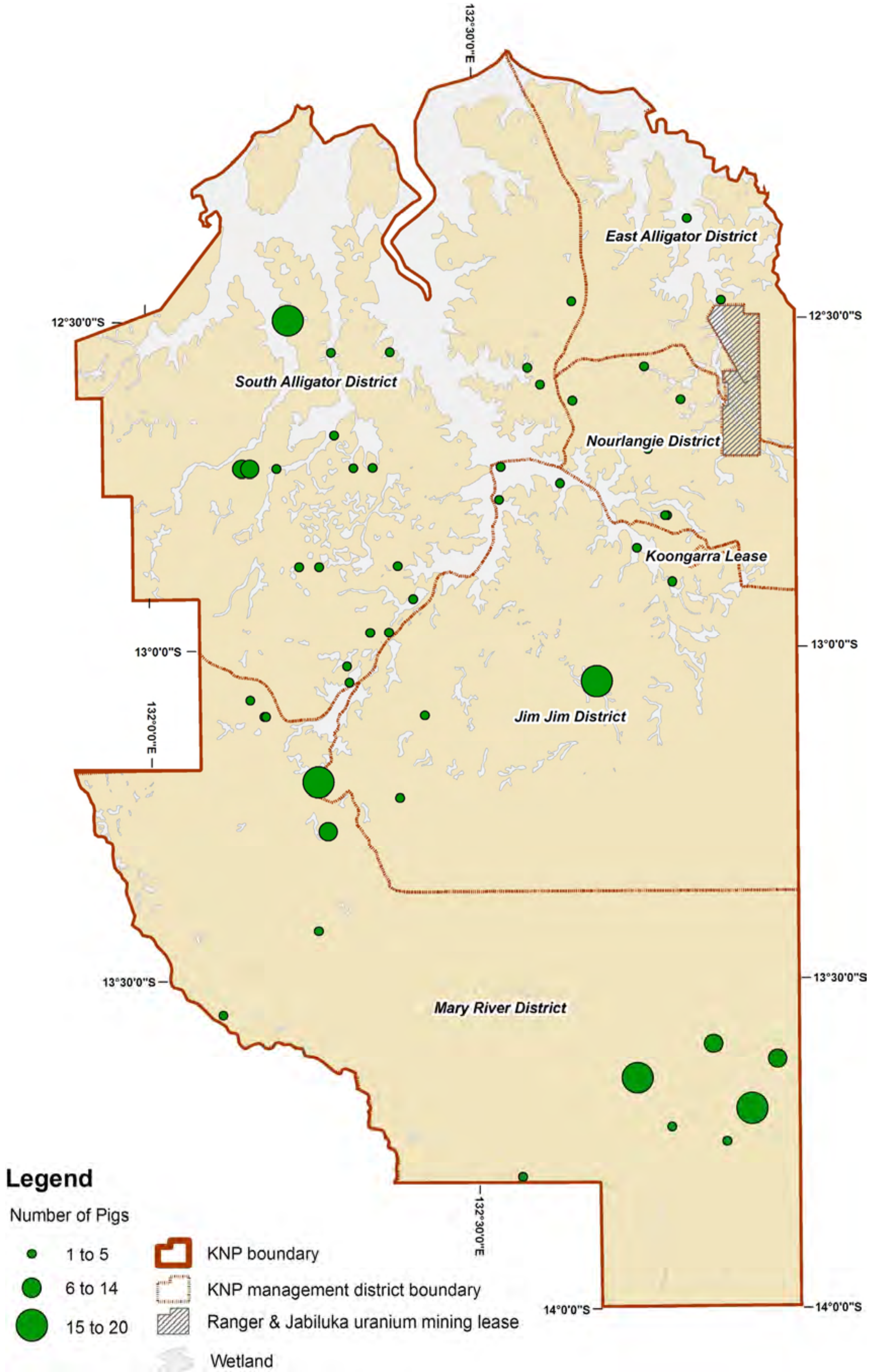


Figure 16 Distribution and number of pigs recorded during aerial surveys of KNP conducted in 2001 and 2003

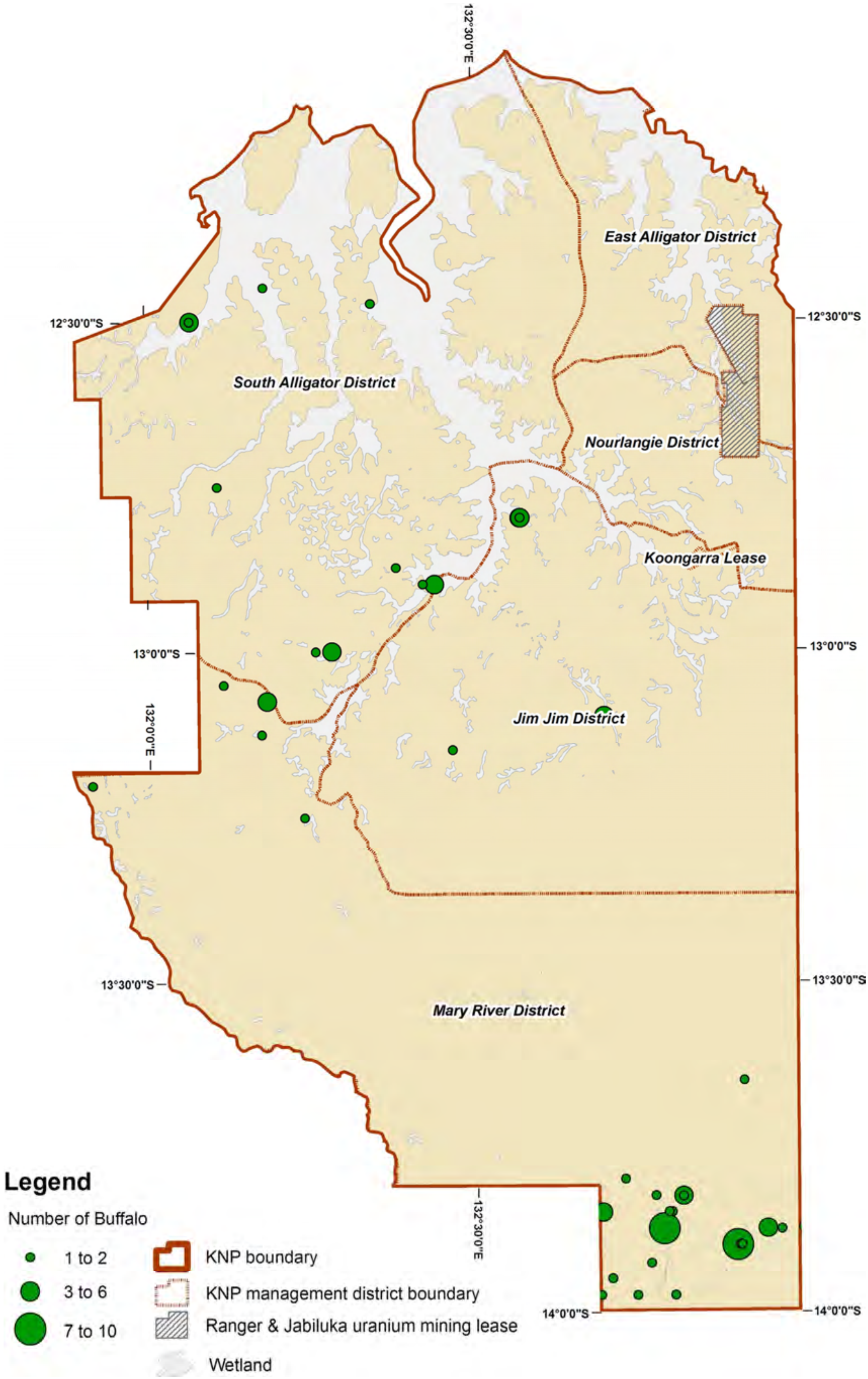


Figure 17 Distribution and number of Buffalo recorded during aerial surveys conducted in 2001 and 2003

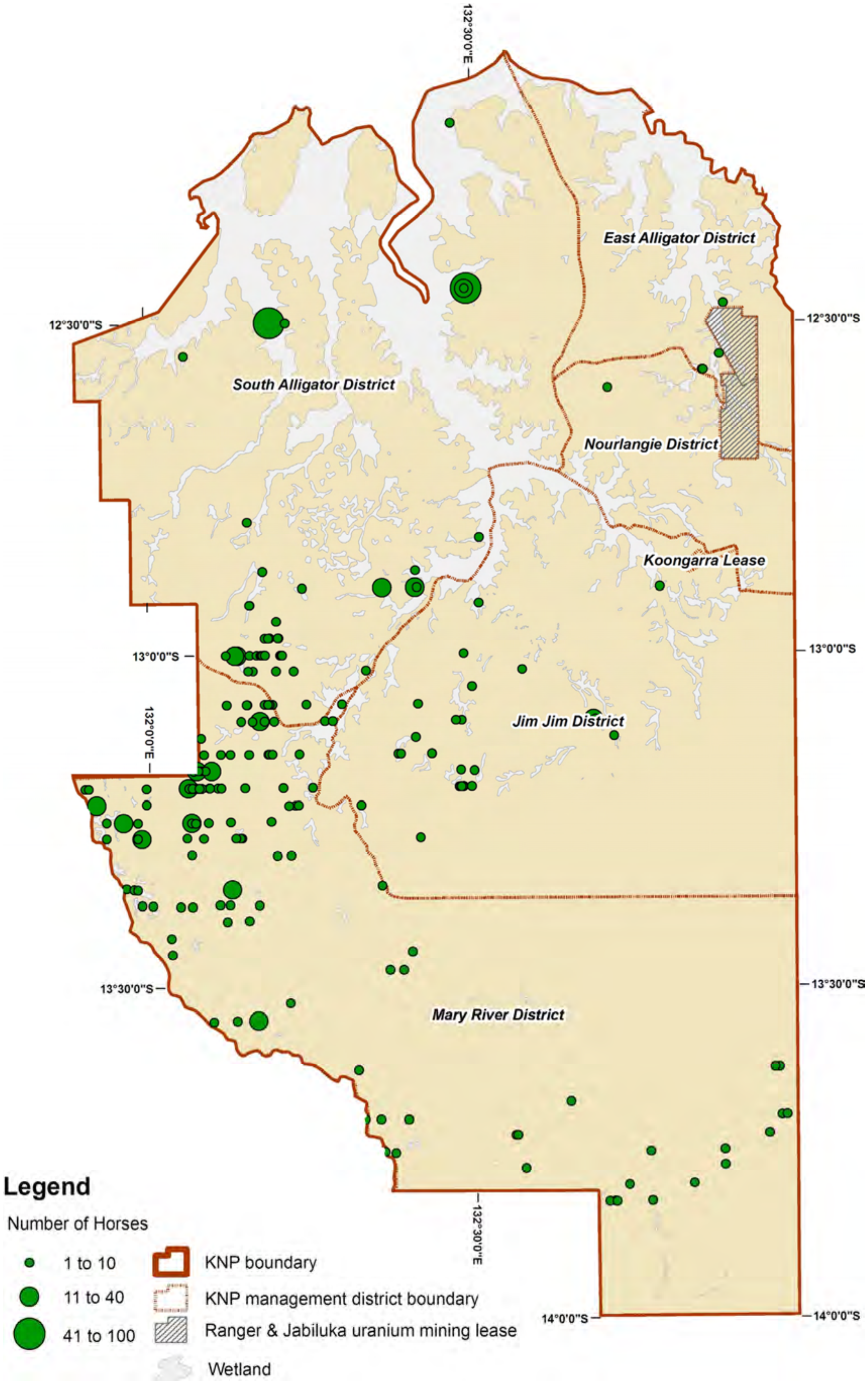


Figure 18 Distribution and number of horses recorded during aerial surveys conducted in 2001 and 2003

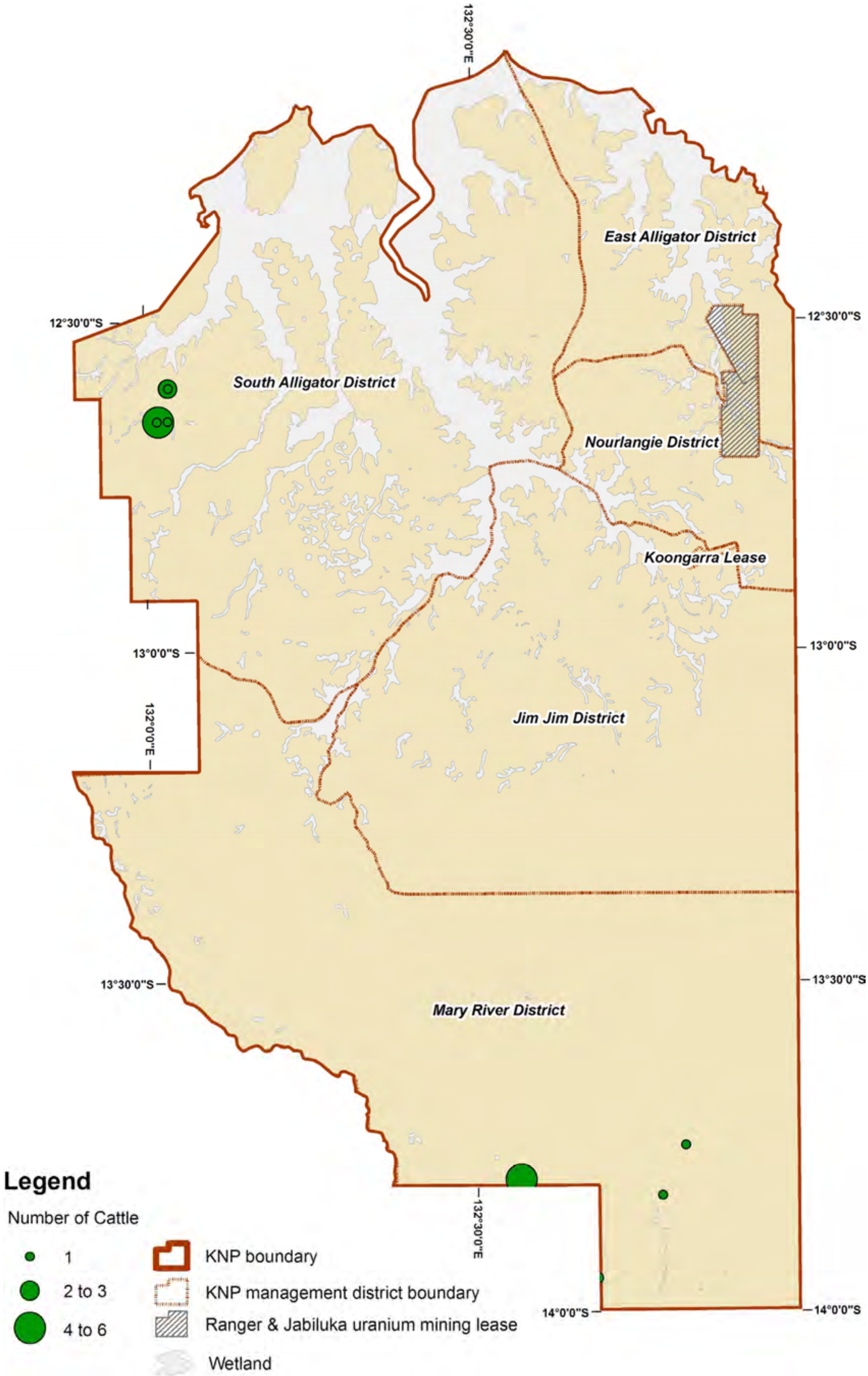


Figure 19 Distribution and number of Cattle recorded during aerial surveys conducted in 2001 and 2003

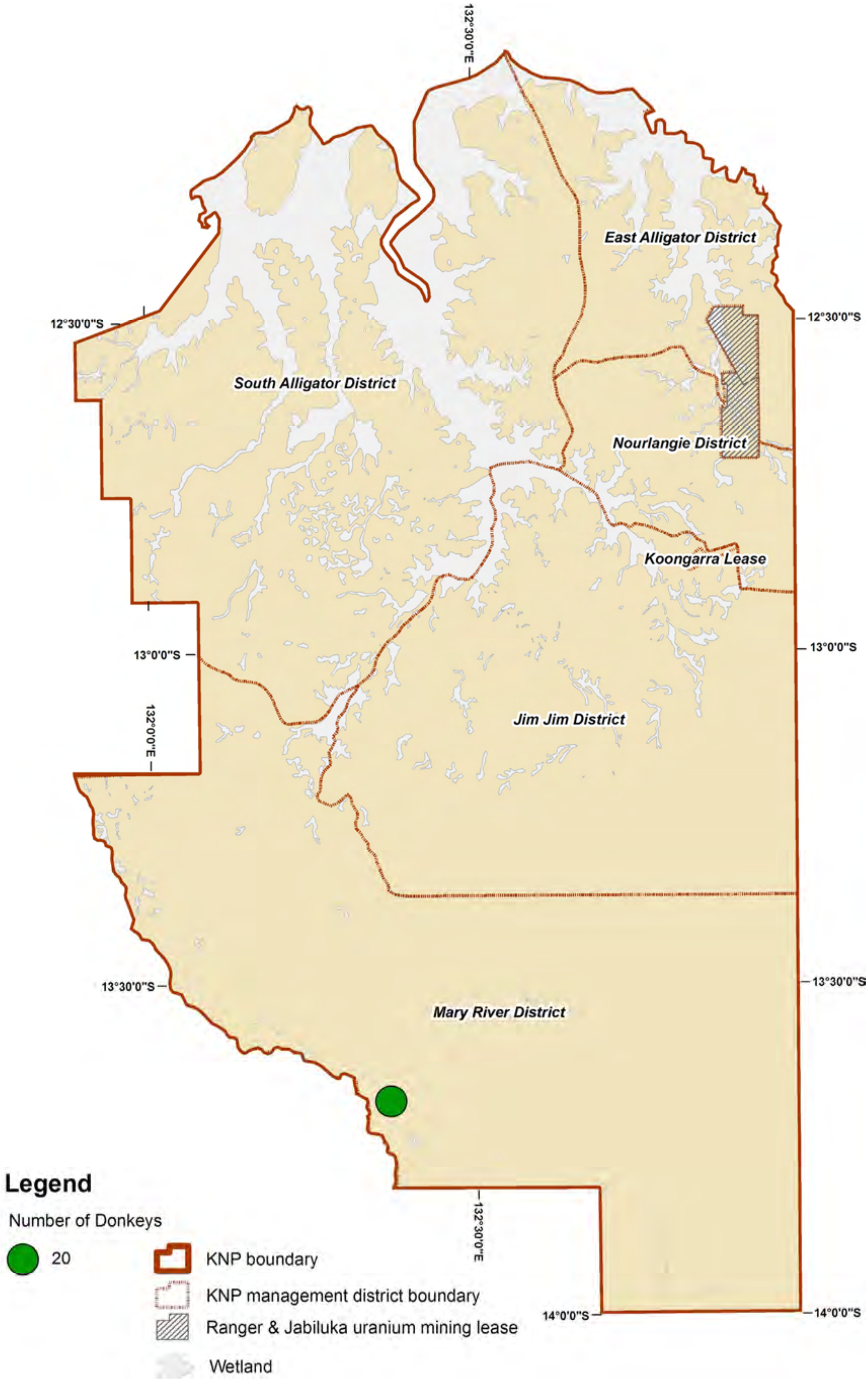


Figure 20 Distribution and number of Donkeys recorded during aerial surveys conducted in 2001 and 2003

3.2.2 Preliminary management zones for the control of feral animals in Kakadu National Park

This dataset delineates preliminary zones for the management, control, and monitoring of feral animals in KNP by PAN (Figure 21). The Natural Resource Management unit of PAN collect monitoring information within each zone with respect to the numbers of feral animals (eg pigs and buffalo) removed by regular shooting programs. The demarcation of management zones assists managers in making quantitative assessment of the effectiveness of feral animal control within and across different zones, with the potential for facilitating the optimum allocation of resources for targeted feral animal control within KNP.

The full metadata report for this dataset is provided in Appendix 1.11.

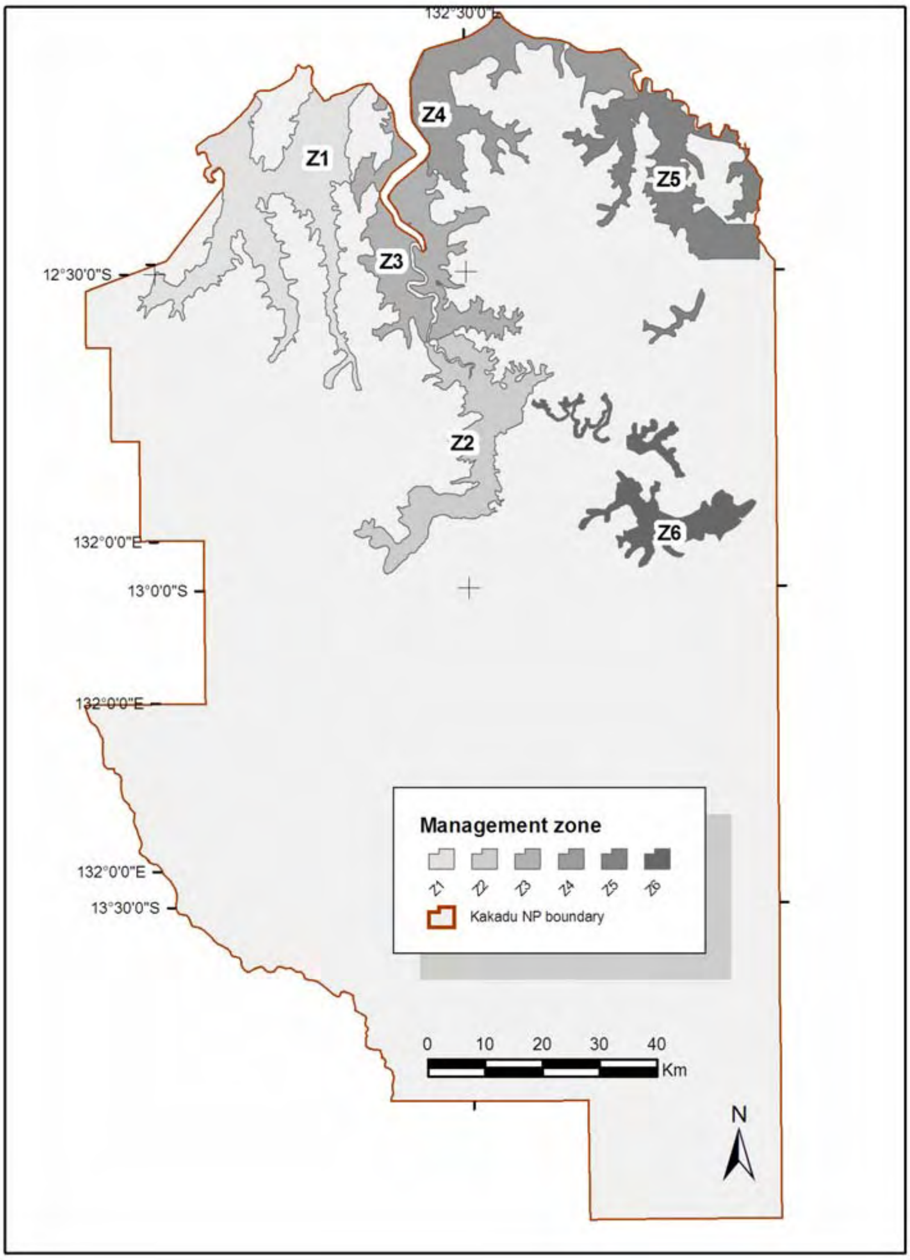


Figure 21 Preliminary feral animal management zones produced for the Natural Resource Management Unit of PAN to monitor and assess feral animal control programs in KNP

4 Environmental characteristics

Spatial information available to represent the different environmental characteristics that can potentially influence the distribution of environmental threats and assets in the region are listed in this section (and summarised in Table 2).

Differentiating the natural physico-chemical attributes of the landscape on spatial and temporal scales is important to developing an understanding of the processes that contribute to the ecological processes and character of the floodplain environment. Current and future patterns in the distribution of exotic weed incursions, native vegetation communities, and freshwater ecosystems can often be explained by the processes limiting their distribution, for example. However, there is a general paucity of information on physico-chemical attributes of tropical floodplain wetlands as they relate to key ecological processes and functions (Finlayson 2005). Information gaps and uncertainties need to be addressed at a local landscape scale in the context of defining natural environmental attributes and physico-chemical processes underpinning floodplain ecology. A more complete understanding of these attributes would be beneficial to refining predictive spatial models for weeds risk assessment and management, for example, and would also assist in the strategic planning and management of natural resources in the region, generally.

Currently, there is insufficient information on spatial and temporal hydrological dynamics and bathymetry of the Magela floodplain in relation to period of inundation, water depth, and flow rate profiles. While these can be modelled from historical gauge records and digital elevation data (DEM), there are notable data quality issues associated with this method- the available DEM is generated from stereo aerial photography where height is determined from surface features (vegetation), and not from actual (and often submerged) ground height. Similarly little or no information outlining spatio-temporal distribution pattern of specific traits exist (pH, nutrients, salinity, redox potential). Although we can generalise that the whole Magela floodplain soils are black-cracking clays, this is inadequate when defining the local regions (and management units) required for strategic risk management. Some information exist on seasonal changes in water quality (in lowland billabongs of the Magela), but this has not been translated at an appropriate spatial scale to the entire floodplain (Walker & Tyler 1982). Information on the spatial change in water salinity, conductivity and pH may also contribute to an understanding of the distribution patterns of vegetation communities. Therefore a longitudinal study of the floodplain defining these traits at an appropriate scale would be beneficial to the management of landscape assets of the Magela floodplain as well as defining spatial units for management of ARR wetlands, generally.

4.1 Topographic elevation data

Topographic elevation information is a key physical factor influencing the ecosystem processes that define different habitats, such as the availability of water, geo-morphological landform, and the dynamic flows of surface and ground water. Elevation data can be used also to delineate the major geomorphic land systems KNP of which there are three: the Arnhem Land plateau; and two lowland systems, the undulating Cainozoic plain, and the sub-coastal/coastal Holocene floodplains, of which the Magela floodplain is a component. A Sub-meter DEM, standardised to ADH and covering the majority of the Magela floodplain has been produced. It is hoped that a detailed history of floodplain inundation patterns can be derived when using these data in conjunction with hydrological data recorded from floodplain gauge-boards (also standardised to ADH).

4.1.1 Digital elevation data of the Magela floodplain downstream of the Ranger uranium mine

The DEM developed for the ecological risk assessment of Magela was produced by merging two data sources standardised to AHD: 1) DIGO Level 2 Digital Terrain Elevation data (provided as ESRI GRID); and 2) a higher-resolution dataset produced by AUSLIG for eriss from aerial photography covering most of the Magela floodplain generated at 30 m horizontal resolution. The resulting dataset has provides continuous coverage over the Magela floodplain, with higher accuracy in low relief areas with surrounding terrestrial woodland and floodplain fringes provided at lower resolution. Vertical accuracy is believed to be in order of ± 0.2 m for the higher resolution component (covering most of the low-relief floodplain area), with the surrounding terrestrial woodland area having an absolute vertical accuracy of ±30 m linear error at 90%.

The full metadata report for this dataset is provided in Appendix 1.12.

4.2 Fire history

Fire histories for the region are an important resource for park managers in determining the success of prescribed burning practises in facilitating conservation of biological diversity, or preventing fire in critical areas such as sites of cultural significance. Fire is also an important disturbance factor influencing establishment or attrition of different plant species. In floodplain environments an absence of fire has been implicated in both reducing the diversity of wetland habitats, as well as in restricting access to traditional hunting areas (Boyden et al 2003). Consequently, it is an important consideration for the management of both threats and assets in the region. Cumulative probability estimates of early and late dry season fires for Kakadu and the Magela floodplain regions are illustrated in Figures 22–25.

4.2.1 Remote sensing fire-scar mapping of annual 'early' and 'late' dry season burning for Kakadu National Park (1980–2004) and adjoining West Arnhemland (1995–2006)

The fire history of Kakadu and adjoining west Arnhem Land provides broad scale annual mapping of both early (April–July) and late dry season (August–end-of-dry-season) fire-scars as derived from satellite remote sensing. The two regions, Kakadu and west Arnhem Land, are kept as separate datasets. The Kakadu dataset provided continuous annual monitoring for the period 1980 to 2006, while the adjacent area in western Arnhem Land provides continuous monitoring for the period 1995 to 2006. The regional monitoring program continues at the time of this publication, and fire-scar mapping is compiled and updated annually by the Fire Research Unit of the Bush Fires Council of the NT. Detailed documentation of the datasets is provided in Russell-Smith and Ryan (1994), Russell-Smith et al (1997), Gill et al (2000) and Turner et al (2002).

Fire-scar history is interpreted from satellite imagery captured at strategic times to determine the frequency and extent of early and late dry season burning. Fire scars were interpreted from Landsat MSS satellite imagery (56x78 m pixel resolution then re-sampled to 100 x 100 m) for the period 1980 to 1995. From 1996 to 2004 data are derived from Landsat TM/ETM (30 m x 30 m re-sampled to 25 m x 25 m). For the west-Arnhem Land component derivation of fire-scars was from Landsat TM, MODIS and AVHRR. Coarser resolution AVHRR (1.09 km2) and MODIS imagery were substituted for the LDS captures for the periods 1995–2001, and

2002–2004, respectively. The resolution of these data is coarser (200 x 200 m pixels), although it can still be used to reliably detect areas where fire has occurred.

For any one year, mapping of 'Early' and 'Late' dry season burning is undertaken. Early fires (EDS) are defined as fires occurring from May to July. For this period imagery is captured at least twice to address the potential problem of under-sampling, where fire-scars can be missed, unless a suitable number image capture times are used (Russell-Smith et al 1997). Late burns (LDS) are defined as fires occurring from August onwards and are derived from a at least one capture time, preferably as late in the dry season as possible (before the onset of cloudy conditions). Cumulative probability estimates of early and late dry season fires for Kakadu and the Magela floodplain regions are illustrated in Figures 22–25.

The full metadata report for this dataset is provided in Appendix 1.13.

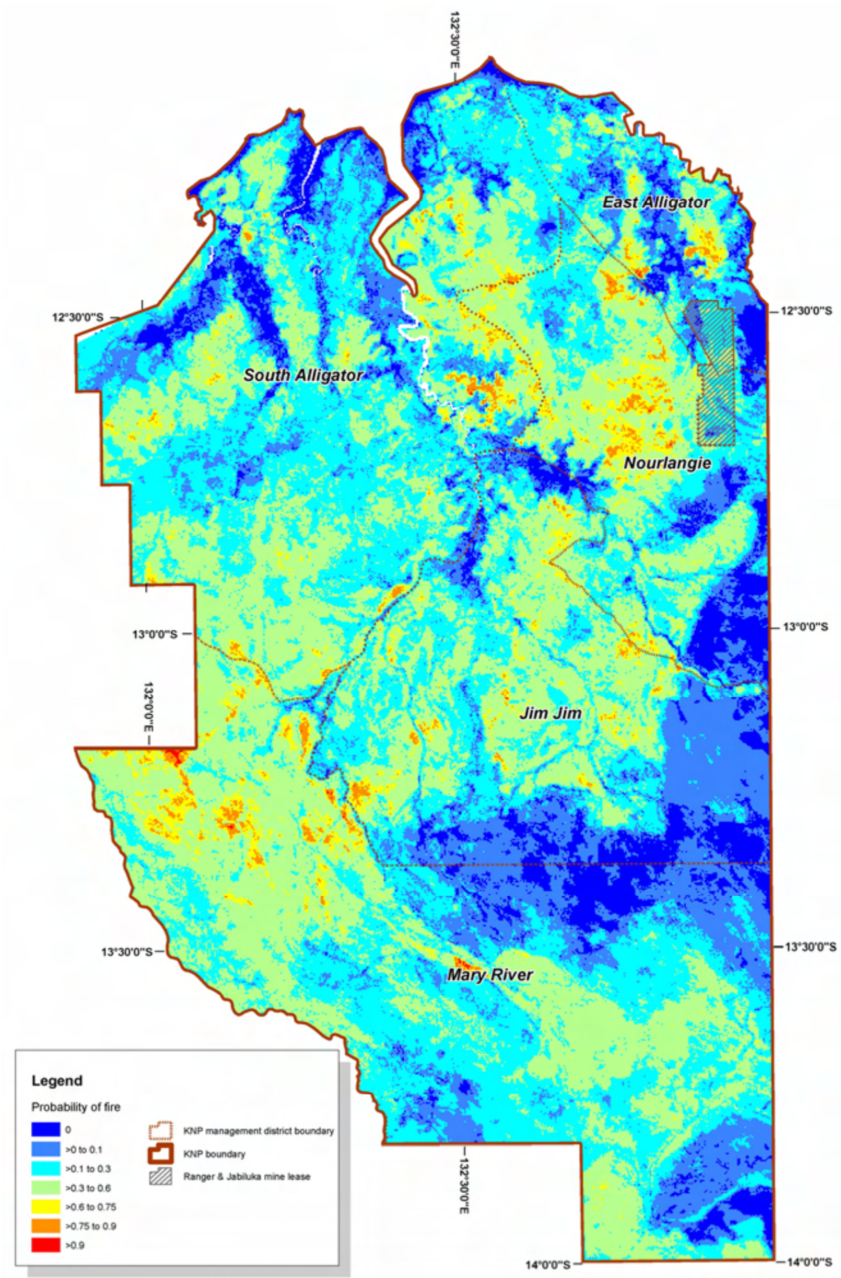


Figure 22 Probability estimates for early dry Season burning across the Kakadu region derived from annual monitoring over a 25-year period (1980–2004) using Landsat fire scar mapping

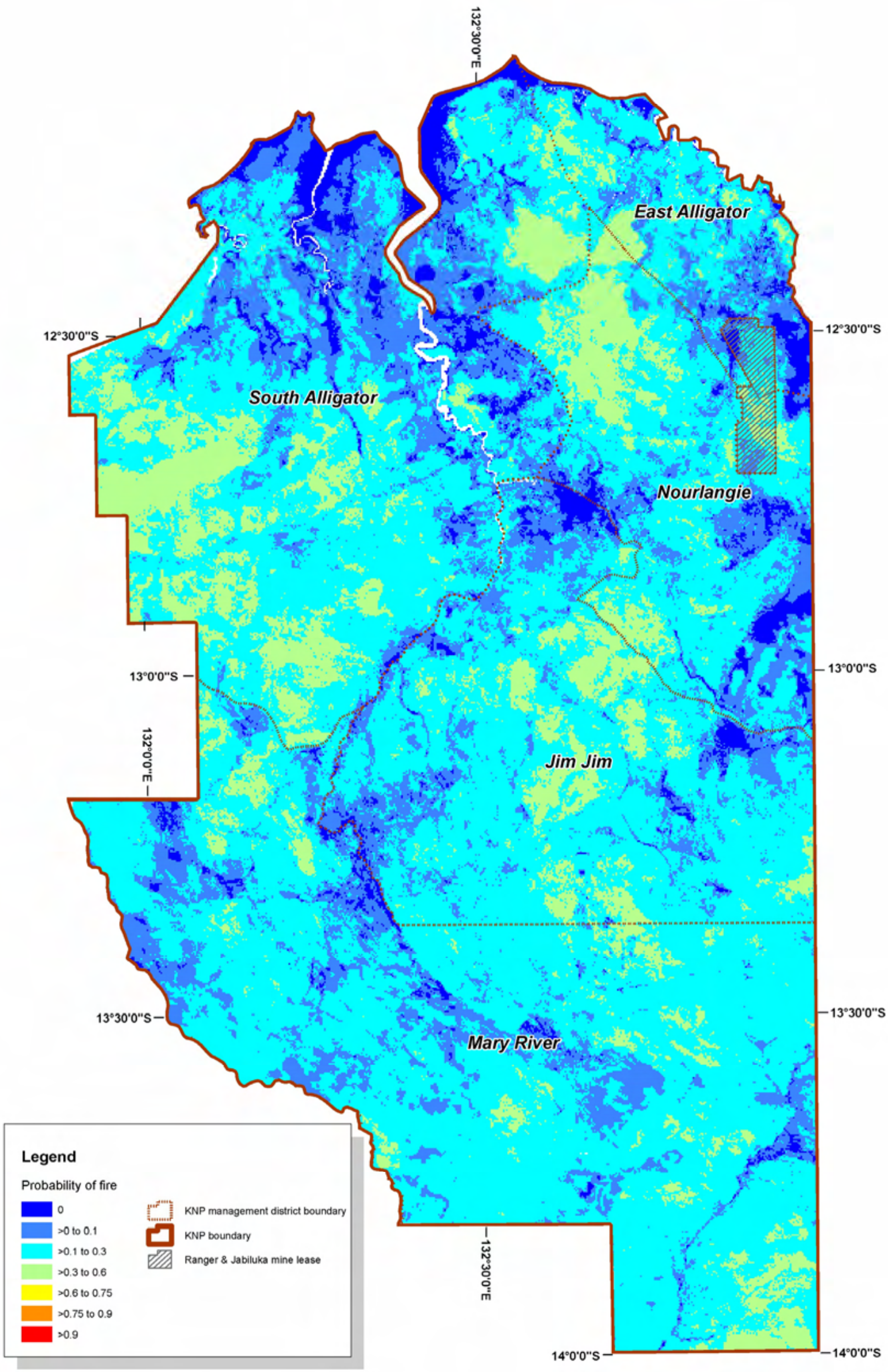


Figure 23 Probability estimates for late dry Season burning across the Kakadu region derived from annual monitoring over a 25-year period (1980–2004) using Landsat fire scar mapping

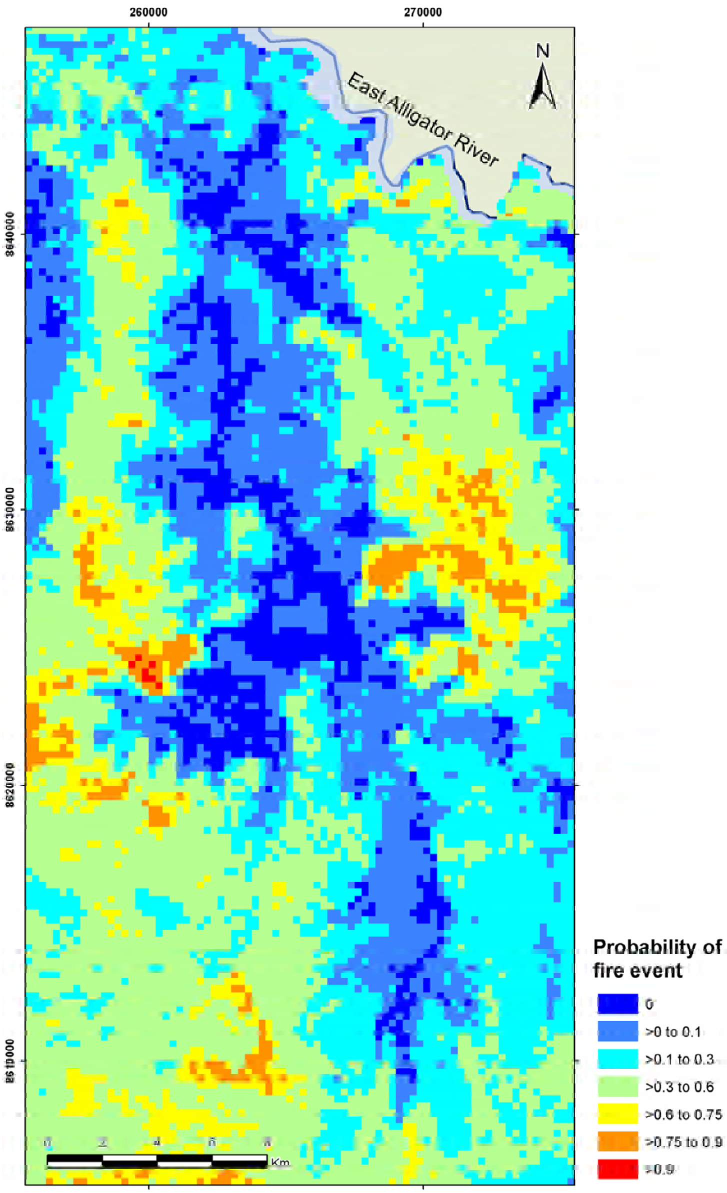


Figure 24 Probability estimates of early dry Season burning across the Magela floodplain region derived from annual monitoring over a 25-year period (1980–2004) using Landsat fire scar mapping

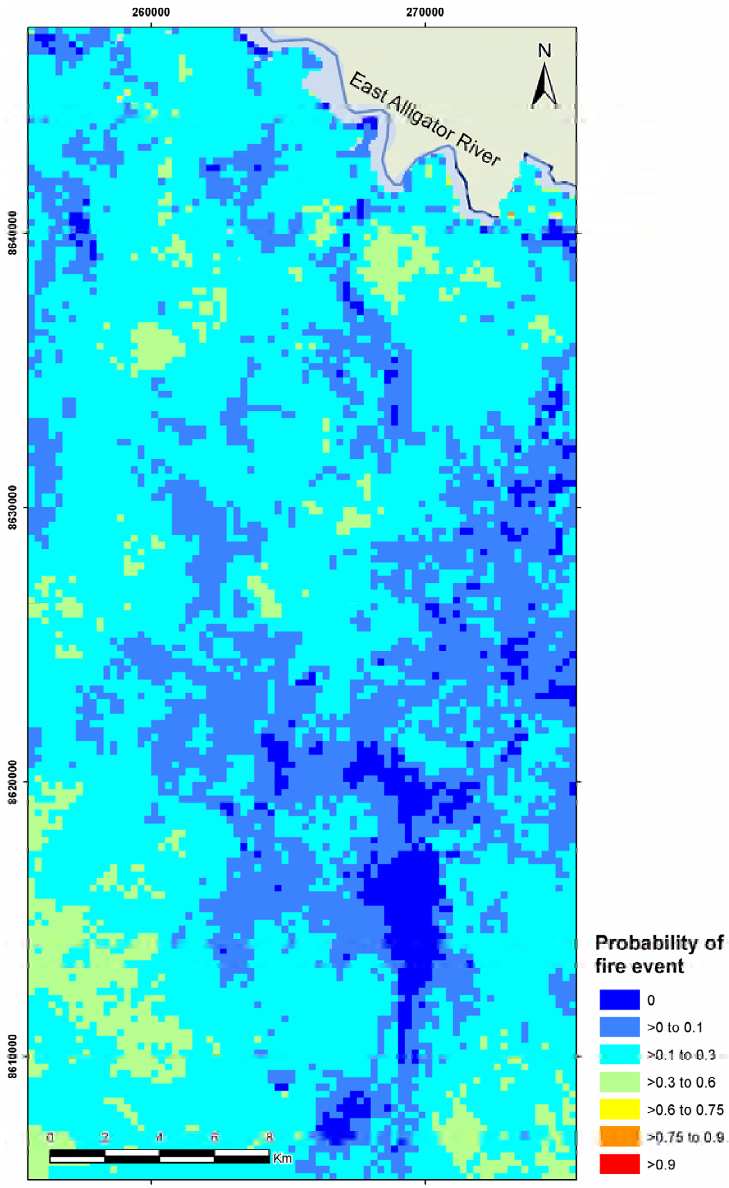


Figure 25 Probability estimates of late dry season burning across the Magela floodplain region derived from annual monitoring over a 25-year period (1980 to 2004) using Landsat fire scar mapping

4.3 Infrastructure

Infrastructure is an important characteristic as it influences accessibility to the environment by land managers, and tourists alike. Unfortunately it can also increase the invasive potential introduced species, such as weeds and feral animals as road vehicles are well known to act as vectors for invasion of both weeds and feral animals. On the other hand roads improve access to implement various management programs, and also provide access for land users.

4.3.1 Infrastructure of the Magela Creek floodplain region (June 2001)

This vector dataset combines data available for roads, tracks, fence lines, and building boundaries from the DIGO 1:50000 topographic map series and linear features digitised from IKONOS satellite imagery captured during June 2001 for the entire Magela floodplain region. The dataset was produced for the ecological risk assessment study of the Magela floodplain and covers this area only (Figure 26).

The full metadata report for this dataset is provided in Appendix 1.14.

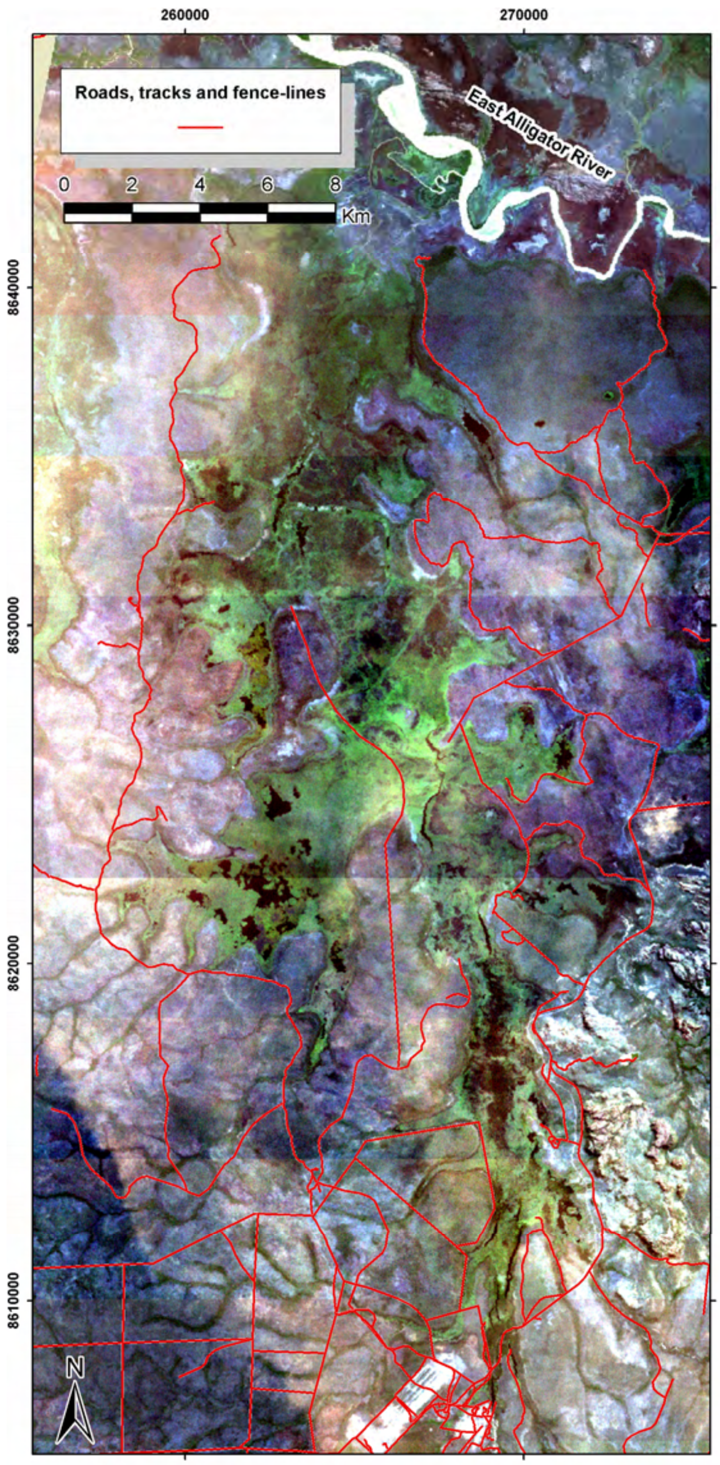


Figure 26 Delineation of roads and tracks of the Magela creek floodplain region derived from 1:250 k AUSLIG topographic map series, 1:50 k topo maps, and IKONOS satellite imagery

5 Discussion

Spatial information technologies such as remote sensing and GIS provide a systematic framework for organising and analysing spatial and temporal information for ecological risk assessment. The use of available knowledge in spatial ecological risk assessment models and GIS can also allow for different management scenarios to be simulated to identify a 'best' solution. GIS is also a powerful visual communication tool.

In context to floodplain landscapes Leuven and Poudevigne (2002, p857) provide a summary of data requirements for GIS-based risk modelling for conservation management. Data requirements are also determined through a participative process including land managers, regulators, scientists, and the general community (Ball 1994, Burgman 2005). Monitoring systems need to be realistic, pragmatic, and defensible. In this context there is potential to further develop and implement more cost-effective and spatially explicit monitoring endpoints for ecological risk assessment. Strategic remote sensing capture and development of more automated processing techniques, for example, can be further integrated into standardised monitoring programs that account for the seasonal variability in the distribution of wetland resources.

However, adherence to an adaptive management system can only eventuate through effective data management based on appropriate integration of GPS, field survey, and database technologies. Implicit is the need also to build and maintain skills capacity among field workers and support staff in rapid assessment techniques for monitoring various environmental indicators. Conversely there is a need to keep field data collection simple as possible and to avoid unnecessary administrative burden on workers involved in hands-on management operations'.

Utility of data for risk assessment studies that represent endpoint elements in an assessment model is enhanced with the progression towards standardised long-term multi-temporal datasets, of appropriate scale (both spatial and temporal) and extent. A sufficient time-series will yield information on spatial change, where detrimental trends can then be examined more closely in context of the risk factors being analysed. It is worth noting that available time-series data were limited for some measurement endpoints of the initial ecological risk assessment for the Magela floodplain. In other cases standardised monitoring information was also not available. Delivery of higher-quality and cost effective products for monitoring and routine analyses is however becoming more practical with technological advances in the spatial information sciences. Remotes sensing, for example, enables synoptic information to be captured over very large areas and at frequent time intervals. This provides the potential to improve detail and accuracy of environmental maps, particularly for dynamic landscapes such as wetlands of the Magela floodplain. Nevertheless the risk remains that inappropriate data processing can produce unreliable results despite the GIS-generated output appearing convincing (Leuven & Poudevigne 2002).

The timely processing of reliable information for ecological risk assessment must consider all aspects of the data management cycle, from existing maps to practical field monitoring exercises. Implicit is the need to embed monitoring in policy frameworks and apply quality control and assurance protocols at every step of data management to ensure successful implementation of ecological risk assessment within a GIS. The provision of metadata libraries that assist data analysts in assessing the fitness for use of data in ecological risk assessment is a critical part of this process (Goodchild 2000). Data quality assessment also allows for appraisal of the decision making process by natural resource managers' (Mowrer & Congalton 2000).

Implementation of routine landscape-scale monitoring for adaptive management of natural resources is ultimately a decision for all stakeholders. For the value of long-term monitoring information to be realised, ongoing commitment and resources are required. Similarly there is a continual need to adapt and manage IT systems supporting the efficient retrieval and analysis of information for routine risk-assessment reporting. These factors are considered critical to the application of ecological risk assessment as a routine decision support tool.

This report provides a review of currently available spatial information with utility for ecological risk assessment of diffuse, landscape-scale threats to natural assets of wetlands in Magela Creek, Kakadu with application also to the broader ARR. It therefore provides a basis to assess the status of this information in context to the quality and availability of data for ecological risk assessment. However, it is beyond the scope of this report to make recommendations as to how future monitoring programs may be focused to address knowledge gaps or improve this information base. The compendium will, however, provide a initial basis for reviewing monitoring systems for landscape-scale ecological risk assessment as well as providing a valuable reference for data managers.

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Appendices

Appendix 1 Metadata reports for GIS data layers

A1.1 Aerial surveys of waterbirds conducted in the Top End of the Northern Territory (April 2000) and Kakadu National Park (November 2003)

DATASET INFORMATION

ANZLIC identifier:	ANZNT0002002011[5]
Dataset name(s)	Aerial surveys of waterbirds conducted in the Top End of the Northern Territory (April 2000) and Kakadu National Park (November 2003).
Custodian(s):	Northern Territory Department of Natural Resources, Environment and the Arts (formerly NT Department of Infrastructure, Planning and Environment), Parks and Wildlife Commission of the Northern Territory and Parks Australia North.
Jurisdiction:	Top End of Northern Territory including Kakadu National Park, Australia

DESCRIPTION

Abstract

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 occur during 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. While the 2003 survey targeted wetlands of KNP only, 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 A2.1. 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, PWCNT 2003, Chatto 2006). Data can be sourced through PWCNT. Scientific comparison with other monitoring datasets should be is limited to surveys using similar methodology.

ANZLIC keyword(s)

FAUNA Native; Surveys, Monitoring, Indicators, Biodiversity, Distribution, Conservation

ISO topic category: Biota

[5] The ANZLIC ID code has been assigned to the Magpie goose (MG) dataset only. The 2003 survey of KNP (a spatial subset of the full MG monitoring program conducted by PWCNT) included counts of other waterbird species and has not been assigned an ID code at the time of publication.

Geographic bounding box (decimal degrees), GDA 1994

	Latitude		Longitude	
	North	South	East	West
2000 Survey[1]	-11.675000°	-14.325000°	133.045898°	129.699905°
2003 Survey[1]	-12.115378°	-13.208714°	133.007423°	131.879663°
Magela extent[2]	-12.225455°	-12.606458°	132.936360°	132.749360°

[1]Full coverage. [2]Spatial subset for Magela ecological risk assessment

Data currency

Beginning date: 19900101

Ending date: Current

Dataset status

Progress: ongoing

Maintenance and update frequency: as needed

Access

Data representation: vector

Stored data format(s)

ESRI point shapefiles and Excel spreadsheets. Raster data layers (points represented as grid cells) are collated in text format as separate worksheets in an Excel workbook. Total dataset size is under 7 Mega bytes.

Available format type

Parent datasets are provided as ESRI point shapefiles registered to the Geodetic Datum of Australia 1994, and projected using the Map Grid of Australia, zone 53 (Kakadu coverage only) or geographic coordinates (Top End coverage).

Access and use constraint(s)

Open. The Parks and Wildlife Commission of the Northern Territory and authors, for datasets relating to specific publications, should be acknowledged. Contact the PWCNT Data Management Officer to discuss requirements.

Data quality

Lineage

Data were collected by trained observers and originated from two systematic aerial surveys conducted in 2000 and 2003 involving standardised sample counts and using pre-determined parallel transect lines spaced at regular 2.5 km intervals and flown using fixed-wing aircraft. Along each transect a height of 73 m (250 ft) and an average speed of 186 km/hr was flown. Observer counts were made within a 200 m swath along each transect concurrently from port and starboard side by separate trained observers using marks on the aircraft wings as guides. Data relating to magpie goose abundance, collated here, will be amalgamated with the PWCNT 'magpie goose' dataset (ANZNT0002002011).

The same general methods were employed for both surveys: 1) conducted in 2000, led by Keith Saalfeld (KS) of PWCNT and; 2) conducted in 2003, led by Peter Bayliss (PB) of ***eriss***. To help maintain observer consistency between surveys, Keith Saalfeld was an observer common to both surveys. Similarly designed surveys have been conducted by the PWCNT on magpie goose populations and nesting distribution since 1983. The 2003 survey also included observations of feral animals which have been extracted as a separate dataset (section 3.2.1).

For the 2003 survey observations were recorded onto a mini-disk audio-recording system. Recordings for PB and Peter Christopherson (observer trainee) appear together on the same minidisk recordings, together. A separate minidisk system was used to record observations by KS. Recordings were transcribed by Caroline Camilleri (CC), James Boyden (JB), and Sarah Gooding (SG) – a volunteer supervised by JB. Transcribing by CC was done directly from mini-disk to an Excel spreadsheet. Transcribing done by JB and SG was first written into log-book then entered into Excel. All raw data are contained in the Excel spreadsheet file named 'Aerial survey data_11_03.XLS'. A description of worksheet in the file is provided in Table 4. Original minidisk recordings and log-book records are retained by Peter Bayliss.

Geographic coordinates for records in the 2003 survey were interpolated using a Visual Basic™ macro program written by KS. This procedure used as input the location coordinates and time for the start and finish points for each transect to interpolate spatial coordinates for individual count records. The formula is based on the linear distance and average flight speed between the beginning and end of each transect and the time at which each data record was logged. The program utilises two input files, 'transect.txt' and 'sighting.txt' and produces an output file, 'sight_ll.txt', containing interpolated positions for each count. The output file was imported to a point shapefile for further manipulation in ArcGIS™. Geographic coordinates for records of the survey conducted in 2000 were derived directly from a Garmin GPS.

For selected species counted in the surveys, Spatial Analyst™ was used to calculate the sum of point-data counts within gridcells intersecting transect lines at 250 m, 500 m and 1 km grid scales. Gridcells that intersected transect lines but contained no point observations for a particular species were given a zero value. Gridcells not intersecting transect lines were treated as 'missing data' and given a value of -9999. The procedures used for making the grid calculations are detailed in Appendix 4.

Positional accuracy

The PWCNT have nominally assigned a horizontal accuracy of ±250 m for datasets adopting this survey methodology.

Spatial coordinates for point records were checked in ArcMap™ for positional anomalies against original waypoint and track-log files logged in OziExplorer™ from a Garmin GPS. Some positional errors were found and corrected (see Table A5.1), after which interpolated point data showed good correlation against track-logs generated from a Garmin™ GPS, although there was evidence of some error propagation on the east-west axis (orientation of transect lines).

The Garmin GPS, considered accurate to ± 15 m, had a position update rate of one second. Thus error propagation on the east-west axis (along the direction of flight) was introduced and can be estimated to be equal to the distance the aircraft travelled in one second. Given the aircraft was travelling at a speed of 186 km/hr, distance travelled in one second is 52 m. This gives a flight-direction error of about 70 m. Deductive estimates of accuracy were also made by *ad hoc* comparison of the distribution of certain features against the AUSLIG 1:250000 map of water bodies. For example, it was shown that there was good correlation between distribution of wetland birds and the distribution of wetland areas on the AUSLIG map series.

Attribute accuracy

Attribute data were screened for errors and corrections made by 1) checking values against original log-book transcriptions; 2) checking for the correct logical sequence of entries (eg time sequence); 3) checking for outlier values for specific observation types. Based on this QA/QC screening, attribute accuracy is considered to be high.

Logical consistency

Logical consistency is considered to be high. Logical consistency tests undertaken included a check for valid values within each attribute field, and visual checks of maps produced from data.

Completeness

The 2000 survey provides complete coverage, within the scale limits of the survey design, of the wetland landscapes between the Moyle River and the East Alligator River; which includes lowland landscapes and wetlands across northern KNP. The 2003 survey provides complete coverage of wetlands of the KNP region only.

The dataset has been subject to rigorous verification and assessment. Attribute data have been validated and are complete.

In conjunction with species count records annotations relating, for example to habitat were sometimes, but not consistently noted. Habitat descriptions and other general notes were recorded under separate attribute fields. These attributes provide only a general guide and have limited use for quantitative data analysis as they are incomplete and inconsistent (observer biased).

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URL: http://www.nt.gov.au/nreta/parks/

Metadata date

Date: 20070710

Additional metadata: Native dataset environment. Microsoft Windows 2000 Version 5.0 (Build 2195) Service Pack 4; ESRI ArcCatalog 8.3.0.800

Supplementary information

Bayliss P & K Yeomans 1990a. Seasonal distribution and abundance of Magpie Goose, *Anseranas semipalmata* Latham, in the Northern Territory and their relationship to habitat, 1983–1986. *Australian Wildlife Research* 17, 15–38.

Bayliss P & K Yeomans 1990b. The use of low level aerial photography to correct bias in aerial survey estimates of Magpie Goose and whistle duck density on Northern Territory floodplains Australia. *Australian Wildlife Research* 17, 1–10.

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A1.2 Aerial surveys of waterbirds conducted in the Alligator Rivers Region from 1981 to 1984 by Morton and Brennan

DATASET INFORMATION

ANZLIC identifier: Not assigned

Dataset names(s) Aerial surveys of waterbirds conducted in the Alligator Rivers Region from 1981 to 1984 by Morton and Brennan

Custodian: Environmental Research Institute of the Supervising Scientist, Department of the Environment, Water, Heritage and the Arts, Australian Government

Jurisdiction: Alligator Rivers Region, including Kakadu National Park, NT, Australia

DESCRIPTION

Abstract

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 & 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, Morton et al 1991, Morton et al 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.

ANZLIC keyword(s)

FAUNA Native: Surveys, Monitoring, Indicators, Biodiversity, Distribution, Conservation

ISO topic category: Biota

Geographic bounding box (decimal degrees), GDA 1994

	Latitude		Longitude	
	North	South	East	West
Transect line coverage for the Magela floodplain site	-12.256786	-12.547485	132.908098	132.774248
Magela extent[2]	-12.225455°	-12.606458°	132.936360°	132.749360°

1 Full coverage for Magela floodplain survey site (note that other sites in the ARR extend outside these bounds

2 Spatial subset for Magela ecological risk assessment

Data currency

Beginning date: June 1981

Ending date: ongoing

Dataset status

Progress: required

Maintenance and update frequency: As needed

Access

Data representation: vector and text

Stored data format(s)

The working spatial datasets produced only for selected species and sample times (at time of publication) are stored as ESRI Point shapefiles, while the complete digital dataset transcribed from original datasheets is stored as an Excel workbook. Raster data layers for selected species (magpie geese & egrets) were produced as a subset for ecological risk assessment studies of the Magela Creek floodplain and have been collated in text format as separate worksheets in a Excel workbook. Total dataset size is under 7 MB.

Available format type

Parent spatial datasets are provided as ESRI Point shapefiles in the Australian Geodetic Datum 1966, and projected using the Map Grid of Australia, zone 53, and have also been produced in GDA94, MGA zone 53. An Excel workbook contains the complete dataset.

Access and use constraint(s)

Open. The Environmental Research Institute of the Supervising Scientist and authors, for datasets relating to specific publications, should be acknowledged. Contact the GIS Officer to discuss user requirements for citation etc.

Data quality

Lineage

The description provided here is for aerial survey data for the Magela floodplain. Full descriptions of data collection methods for the study are described in (Morton, Brennan & Armstrong 1991). The Magela floodplain was sampled monthly from June 1981 to August 1984 using seventeen predetermined, roughly parallel, east-west oriented transect lines intersecting the Magela floodplain at a spacing of between 1 to 2 km. Transects did not extend into surrounding terrestrial woodland and transect length was dependent on the shape of the floodplain. Transects were navigated according to natural features (prior to the use of GPS technology). Transects were flown in a fixed wing Cessna 206 at a height of 30 m (100 ft) and at an average ground speed of 140 km/h (75 knots). A transect observation view width of 100 m (on the ground) was demarcated by two marks on each wing strut. The aerial surveys were conducted with two observers located from back-right (S Morton) and back-left (K Brennan), and a navigator.

Observers estimated the number of birds of all species, noting the counts on a cassette recorder, with a time-stamp being called by the navigator every 30 seconds. Cassette recorders were switched on for the entire transect, allowing counts to be divided into 30 second increments (approximately 1.2 km on the ground). On return to the laboratory the navigator (MD Armstrong) transcribed counts onto datasheets and adjusted the timing of segments such that each transect was composed of the appropriate number of units. This ensured that the counts in each unit were based on a ground observation distance of 1.2 km (Morton et al 1991).

The complete original hardcopy transcripts from aerial survey tape-cassette recordings were digitised to MS Excel by Gary Fox in 2005, and includes the sites: Magela, Nourlangie, East Alligator, Cooper and Boggy Plains. Thence selected aerial survey data from the Magela floodplain transects were migrated to ArcGIS™ for magpie geese and egrets for the following sample times: October 1981, ’82, ’83 and May 1982,’83.

Geographic coordinates for the selected records were interpolated using a Visual Basic Macro written by KS. For each transect this procedure used, as input, the location coordinates and time for the start and finish points of each transect to interpolate spatial coordinates for count records (grouped into 30 sec intervals). The position estimate was then determined by the linear distance between the beginning and end of each transect and the time (in this case the 30 second time unit) at which each data record was logged. The program utilises two input files, ‘transect.txt’ and ‘sighting.txt’ and produces an output file, ‘sight_ll.txt’, containing interpolated positions for each count. The output file was imported to a point shapefile for further manipulation in ArcGIS™.

The resulting shapefiles generated for magpie geese and egret data provide, for each 1.2 km unit along a transect, two points representing a counts for each observer. Note that a ‘point’ observation represents the total count for one observer within a specified 1.2 km transect unit, and that each unit will have two observation points sharing exactly the same spatial coordinates.

For selected sample times (October 1982 & May 1983 surveys), raster datasets were derived at 250m grid resolution for magpie geese and egrets. These dataset layers were derived to represent the total count (summed from both observers) within each 1.2 km transect unit.

MS Access™ was used to calculate the sum of counts from both observers for each transect unit. Raster files were generated from the summary tables using Spatial Analyst™. Gridcells intersecting transect lines, but contained no point observations, were given a zero value. Gridcells not intersecting transect lines were treated as 'missing data' and given a value of -9999. The procedures used for making the grid calculations are detailed in Appendix 4.

Attribute accuracy

Attribute accuracy is considered to be good. Attribute data were screened for errors and corrections made by 1) checking values against original log-book transcriptions; 2) checking for the correct logical sequence of entries (eg time sequence); 3) checking for outlier values for specific observation types.

Logical consistency

Logical consistency is considered to be high. Logical consistency tests undertaken included a check for valid values within each attribute field, and visual checks of maps derived from data.

Completeness

Original hardcopy transcriptions for the entire aerial survey study have been digitised to MS Excel™. Only a subset of this dataset has been migrated to GIS form. This subset is considered complete and includes only magpie goose and egret data for the Magela floodplain site for the sampling times October '81,'82, '83 and May '82 and '83.

Contact information

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Metadata date

Date: 20070710

Additional metadata: Native dataset environment. Microsoft Windows 2000 Version 5.0 (Build 2195) Service Pack 4; ESRI ArcCatalog 8.3.0.800

Supplementary information

Morton S, Brennan K & Armstrong M 1990a. Distribution and abundance of Ducks in the Alligator Rivers Region, Northern Territory. *Australian Wildlife Research* 17, 573–590.

Morton S, Brennan K & Armstrong M 1990b. Distribution and abundance of magpie geese, Anseranas semipalmata, in the Alligator Rivers Region, Northern Territory. *Australian Journal of Ecology* 15, 307–320.

Morton S, Brennan K & Armstrong M 1991. Distribution and abundance of waterbirds in the Alligator Rivers Region, Northern Territory. Open file record 86, Supervising Scientist for the Alligator Rivers Region, Canberra. Unpublished paper.

Morton S, Brennan K & Armstrong M 1993a. Distribution and abundance of Grebes, Pelicans, Darters, Cormorants, Rails and Terns in the Alligator Rivers Region, Northern Territory. *Wildlife Research* 20, 203–217.

Morton S, Brennan K & Armstrong M 1993b. Distribution and abundance of Herons, Egrets, Ibises, and Spoonbills in the Alligator Rivers Region, Northern Territory. *Wildlife Research* 20, 23–43.

A1.3 Kakadu National Park Vegetation (Schodde et al 1987)

DATASET INFORMATION

ANZLIC identifier: ANZCW0501002741

Dataset name(s): Kakadu National Park Vegetation (Schodde et al 1987)

Custodian: Parks Australia North, Department of the Environment, Water, Heritage and the Arts, Australian Government

Jurisdiction: Kakadu National Park, Northern Territory, Australia

Description

Abstract

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 (Schodde et al 1987) 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. 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 these have been 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 can not 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.

ANZLIC keyword(s)

VEGETATION Structural; FLORA Native; Classification, Distribution, Mapping

ISO topic category: Biota

Geographic bounding box (decimal degrees)

Bounding Latitude		Bounding Longitude	
North	South	East	West
-12°	-14°	133°	131°

Data currency

Beginning date: 1 August 1986

Ending date: 1 August 1987

Dataset status

Progress: Complete

Maintenance and update frequency: Not planned

Access

Data representation: vector

Stored data format(s)

The working dataset is stored as an ArcGIS™ polygon shapefile. Derived datasets include: 1) A full coverage raster layer of KNP at 1km resolution for the purpose of spatial risk assessment studies on feral animals in KNP. This file is stored as a separate worksheet within a Excel workbook; and 2) Two raster layers derived for ecological risk assessment at the extent of the Magela Ck floodplain at 250 m and 500 m resolution, respectively, stored as separate worksheets within a Excel workbook. Total dataset size is under 24 Mb

Available format type

Parent datasets are provided as an ArcGIS™ polygon shapefile in the Australian Geodetic Datum 1966, and projected using the Map Grid of Australia, zone 53, and have also been re-projected to GDA94, MGA zone 53.

Access and use constraint(s)

No restrictions. The Department of the Environment, Water, Heritage and the Arts and original author should be acknowledged in any use of the data.

Data quality

Lineage

Each 1:100 000 map sheet produced by the ANPWS Research and Survey Program under project 190/101/14 was scanned by AUSLIG to produce 100m resolution raster coverage of the vegetation. The map was sent to ANPWS for ground checking. The original artwork was kept by AUSLIG. Once the vegetation data were revised they were imported into the Kakadu ERMS database using a 100 m cell-size.

All coverages were taken from ERMS with an initial 16Bit ERDAS GIS export. Conversion was undertaken using Imagegrid/Gridpoly in Arc/Info to an Arc coverage. Topology was applied through MapInfo using export/import for transport.

As a result of the conversion process, it was found that the coverage file contained a number of missing data 'sliver' polygons, between the boundaries of some map classes, having a maximum width of 100 metres. To clean these slivers, the coverage was first converted to a polygon shapefile. Slivers were then eliminated using the 'Eliminate' function in ArcToolbox under the 'Data Management Tools' Generalisation menu. Slivers were merging with neighbouring polygons with the largest shared border.

For the purposes of Ecological Risk Assessment the Spatial Analyst™ was used to produce spatial subsets in raster format for the Magela floodplain area at 250 and 500 m grid cell resolutions. A 1 km raster grid was also produced for the entire KNP coverage area.

Positional accuracy: Horizontal accuracy considered to be ±100 m

Attribute accuracy

V032: Death of paperbarks Jan 1993 includes attributes classifying density of mortalities.

V034: Primary paperbark forest with undefined grid-code.

V014: Death of paperbarks Dec 1992 includes attributes classifying cause and rate of death. grid-codes undefined.

V134: Primary paperbark patches with grid-code defined in field Table to define type of 'patch'.

Logical consistency

No particular tests carried out by Department of the Environment, Water, Heritage and the Arts. However, missing data 'slivers' (of up to 100 m in width) resulting from the export/import process were detected and removed (see lineage section)

Completeness: Complete for year of coverage.

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Metadata date

Date: 20070710

Additional metadata: Native dataset environment Microsoft Windows 2000 Version 5.0 (Build 2195) Service Pack 4; ESRI ArcGIS™ 9

Supplementary information

Schodde R, Headley AB, Mason IJ & Martenz PN 1987. Vegetation habitats Kakadu National Park, Alligator Rivers Region, Northern Territory, Australia. Final Report to Australia National Parks and Wildlife Service. CSIRO Division of Wildlife and Rangelands Research, Canberra.

A1.4 Land units of the Magela Creek catchment (Wells 1979)

DATASET INFORMATION

ANZLIC identifier: Not defined

Dataset name(s): Land units of the Magela Creek catchment (Wells 1979)

Custodian: Northern Territory Government Department of Natural Resources, Environment and the Arts is custodian of the original dataset while Environmental Research Institute of the Supervising Scientist is the custodian of the re-projected dataset (see Abstract);

Jurisdiction: Alligator Rivers Region, Kakadu National Park, NT, Australia

Description

Abstract

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***). This work is a refinement of previous broader scale land system classifications conducted by Christian and Stewart (1953), Storey et al (1969) at a 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.

ANZLIC keyword(s)

BOUNDARIES, Biophysical classification. ECOLOGY Landscape classification, LAND cover classification, FLORA native, distribution, classification

ISO topic category: Biota

Geographic bounding box

	Bounding Latitude		Bounding Longitude	
	North	South	East	West
Original dataset[1]	-12.246441°	-12.849589°	133.006645°	132.718131°
Magela extent[2]	-12.225455°	-12.606458°	132.93636°	132.74936°

[1]Complete dataset. [2]Derived spatial subset for ecological risk assessment of the Magela floodplain

Data currency

Beginning date: 1979

Ending date: 1979

Dataset status

Progress: Complete

Maintenance and update frequency: Irregular

Access

Data representation: vector

Stored data format(s):

The working dataset is stored as an ArcGIS™ polygon shapefile. The raster grid produced for ecological risk assessment of Magela floodplain at 250 m resolution is stored as text in a Excel workbook. Dataset size is approximately 2.2 MB.

Available format type

ArcGIS™ polygon shapefiles. The dataset is provided in both Geodetic Datum of Australia 1994, projected using the Map Grid of Australia, zone 53; and Australian Geodetic datum 1966, projected in Australian Map Grid zone 53.

Access and use constraint(s)

Contact the GIS Officer to discuss user requirements for citation etc.

Data quality

Lineage

The land unit classification of the Magela catchment was produced by Wells (1979) for the Land Conservation Unit of the Territory Parks and Wildlife Commission of the NT. Data were supplied to ***eriss*** by PWCNT as an Arc Coverage file with simple attribute identification. More comprehensive attribute descriptions were added by John Lowry of ***eriss***, basing descriptions on the Wells (1979) report.

The land unit map was checked for registration anomalies against base Landsat scenes of known datum and projection. The Land unit map did not align well with either AGD66, WGS84, or GDA94 datums, with a visible shift of at least 400 m against the Landsat AGD66 image. A decision was made to re-register the data using procedures in ENVI™ and ArcGIS as detailed in Appendix 7.

The re-registered dataset was then used to derive the spatial subset for the Magela floodplain ecological risk assessment.

Positional accuracy

100 m horizontal accuracy based on 1:50000 aerial photo accuracy. The average RMS error calculated for the GCP file used to re-register the map to a base Landsat scene was 27 metres, using 198 GCPs.

Attribute accuracy

Considered to be high. Details of land unit classification methods are provided in Wells 1979.

Logical consistency

A visual check of maps in the preparatory stages of map production was used to check logical consistency. Map class attributes of the re-registered image were also checked visually against original land units map.

Completeness

Complete

Contact information

Contact organisation: Environmental Research Institute of the Supervising Scientist

Contact position: GIS Officer

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E-mail address: john.lowry@environment.gov.au

Metadata date:

Date: 20070710

Additional metadata:

Native dataset environment; Microsoft Windows XP Version 5.0 (Build 2195) Service Pack 4; ESRI ArcCatalog 8.3.0.800

Supplementary information

Wells MR 1979. Soil studies in the Magela Creek catchment, 1978. Part 1. 1979. Northern Territory. Territory Parks and Wildlife Commission, Land Conservation Unit.

Christian CS & Stewart GA 1953. *General report on the survey of the Katherine – Darwin Region*, 1946. Land Research Series No 2 CSIRO, Australia.

Story R, Williams MAJ, Hooper ADL, O'Ferrall RE & JR McAlpine 1969. *Lands of the Adelaide–Alligator Area, Northern Territory*. Land Research Series No 25, CSIRO Australia

Story R, Galloway RW, McAlpine JR, Aldrick JM, & MAJ Williams 1976. *Lands of the Alligator Rivers Area, Northern Territory*. Land Research Series No 38, CSIRO Australia.

A1.5 A macrophyte vegetation classification of the Magela Creek floodplain, Alligator Rivers Region (Finlayson, Bailey et al 1989)

DATASET INFORMATION

ANZLIC identifier: Not defined

Dataset name: A macrophyte vegetation classification of the Magela Creek floodplain, Alligator Rivers Region (Finlayson, Bailey & Cowie 1989).

Custodian: Environmental Research Institute of the Supervising Scientist (***eriss***), Supervising Scientist Division, Department of the Environment, Water, Heritage and the Arts; Australian Government

Jurisdiction: Northern Territory including Kakadu National Park, Australia

Description

Abstract

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.

ANZLIC keyword(s)

VEGETATION Floristic; FLORA Native; Classification, Distribution, Mapping

ISO topic category: Biota

Geographic bounding box

The following coordinates represent the bounding box chosen for each of the data layers developed for the risk assessment. This area incorporates the Magela floodplain and the immediate surrounds. These coordinates do not represent the extents of the actual data points sampled.

	Bounding Latitude		Bounding Longitude	
	North	South	East	West
Parent dataset	-12.2271327	-12.589817	132.906773	132.795271
Magela extent[2]	-12.225455°	-12.606458°	132.93636°	132.74936°

[1]Parent dataset. [2]Derived dataset for Magela ecological risk assessment

Data currency

Beginning date: March 1982

Ending date: 1986

Dataset status

Progress: Complete

Maintenance and update frequency: Irregular

Access

Data representation: vector

Stored data format(s)

The working dataset is stored as an ArcGIS™ polygon shapefile. Raster layers produced at 250 m and 500 m resolution for the ecological risk assessment of Magela floodplain (incomplete coverage) are stored in a Excel workbook as separate worksheets. Dataset size is approximately 12.8 MB

Available format type

ArcGIS™ polygon shapefile. Data are provided in Geodetic Datum of Australia 1994, and projected using the Map Grid of Australia, zone 53

Access and use constraint(s)

Contact the GIS Officer to discuss user requirements for citation etc.

Data quality

Lineage

There is no available information on how the vegetation map produced by Finlayson 1989 was transferred to a digital spatial data file. However, it is likely the map was digitally scanned and the resulting raster map was registered to either the 1:100 000 or 1: 250 000 topographic map series using spatial adjustment tools in ArcGIS™. From the raster layer data a polygon shapefile was likely produced by hand using the edit facility in ArcGIS™, using the registered raster layer as a background for the digitisation process.

Positional accuracy

A nominal accuracy of ± 250 m has been assigned based map registration using the AUSLIG 1:250 000 topographic map series. Positional accuracy is uncertain, particularly since it is unclear how the original vegetation map was geo-registered in an ArcGIS™ environment. However a visual check of the map against IKONOS satellite imagery show reasonable accuracy of the floodplain boundary

Attribute accuracy

Map classes used are broad categories. Map classes were defined manually by aerial photo interpretation and may be subject to observer biases. Vegetation communities have been described qualitatively. Geo-referenced ground-validation data is absent so a quantitative accuracy assessment is not available.

Logical consistency

A visual check of maps in the preparatory stages of map production

Completeness

Complete

Contact information

Contact organisation: Environmental Research Institute of the Supervising Scientist

Contact position: GIS Officer

Mail address: GPO Box 461, Darwin, NT, Australia 0801

E-mail address: john.lowry@environment.gov.au

Metadata date

Date: 20070710

Additional metadata

Native dataset environment. Microsoft Windows 2000 Version 5.0 (Build 2195) Service Pack 4; ESRI ArcCatalog 8.3.0.800

Supplementary information

Finlayson CM, Bailey BJ & Cowie ID 1989. *Macrophyte vegetation of the Magela Creek flood plain, Alligator Rivers Region, Northern Territory*. Research Report 5, Supervising Scientist for the Alligator Rivers Region, AGPS, Canberra.

A1.6 A vegetation map of the Magela floodplain (Lowry et al, in prep)

DATASET INFORMATION

ANZLIC identifier: Not defined

Dataset name(s): A vegetation map of the Magela floodplain (Lowry et al, in prep)

Custodian: Environmental Research Institute of the Supervising Scientist (*eriss*); Supervising Scientist Division; Department of the Environment, Water, Heritage and the Arts; Australian Government

Jurisdiction: Kakadu National Park, NT, Australia

Description

Abstract

The aim in producing a new vegetation map for the Magela floodplain was to assess change in vegetation communities in context to previous map classifications for the floodplain. In particular change was to be assessed over a 30-year timeframe in context to the vegetation classification produced by Finalyson 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 (in prep) was produced from a systematic survey conducted between March and April 2003.

ANZLIC keyword(s)

VEGETATION Floristic; FLORA Native; Classification, Distribution, Mapping, Monitoring, Fire

ISO topic category: Biota

Geographic bounding box (decimal degrees)

The following coordinates represent the bounding box chosen for each of the data layers developed for the risk assessment. This area incorporates the Magela floodplain and the immediate surrounds. These coordinates do not represent the extents of the actual data points sampled.

	Bounding Latitude		Bounding Longitude	
	North	South	East	West
Parent dataset	-12.2271327	-12.589817	132.906773	132.795271

Beginning date: 2003

Ending date: 2003

Dataset status

Progress: ongoing

Maintenance and update frequency: Irregular

Access

Data representation: raster & vector

Stored data format(s)

Working dataset is an ArcGIS™ polygon shapefile. Dataset size is approximately 700 Kb

Available format type

ArcGIS™ polygon shapefile Data are provided in Geodetic Datum of Australia 1994, and projected using the Map Grid of Australia, zone 53

Access and use constraint(s)

Contact the GIS Officer to discuss user requirements for citation etc.

Data quality

Lineage

A provisional vegetation map was prepared from high-resolution IKONOS satellite imagery captured in June 2002. Using this map and historical data (from other vegetation maps, including

Finalyson et al 1989), and focussing on areas where vegetation change was apparent a systematic survey of the floodplain was then undertaken by airboat and helicopter. Full details on map production are provided in Lowry et al (in prep).

Positional accuracy

No quantitative positional accuracy assessment available, however outline of floodplain appears to correspond with AUSLIG 1:100 000 map features

Attribute accuracy

Map class attributes represent generalised cover classes similar to those used in Finalyson et al 1989

Logical consistency

A visual check of maps in the preparatory stages of map production

Completeness: accompanying publication not completed

Contact information

Contact organisation: Environmental Research Institute of the Supervising Scientist

Contact position: GIS Officer

Mail address: GPO Box 461, Darwin, NT, Australia 0801

E-mail address: john.lowry@environment.gov.au

Metadata date

Date: 20070710

Additional metadata

Native dataset environment. Microsoft Windows 2000 Version 5.0 (Build 2195) Service Pack 4; ESRI ArcCatalog 8.3.0.800

Supplementary information

Lowry JB, Boyden JM, Finlayson CM & Begg GW (in prep). Biophysical mapping of the Magela floodplain. Supervising Scientist Report, Supervising Scientist, Darwin NT.

A1.7 Para grass distribution at 1991 and 1996 for a selected area of the Magela floodplain (Knerr 1998)

DATASET INFORMATION

ANZLIC identifier: Not defined

Dataset name(s): Para grass distribution at 1991 and 1996 for a selected area of the Magela floodplain (Knerr 1998)

Custodian: Environmental Research Institute of the Supervising Scientist (Supervising Scientist Division) for Parks Australia North; Department of the Environment, Water, Heritage and the Arts; Australian Government.

Jurisdiction: Kakadu National Park, Northern Territory, Australia.

Description

Abstract

As part of a university honours project, a vegetation survey and mapping study was conducted by Nunzio Knerr to estimate the change in distribution of para grass (*Urochloa mutica*, or formerly *Brachiaria mutica*) from 1991 to 1996 for a selected area of the Magela. floodplain (Knerr 1998). Four vegetation communities were examined (dominated by either *Urochloa mutica*, *Oryza meriondalis*, *Hymenachne acutigluma*, and *Pseudoraphis spinecens*). The plant communities used for mapping units follow Finalyson et al (1989), with the addition of para grass, which was described as 'growing in dense clumps and dominates… throughout the year'. Knerr (1998) concluded that the Oryza grassland was the primary native community displaced by para grass invasion, based on comparisons with historical records (Finalyson et al 1989). Mapping was undertaken using georefereced ground data in conjunction with aerial photo interpretation at a scale of 1:25000.

Positional anomalies in the projection of the original GIS dataset were identified and have been rectified for the 1996 dataset to an acceptable accuracy level (by re-registering to a standard QuickBird™ satellite image using the RST procedure in ENVI™). Resulting map is shown in Figure 12. To date, projection anomalies have not been resolved for the 1991 distribution map, and this will need to be reregistered if it is to be of any value.

ANZLIC keyword(s)

FLORA Exotic: Monitoring, Surveys, Indicators, Distribution, Mapping, Models

ISO topic category: Biota

Geographic bounding box

	Bounding Latitude		Bounding Longitude	
	North	South	East	West
Parent dataset[1]	-12.394600	-12.441590	132.80704	132.88491

[1]Parent dataset provides incomplete coverage of the Magela floodplain

Data currency

Beginning date: 1996

Ending date: 1998

Progress: Complete

Maintenance and update frequency: Irregular

Access

Data representation: raster and vector

Stored data format(s)

Available format type

Access and use constraint(s)

Contact the GIS Officer to discuss user requirements for citation etc.

Data quality

Lineage

Field data for mapping was obtained from visual assessment of dominant species at 1048 (differential) GPS locations recorded between April and May 1996. These data were plotted at a scale of 1:25000 (using Garmin PCX interface software and ArcInfo GIS). Colour aerial photos for the area of interest on the floodplain were captured in June 1996 at 1:25000 (with 60% forward overlap and 20% side overlap for stereo viewing and mosaic purposes). Eight ground control targets georefereced with a differential GPS were placed at strategic locations to enable the 1991 photography to be geo-registered. In conjunction with geo-referenced field data, vegetation communities were interpreted from photos. The vegetation types were mapped by tracing onto drafting film using a stereo viewer. Para grass infested areas were mapped in more detail by adding an 8x objective lens to the stereo viewer. Maps were then digitised using Generic Cadd 6.1 software with a digitising tablet. This area of the floodplain was mapped also using the same method for 1991 aerial photo (for which detailed field data did not exist). Images were converted into DXF format and then imported into ArcInfo version 6. Images were then georectified using the reference markers and 10 other readily identifiable locations.

In 2005 the GIS dataset was sourced from the ***eriss*** archives and QA/QC checks were undertaken. Projection anomalies were discovered with the image not aligning accurately against standard projections (WGS84, AGD66 GDA94). The original projection remains a mystery as no metadata have been found specifically relating to the GIS data files. However, the 1996 data were re-registered by James Boyden against a standard 'map-registered' QuickBird™ product to a to a reasonable standard using 160 points (identifiable channel boundaries and floodplain margins as control points). '

Positional accuracy

The 1996 image was originally validated used 1048 georefereced locations. However, the validation dataset (location and vegetation composition information) has been lost. Therefore the spatial accuracy of the para grass distribution produced cannot be independently validated with quantified accuracy using original field data,

Positional alignment problems were encountered in attempting to overlay vector layers produced in the original study onto a reference image. However, when the 1996 image was re-registered to a standard map registered QuickBird™ base image the horizontal RMS error was ±13 m using 160 GCPs.

Attribute accuracy

Because the quantitative field dataset for the 1996 image has been lost it is not possible to check the density of para grass in areas defined as 'para grass'. However it can be assumed that the mapping unit for para grass was based on areas of dense para grass cover, as indicated by Knerrs' description of the community: Para grass 'grows in dense clumps and dominates this community throughout the year'.

Aerial photographic interpretation techniques only, and in the absence of field data for the same time period, was used to determine para grass distribution from the 1991 imagery.

Logical consistency

A visual check of maps in the preparatory stages of map production

Completeness

data are complete for the para grass attribute for area of image coverage. Map units for Surrounding vegetation communities (*Oryza* & *Hymenachne*) are missing from the current vector dataset, but can be determined from hardcopy maps produce in the accompanying thesis (Knerr 1998)

Contact information

Contact organisation: Environmental Research Institute of the Supervising Scientist

Contact position: GIS Officer

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E-mail address: john.lowry@environment.gov.au

Metadata date

Date: 20070710

Additional metadata

Microsoft Windows 2000 Version 5.0 (Build 2195) Service Pack 4; ESRI ArcCatalog 8.3.0.800

Supplementary information

Knerr NJA 1998. Grassland community dynamics of a freshwater tropical floodplain: Invasion of Brachiaria mutica (Para grass) on the Magela Floodplain, Kakadu National Park. Internal report 275, Supervising Scientist, Canberra. Unpublished paper.

Finlayson CM, Bailey BJ & Cowie ID 1989. *Macrophyte vegetation of the Magela Creek flood plain, Alligator Rivers Region, Northern Territory*. Research Report 5, Supervising Scientist for the Alligator Rivers Region, AGPS, Canberra.

A1.8 Airboat and helicopter surveys of para grass on the Magela floodplain conducted by the Environmental Research Institute of the Supervising Scientist from 2003–2004

DATASET INFORMATION

ANZLIC identifier:	Not defined
Dataset name:	Airboat and helicopter surveys of para grass on the Magela floodplain conducted by the Environmental Research Institute of the Supervising Scientist from 2003–2004
Custodian:	Environmental Research Institute of the Supervising Scientist (***eriss***, Supervising Scientist Division) for Parks Australia North, Department of the Environment, Water, Heritage and the Arts; Australian Government
Jurisdiction:	Kakadu National Park, Northern Territory, Australia

Description

Abstract

With limited resources it was not possible to conduct a systematic survey of para grass for the entire Magela floodplain. However, in March 2003, as part of a broader floodplain vegetation mapping program (Sections 2.2.4 & A1.6, Figure 11), two rapid-assessment, mobile-airboat surveys were conducted by a trained observer/recorder, where vegetation types, including para grass, were ranked in order of cover dominance for about 1200 locations spanning the length of the floodplain. Using this information and historical information on para grass distribution (Knerr 1998), it was decided to focus further para grass-specific survey efforts within the region of the largest infestation located near the centre of the Magela floodplain where the aim was to obtain more detailed information on environmental and native plant associations of para grass across its range. Therefore in June 2004, another airboat survey of this region was completed, followed by a low level helicopter survey. For this airboat survey, the percentage cover of dominant plant species and open water were recorded in detail for some 80 sites located along four transverse (east-west orientated) transects (each approximately 3.5 km in length and spaced at about 1km intervals) and two longitudinal adjoining transects. Sites observations were made at approximately 250 m intervals along the transect where each was taken in a 20 m radius of the bow from the standing airboat.. Water depth measurements (with coincident measurement at the Jabiluka gauging station) and photographs were also taken at most 2004 sites. The main purpose of the accompanying helicopter survey was to delineate larger, homogeneous patches of para grass across a broader extent than could be achieved using the airboat alone. Larger patches of homogeneous vegetation were later used as training (and validation sites) for classification of a coincident remote sensing image capture (Sections 3.1.3 & A1.9, Figure 13).

Surveys of dominant floodplain vegetation types in the Magela floodplain were conducted using airboats on 05/03/03 – 06/03/03 & 18/03/03 – 19/03/03 & 16/06/04. The helicopter survey was conducted on 18/06/04. The locations of all observation points for all surveys were recorded using a handheld Garmin eTrex™ GPS unit. Point data records for para grass are illustrated in Figure 12

ANZLIC keyword(s)

FLORA Exotic and Native: monitoring, surveys, indicators, distribution

ISO topic category: Biota

Geographic bounding box (decimal degrees)

The following coordinates represent the bounding box chosen for each of the data layers developed for the risk assessment. This area incorporates the Magela floodplain and the immediate surrounds. These coordinates do not represent the extents of the actual data points sampled.

	Bounding Latitude		Bounding Longitude	
	North	South	East	West
Parent dataset[1]	-12.225455°	12.606458°	132.936368°	132.74936°
Magela extent[2]	-12.225455°	-12.606458°	132.93636°	132.74936°

[1]Parent dataset combining both 2001 & 2003 surveys. [2]Derived subset for Magela ecological risk assessment

Data currency

Beginning date: 05/03/03 (See abstract for details)

Ending date: 18/06/04 (See abstract for details)

Dataset status

Progress: ongoing

Maintenance and update frequency: Irregular

Access

Data representation: vector and raster

Stored data format(s)

ESRI point shapefiles and raster text files. Total dataset size approximately 5 MB

Available format type

ESRI point shapefiles projected to the Geodetic Datum of Australia 1994, Map Grid of Australia, zone 53

Access and use constraint(s)

Contact the GIS Officer to discuss user requirements for citation etc.

Data quality

Lineage

Field waypoints obtained with a Garmin eTrex GPS were downloaded to excel spreadsheets as geographic coordinates projected to WGS84. All observations (for the relevant waypoint) taken at each site (see abstract) were manually entered into the spreadsheets by James Boyden and Dave Walden from the original field notebooks. Each entry was later checked by DW. Each vegetation type was given a code (see Appendix A3.2–3.5) and these were entered for each waypoint to represent the dominant community at that point. Para grass waypoints were extracted for each of the individual surveys and combined to give all para grass sited within the survey area.

Positional accuracy

A positional accuracy of +/- 15 m is known for the Garmin GPS equipment used to collect point data from while stationary. A more realistic estimate of accuracy is likely to be +/- 50 m as further error may have been introduced from movement in helicopter and airboat, while GPS information was being logged

Attribute accuracy

Attribute data were checked for errors against original field notes

Logical consistency

A visual check of maps in the preparatory stages of map production

Completeness: Complete

Contact information

Contact organisation: Environmental Research Institute of the Supervising Scientist

Contact position: GIS Officer

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E-mail address: john.lowry@environment.gov.au

Metadata date

Date: 20070710

Additional Metadata: Microsoft Windows 2000 Version 5.0 (Build 2195) Service Pack 4; ESRI ArcCatalog 8.3.0.800

Supplementary information

Walden D, Bayliss P, Boyden J & K Ferdinands (in press). An ecological risk assessment of the major weeds on the Magela Creek floodplain, Kakadu National Park. Supervising Scientist Report 194, Supervising Scientist, Darwin NT.

A1.9 A preliminary classification of para grass distribution on a selected region of the Magela floodplain derived from high resolution multi-spectral Quickbird™ satellite imagery captured on 25 June 2004

DATASET INFORMATION

ANZLIC identifier: Not defined

Dataset name: A preliminary classification of para grass distribution on a selected region of the Magela floodplain derived from high resolution multi-spectral Quickbird™ satellite imagery captured on 25^{th} June 2004

Custodian: Environmental Research Institute of the Supervising Scientist (***eriss***, Supervising Scientist Division) for Parks Australia North; Department of the Environment, Water, Heritage and the Arts, Australian Government.

Jurisdiction: Kakadu National Park, Northern Territory, Australia.

Description

Abstract

This map production shows the distribution and density of the environmental weed, para grass (*Urochloa mutica*) over a central 64 km^2 area of the Magela Creek floodplain. It was produced using supervised classification of multispectral QuickBird™ satellite imagery (captured on 25 June 2004), in conjunction with spatially referenced ground and helicopter survey data. The quality of the base QuickBird™ image is excellent. Image capture timing occurred when fire had not occurred and spectral discrimination of para grass from other major floodplain plant communities was considered most pronounced. However, it was apparent that some senescent grassland types associated with surrounding open woodland (non-floodplain areas) were misclassified as para grass. Classification accuracy assessment indicated an overall accuracy of 86% and a producer accuracy for para grass ranging from 90 to 97%, indicating that there is potential to monitor para grass using QuickBird™ imagery (Boyden et. al. 2007)

The satellite image captures an Area of Interest (AOI) considered to be the centre of the largest para grass infestation of the floodplain located in the Nankeen billabong area. The AOI also incorporates native vegetation communities that are potentially threatened by this infestation (*Oryza*, *Eleocharis* and *Hymenachne* spp), in addition to floodplain margin areas that already have para grass infestations or have the potential to become infested. Full coverage of the floodplain was not possible at the time of image capture due to the relatively high cost of this type of imagery.

The percentage cover of para grass was calculated within 250 m^2 grid cells using zone statistics in Spatial Analyst™ (Figure 13).

The map assists monitoring and weed control targeting, and the layer may be overlayed with other spatial data such as bathymetry and native vegetation to facilitate predictive modelling.

ANZLIC keyword(s)

FLORA Exotic: Monitoring, Surveys, Indicators, Distribution, Mapping, Models

ISO topic category: Biota

Geographic bounding box

	Bounding Latitude		Bounding Longitude	
	North	South	East	West
Parent dataset[1]	-12.371°	-12.465°	132.820°	132.905°
Magela extent[2]	-12.225455°	-12.606458°	132.93636°	132.74936°

[1]Parent dataset combining both 2001 & 2003 surveys. [2]Derived subset for Magela ecological risk assessment

Data currency

Beginning date: 25 June 2004 (time of image capture)

Ending date: 25 June 2004 (time of image capture)

Progress: ongoing

Maintenance and update frequency Irregular

Access

Data representation: raster and vector

Stored data format(s)

Original satellite image coverage supplied by Digital Globe™ as six images in QuickBird™ GeoTiff format. A mosaic of these images is also stored in ENVI™ format. Original map classification files are stored in ENVI™ classification file formats. The original para grass percent-cover map produced at 250 m resolution is stored as an ESRI grid file and a shapefile. This data produced for the ecological risk assessment of the Magela floodplain is stored as a separate worksheet in a Excel workbook. Total size of datasets, combined, is approximately 4.4 Gigabytes.

Available format type

Original data supplied as six images in QuickBird™ GeoTiff format projected to the WGS84 geographic coordinate system. Map classification files supplied in ENVI™ classification format, re-projected to Geodetic Datum of Australia 1994, using the Map Grid of Australia, zone 53.

Access and use constraint(s)

Contact the GIS Officer to discuss user requirements for citation etc. The use and/or dissemination of this data and/or of any product in any way derived there from are restricted. Unauthorised use and/or dissemination is prohibited. Refer to Digital Globe Inc. end user license agreement for Order No 51771, Order item No 000000126361.

Data quality

Lineage

The vegetation class map was derived from a high-resolution QuickBird™ satellite remote sensing using multispectral (RGB-visible and Near-Infrared bands at 2.7 m pixel resolution) and panchromatic (0.6 m pixel resolution) images. A ENVI™ mosaic of the complete coverage (constituting six GeoTiff files) of multispectral data was created from which the floodplain area, and fringing vegetation was clipped out as a separate ENVI™ file. Image classification was conducted on this clipped file in ENVI™ using the Maximum Likelihood Classifier algorithm.

Training-sites for classification were selected using spatially referenced field notes and photographs. Vegetation surveys conducted from the ground (05/03/03–06/03/03 & 18/03/03–19/03/03 & 16/06/04) and by helicopter (18/06/04) using a Garmin eTrex™ GPS, were used to provide this information and additionally provided ground-truth data for classification validation. In cases where there was uncertainly between the interpretation of field notes and the location of features on imagery, areas were omitted from the training-site selection process.

Para grass growing in moister areas was spectrally distinct to that found in drier areas, having a greener and less ‘senescent’ signature (and with moister stands being confined to lower-elevation floodplain areas and drier stands to floodplain margins). Accordingly, the classification procedure used three sets of training sites, ‘greener’ to ‘more senescent’, to guide classification and improve accuracy.

Classification accuracy assessment, using independent validation site data produced an overall map accuracy of 86% (kappa coefficient = 0.83) was calculated for the classification. Producer accuracy for para grass ranged from 90 to 97% between the three forms of para grass (Boyden et al 2007).

The resulting class map was resampled to 5 m pixels in ENVI™ using nearest neighbour resampling. From this map a raster layer was produced for para grass only (other map classes removed). Using this file (and a 250 m zone-grid overlay of the coverage area), the percentage cover of para grass within each 250 m grid cells was calculated using the Zone Statistics option of Spatial Analyst in ArcGIS™. That is the total number of 5 m ‘para grass’ pixels falling within each 250 m grid cell was divided by the total area of each grid cell to derive a percentage cover (Figure 13).

Positional accuracy

Reflective 3 m^2 Ground Control Points (GCPs) were deployed in the field at the time of image capture and geo-referenced with a Omnistar™ dGPS (horizontal accuracy to within 1 metre) to validate horizontal accuracy of the standard, map-registered, QuickBird™ product provided by to Digital Globe Inc. All targets were identified on the QuickBird™ image within 1 to 2-pixels (4 m) from dGPS coordinates. The use of fixed GCPs also allows potential for future co-registration of multi-temporal imagery for monitoring purposes.

Training sites and ground-truth data were geo-referenced using a Garmin™ Etrex GPS (at ±15 m accuracy with a 1-second position update frequency).

Attribute accuracy

No systematic field validation, post-classification, was undertaken to confirm classification accuracy of the vegetation map produced using the Maximum Likelihood algorithm. It was apparent that some senescent grassland types associated with surrounding open woodland (non-floodplain areas) were misclassified with the 'senescent para grass' sub-class produced in this initial classification. Para grass distribution is restricted to the floodplain and its margins and generally does not extend into the drier open woodland areas.

Logical consistency

A visual check of maps in the preparatory stages of map production.

Completeness

Data are complete for a 64 km portion of the Magela floodplain.

Classification is incomplete insofar that only an initial classification has been conducted. Accuracy assessment and refinement of the classification method, including validation of training site information and the adoption of suitable sample sizes for supervised classification and accuracy assessment still needs to be conducted.

Legends provide only limited descriptive information on major plant species or vegetation communities occurring at ground level. Trees (paperbark forest) were omitted from the classification

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Metadata date

Date: 20070710

Additional metadata

Microsoft Windows 2000 Version 5.0 (Build 2195) Service Pack 4; ESRI ArcCatalog 8.3.0.800

Supplementary information

Boyden J, Walden D, Bartolo R & Bayliss P 2007. Utility of VHR remote sensing data for landscape scale assessment of the environmental weed Para grass [*Urochloa mutica*, (FORSSK), Nguyen] on a tropical floodplain. In *Proceedings of the 28th Asian Conference on Remote Sensing*. Kuala Lumpur November 12–16 2007 (published on CD ROM).

Walden D, Bayliss P, Boyden J & K Ferdinands (in press). An ecological risk assessment of the major weeds on the Magela Creek floodplain, Kakadu National Park. Supervising Scientist Report 194, Supervising Scientist, Darwin NT.

A1.10 Aerial surveys of feral animals conducted in Kakadu National Park in November 2001(south KNP) and November 2003 (north KNP)

DATASET INFORMATION

ANZLIC identifier:	Not defined
Dataset name:	**Aerial surveys of feral animals conducted in Kakadu National Park in November 2001(south KNP) and November 2003 (north KNP).**
Custodian:	**Environmental Research Institute of the Supervising Scientist (*eriss*, Supervising Scientist Division) for Parks Australia North; Department of the Environment, Water, Heritage and the Arts; Australian Government.**
Jurisdiction:	Kakadu National Park, Northern Territory, Australia

Description

Abstract

The dataset provides information on the distribution and abundance of feral animals (pigs, buffalo, cattle, horses and donkeys) and visual estimates of ground surface damage by pigs and buffalo within KNP from aerial survey conducted in 2001 and 2003. Combined data offers complete coverage of the lowland landscapes within KNP. A map showing the location and coverage of the transects is shown in Figure A2.1. All records are point records rather than records relating to a specific area.

Data originated from two systematic aerial surveys involving standardised sample counts and using pre-determined transect lines spaced at regular intervals and flown using fixed-wing aircraft. The aircraft flew at a height of 72.6 m (250 ft) at an average speed of 186 km/hr along each transect. Observer counts were made from both the port and starboard side by trained observers within a 200 m swath along each transect (using marks on the aircraft wings as guides). Transects were 2.5 km apart over the coverage area. The same general methods were applied to both surveys.

Observations were made of feral animal abundances (Figures 16–20), as well as a visual assessment of feral animal damage, where areas of low, medium, or extensive ground disturbance were recorded. Feral animal ground damage was distinguished, where possible, as being caused by either Pigs or by Buffalo, as listed by 'species' attribute as either 'Pig rooting' or 'Buffalo damage'. However observers have expressed some doubt as to the ability to consistently and accurately separate between the specific types of ground damage (Bayliss pers com 2005). Nevertheless the vast majority of damage observed in the 2001 and 2003 surveys was attributed to feral pigs. The level of observed damage is classified by the 'Number' attribute by the values of 1, 2 and 3, representing either low, medium, or extensive damage, respectively (Figures 14–15).

Damage estimate data are complementary to abundance data and are considered a more robust method of estimating actual population levels for pigs, in comparison to aerial counts methods. However there remains a paucity of quantitative data linking damage extent to actual population levels, and relationships are likely to be site-specific.

Each record has spatial coordinates and is stored as a point, rather than records relating to a specific area. However, raster data files have also been derived from point records, for each animal species counted in the survey. In these cases Spatial Analyst™ was used to calculate the sum of point-data counts for within grid cells that intersected transect lines at 250 m, 500 m and 1 km grid scales.

All attribute fields for the shapefile are described in Table A2.1. A map showing the location and coverage of the transects for both surveys is shown in Figure A2.1. All records are point records rather than records relating to a specific area.

Scientific comparison with other datasets should be limited to surveys using similar methodology. NRETA have been conducting similar surveys (eg 'Top End Feral 1985', ANZLIC identity code ANZNT0002002015).

ANZLIC keyword(s)

FAUNA Exotic: Monitoring, Surveys, Indicators, Distribution

ISO topic category: Biota

Geographic bounding box

	Bounding Latitude		Bounding Longitude	
	North	South	East	West
Parent dataset[1]	-12.115378°	-13.208714°	133.007423°	131.879663°
Magela extent[2]	-12.225455°	-12.606458°	132.93636°	132.74936°

[1]Parent dataset combining both 2001 & 2003 surveys. [2]Derived subset for Magela ecological risk assessment

Data currency

Beginning date: 25 November 2001

Ending date : 13 November 2003

Dataset status

Progress: Complete

Maintenance and update frequency: Irregular

Access

Data representation: vector and text

Stored data format(s)

The parent datasets are stored as ESRI Point shapefiles. Raster layers were also produced for all feral species counted for the full KNP coverage and for each ground disturbance class (pigs and buffalo) at 1km resolution and are stored as text in separate worksheets in a Excel workbook. Similar data were produced for the Magela floodplain extent for pigs and ground disturbance classes only and are stored in a Excel file. These files contain brief metadata summaries for each layer. Dataset size is approximately 13.9 MB.

Available format type

Data (produced as subsets for separate species and as a complete dataset) are provided as ESRI Point shapefiles in Geodetic Datum of Australia 1994, and projected using the Map Grid of Australia, zone 53.

Access and use constraint(s)

The data is generally available for distribution within the Northern Territory. Charges may apply for both hard and digital copy. For digital information, a digital data agreement may be required. Please refer to the contact within this metadata to discuss specific user requirements for citation etc.

Data quality

Lineage

Data originated from two systematic aerial surveys involving standardised sample counts and using pre-determined transect lines spaced at regular intervals. Surveys were flown using fixed-wing aircraft at a height of 72.6 m (250 ft) and an average speed of 186 km/hr. Observer counts were made within a 200 m swath along each transect using marks on the aircraft wings as guides. This was done concurrently from port and starboard sides by independent trained observers. Transect lines had a east-west orientation and were spaced at 2.5 km intervals across the coverage area.

The same general methods were adopted for the two surveys: 1) conducted in 2002 of the southern half of Kakadu National Park (KNP), led by Keith Saalfeld (NRETA) and; 2) conducted in 2003 of the northern half of Kakadu National Park (KNP), led by Peter Bayliss (***eriss***). Along each transect observations were made from port and starboard by separate observers of feral animal abundances and a visual assessment of feral animal damage, where areas of low, medium, or extensive ground disturbance were recorded.

Observations were recorded onto a mini-disk audio-recording system in the 2003 survey. Recordings for PB and PC appear on the same minidisk recordings, together, while KS recordings were made on a separate minidisk system. Recordings were transcribed by Caroline Camilleri (CC), James Boyden (JB), and Sarah Gooding (SG) – a volunteer supervised by JB. Transcribing by CC was done directly from mini-disk to an Excel spreadsheet. Transcribing done by JB and SG was first written into log-book then typed into Excel. All raw data are contained in the Excel spreadsheet file named ‘Aerial survey data_11_03.XLS’. A description of each worksheet in the file is provided in Appendix 2A.

Coordinates for records in the 2003 survey were interpolated using a Visual Basic Macro program written by KS. This procedure used the location coordinates and the time of the start and finish points for each transect to interpolate the spatial coordinates of individual count records. The formula is based on the linear direction and average flight speed between the beginning and end of each transect and the time at which each data record was logged. The program utilises two input files, ‘transect.txt’ and ‘sighting.txt’ and produces an output file, ‘sight_ll.txt’, containing interpolated positions for each count. The output file was imported to a point shapefile for further manipulation in ArcGIS™. Spatial coordinates for the survey conducted in 2001 were derived directly from a Garmin GPS.

Each survey covered a separate area of the KNP, the 2001 survey the southern half, and the 2003 survey the northern half. The combined survey data provides complete coverage of the lowland landscapes within KNP, while a small area of the east Arnhem escarpment and plateau bounded by the coordinates (North Bounding Latitude –13.18°; South Bounding Latitude –13.59°; East Bounding Longitude –132.99°; West Bounding Longitude –132.43°) was omitted from the survey. Original data files for each survey were merged into one shapefile. An additional attribute named ‘survey’, was added to identify the original source file from both surveys.

From the merged dataset for each animal species counted, Spatial Analyst was used to calculate the sum of point-data counts for within grid cells that intersected transect lines at 250 m, 500 m and 1 km grid scales. Grid cells that intersected transect lines but contained no point observations for a particular species were given a zero value. Grid cells not intersecting transect lines were treated as ‘missing data’ and given a value of –9999. The procedures used for making the grid calculations are outlined in Appendix 4.

Positional accuracy

A nominal horizontal accuracy of ± 70 m has bee assigned based on the details that follow.

Spatial coordinates for point records were checked in ArcMap™ for positional anomalies against original waypoint and tracklog files in OziExplorer™. A number of positional errors were found and corrected (see Table A2.3), after which interpolated point data showed good correlation against tracklogs generated from a Garmin™ GPS, although there was evidence of some error propagation on the east-west axis (orientation of transect lines).

It should be noted that the Garmin GPS device, considered accurate to ± 15 m, had a position update rate of one second, and that error would also be introduced on the east-west axis equal to the distance the aircraft travelled in one second. Given the aircraft was travelling at a speed of 186 km/hr, distance travelled in one second is 52 m. Deductive estimates of accuracy were also made by ad-hoc comparison of the distribution of certain features against AUSLIG 1:250000 map of water bodies. For example, it was shown that there was good correlation between distribution of wetland birds, feral animal damage, and distribution of wetland areas provided from the AUSLIG 1:250k topographic map series.

Attribute accuracy

Attribute data were screened for errors and corrections made by 1) checking values against original log-book transcriptions; 2) checking for the correct logical sequence of entries (eg time sequence); 3) checking for outlier values that differ from allowable values for specific observation types (eg feral damage estimates had a value of 1, 2 or 3 only).

Published data, using similar methods, show that count precision and accuracy is sufficient for estimating population density at a landscape scale for buffalo, cattle, horses and donkeys (Bayliss & Yeomans 1989). In the 1985 survey of the Top End, NT, standard error rates (as a percentage of total count) were found to be ± 6.6, 5.7, 8.5, and 21 for buffalo, cattle, horses, and donkeys respectively. Accuracy and precision is species specific and is influenced by a number of factors including habitat (eg the amount of obstructive canopy cover), where it has been found that accuracy can be improved by applying habitat-specific visibility correction factors (Bayliss & Yeomans 1989). Observer bias is another source of potential error but there are methods for measuring and accounting for this factor and thereby improving overall accuracy (Bayliss & Yeomans 1989b) although this has not been assessed for the current dataset. Ideally there should be at least one trained observer common between independent surveys so biases can be accounted for and corrected between surveys.

Pig numbers can not be estimated with sufficient accuracy using these survey methods (Bayliss & Yeomans 1989). However, it has been postulated that the relationship between the degree and extent of ground disturbance (measured during the survey) and actual population abundance of pigs could be used as a surrogate to measure pig abundance.

Logical consistency

Logical consistency tests undertaken included a check for valid values within each feral animal damage class, and visual checks of maps derived from data.

Completeness

The combined surveys provide complete coverage of the lowland landscapes within KNP. Each survey covered a separate area of the KNP, the 2001 survey the southern half, and the 2003 survey the northern half. When combined complete coverage is provided within the boundary of KNP except for a region of the east Arnhem Land escarpment and plateau bounded by the coordinates:

North Bounding Latitude: -13.18°

South Bounding Latitude: -13.59°

East Bounding Longitude: 132.99°

West Bounding Longitude: 132.43°

The dataset has been subject to rigorous verification and assessment. While positional data have been interpolated for the 2003 survey the spatial accuracy of data appears to be good. Attribute data have been validated and are complete.

Along with species count and feral damage estimates, ancillary data were sometimes, but not consistently recorded. This included habitat descriptions, general notes, and descriptions regarding the ‘type’ of feral damage observed, recorded under three separate attribute fields. Since these attributes are incomplete and inconsistent they provide only general guide and have limited use for quantitative data analysis.

Contact information

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Metadata date

Date: 20070710

Additional metadata

Microsoft Windows 2000 Version 5.0 (Build 2195) Service Pack 4; ESRI ArcCatalog 8.3.0.800

Supplementary information

‘Top End Feral 1985’, ANZLIC identity code ANZNT0002002015

Bayliss P & Yeomans K 1989. Distribution and abundance of feral livestock in the 'Top End' of the Northern Territory (1985–96), and their relation to population control. *Australian Wildlife Research* 16, 651–76.

A1.11 Preliminary management zones for the control of feral animals in Kakadu National Park

DATASET INFORMATION

ANZLIC identifier: Not defined

Dataset name(s): Preliminary management zones for the control of feral animals in Kakadu National Park

Custodian: Environmental Research Institute of the Supervising Scientist (***eriss***, Supervising Scientist Division) for Parks Australia North; Department of the Environment, Water, Heritage and the Arts; Australian Government.

Jurisdiction: Northern Territory including Kakadu National Park, Australia

Description

Abstract

This dataset delineates zones for the management, control, and monitoring of feral animals in KNP by PAN (Figure 21). The Natural Resource Management unit of PAN collect monitoring information within each zone with respect to the numbers of feral animals (eg pigs and buffalo) removed by regular shooting programs. The demarcation of management zones assists managers in making quantitative assessment of the effectiveness of feral animal control within and across different zones, thereby facilitating the optimum allocation of resources for targeted feral animal control within KNP.

ANZLIC keyword(s)

BOUNDARIES Administrative; FAUNA Exotic: monitoring, feral animals

ISO topic category: Environment

Geographic bounding box

	Bounding Latitude		Bounding Longitude	
	North	South	East	West
Parent dataset[1]	-12.082352°	-12.982354°	132.980946°	131.966137°
Magela extent[2]	-12.225455°	-12.606458°	132.93636°	132.74936°

[1]Parent dataset combining both 2001 & 2003 surveys. [2]Derived subset for Magela ecological risk assessment

Data currency

Beginning date: 2003

Ending date: 2003

Dataset status

Progress: Complete

Maintenance and update frequency : As needed

Access

Data representation: vector

Stored data format(s)

The working dataset is an ESRI polygon shapefile. Dataset size is approximately 1.1 Megabyte

Available format type

Data are provided as a ESRI polygon shapefile in Geodetic Datum of Australia 1994, and projected using the Map Grid of Australia, zone 53

Access and use constraint(s)

REQUIRED: Restrictions and legal prerequisites for accessing the data set.

REQUIRED: Restrictions and legal prerequisites for using the data set after access is granted.

This element may describe access constraints applied to assure the protection of privacy or intellectual property, and any special restrictions or limitations on obtaining the resource. If access is unrestricted, that too should be stated.

Contact the GIS Officer to discuss user requirements for citation etc.

Data quality

Lineage

The management zones were provided by Simon O'Connor in 2003 to ***eriss*** on AUSLIG 1:50 000 and 1:100 000 topographic map sheets as hand-drawn areas from the NRM group of PAN. The zones were then hand-digitised in ArcMap to a polygon shapefile by James Boyden using geo-referenced versions of the same maps projected in AGD66, AMG zone 53. The resulting shapefile was reprojected to GDA94, MGA zone 53.

The initial array contained 69 zones and many small areas that often overlapped into multiple zones, or contained 'sub-zones'. Consequently, the allocation of zones within the initial array were rationalised such that each zone was representative of a unique and unambiguous area, defined only by one bounding polygon, and not related to other zones.

The original allocation of zones, and the modified version are provided as two separate shapefiles.

Positional accuracy

Horizontal accuracy is considered accurate to ± 100m based on 1:100 000 maps. Accuracy of zone boundaries was checked after the initial digitisation process against original maps provided by PAN, and

Attribute accuracy

Currently there are no attributes associated with this dataset other than the name given to individual zones. These names are considered correct

Logical consistency

Topological consistency was maintained by ensuring boundaries between zones did not overlap using the 'snap-to' function in ArcMap editor. A unique name attribute was assigned to individual zones allowing demarcation.

Completeness

Since its creation the digital dataset has not been reviewed by the NRM group of PAN. It is envisaged that managers will review the dataset and make any additions to on a needs basis, and that monitoring information associated with each zone will eventually be incorporated as additional attributes.

Contact information

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Metadata date

Date: 20070710

Additional metadata

Microsoft Windows 2000 Version 5.0 (Build 2195) Service Pack 4; ESRI ArcCatalog 8.3.0.800

Supplementary information

No supplementary information at time of publication

A1.12 Digital elevation data of the Magela floodplain downstream of the Ranger uranium mine

DATASET INFORMATION

ANZLIC identifier: Not defined

Dataset name: Digital elevation data of the Magela floodplain downstream of the Ranger uranium mine

Custodian: Environmental Research Institute of the Supervising Scientist (***eriss***); Supervising Scientist Division; Department of the Environment, Water, Heritage and the Arts; Australian Government.

Jurisdiction: Kakadu National Park, Northern Territory, Australia

Description

Abstract

The DEM developed for the ecological risk assessment of Magela was produced by merging two data sources standardised to AHD: 1) DIGO Level 2 Digital Terrain Elevation data (provided as ESRI GRID); and 2) a higher-resolution dataset produced by AUSLIG for ***eriss*** from aerial photography covering most of the Magela floodplain generated at 30 m horizontal resolution. The resulting dataset has provides continuous coverage over the Magela floodplain, with higher accuracy in low relief areas with surrounding terrestrial woodland and floodplain fringes provided at lower resolution. Vertical accuracy is believed to be in order of ± 0.2 m for the higher resolution component (covering most of the low-relief floodplain area), with the surrounding terrestrial woodland area having an absolute vertical accuracy of ±30 m linear error at 90%.

ANZLIC keyword(s)

LAND Topography

ISO category: Environment

Elevation

Geographic bounding box

The following coordinates represent the bounding box chosen for each of the data layers developed for the risk assessment. This area incorporates the Magela floodplain and the immediate surrounds.

	Bounding Latitude		Bounding Longitude	
	North	South	East	West
Magela extent	-12.225455°	-12.606459°	132.93646°	132.74936°

Beginning date: 20060623

Ending date: 20060623

Dataset status

Progress: Complete

Maintenance and update frequency: Irregular

Access

Data representation: vector and raster

Stored data format(s)

Low-resolution data (1-second DEM) were originally supplied by DIGO as a ESRI grid file at 250 m pixel resolution. The file size is 1 degree x 1 degree geographic cell identified by its southwest corner attributes. A mosaic dataset providing complete coverage of KNP was produced from these data tiles.

The original ‘high-resolution dataset is provided as a ESRI coverage and point shapefiles, with points arranged at 30 m intervals forming a grid across the coverage area, with each point representing the estimated height in metres (AHD). The dataset is projected using GDA 94

The derived data file which includes high- and low-resolution data resample to a 30 m grid, and covering the AOI for ecological risk assessment of the Magela floodplain only, is stored as ESRI grid and polygon shapefiles. A further file was derived from this at 250m raster resolution and is stored as a separate worksheet in a Excel workbook. Total size of combined dataset is approximately 3.4 Gigabytes

Available format type

Data have been reproduced in the Geodetic Datum of Australia 1994, re-projected to the Map Grid of Australia, zone 53. Vertical height is in metres, represented as the Australian Height Datum.

Access and use constraint(s)

Contact the GIS Officer to discuss user requirements for citation etc.

Data quality

Lineage

The DEM data used for the ecological risk assessment modelling was adapted from two data sources; 1) a high-resolution 30 m raster dataset from AUSLIG covering most of the Magela floodplain; and 2) a one-second resolution DTM with vertical precision of 1m from DIGO:

Documentation has not been cited for this dataset, however the following is believed to be correct. A high-resolution DEM was produced in about 1984 by AUSLIG (Darwin) for the Environmental Research Institute of the Supervising Scientist from aerial photography flown by AirResearch Pty Ltd . Data cover most of the Magela Creek floodplain including, and downstream of, the Ranger Uranium Mine. Conventional stereo-photogrammetric techniques were used to generate x,y,z data-points. Data was originally received by ***eriss*** in ‘x y z’ format. The GENERATE command in ARC/INFO was used for importing these points into a coverage. The original data was manipulated with ‘nawk’ in Unix using the following command:

cat original_file | nawk '{print NR ‘,’ $1 ‘,’ $2 ‘,’ $3}' > elevxyz Put the word 'END' at the end of the file.

A similar procedure, using the JOINITEM command to add the z values to the P-Attribute-Table of the coverage, was adopted to get a file with z values that was easy to use:

cat elevxyz | nawk '{print NR ‘,’ $4 }' > elevz.

Easting and northing coordinates are in AGD66, AMG and elevation in meters. There are some 553491 data points distributed mostly in a grid pattern at 30–35 m resolution, with a higher concentration of points taken at the edged of drainage channels on the floodplain (lowest point heights).

Digital Terrain Elevation Data, Level 2 produced by DIGO is a uniform matrix of terrain elevation values which provides basic quantitative data. This was developed by DIGO for military systems that require terrain elevations, slope, and/or surface roughness information. Level 2 post spacing is 1 arc second (approximately 30 metres). For complete product specifications refer to MIL–D–89020, Digital Elevation Terrain Data Level 2, 26 February 1990 and DMA Product Specifications for Digital Terrain Elevation Data Level 2, Second Edition, April 1986 (PS/1CD/200). From this dataset a raster coverage was generated at 30 m resolution for the entire KNP

Rationale for amalgamating low and high resolution DEM datasets

There was a need to retain the high-resolution information necessary to define low gradient relief of the floodplain while also providing complete coverage of the area selected for the ecological risk assessment of Magela. As the higher-resolution dataset did not provide complete spatial coverage, gaps in the high-resolution data (in non-floodplain woodland, and at the fringes of the floodplain) were substituted with the DIGO dataset.

Interpolation procedure for high-resolution DEM

Interpolation of the high-resolution raster DEM was conducted using the Inverse Distance Weighted (IDW) technique in the Spatial Analyst Toolbox of ArcGIS™ 9. The DEM surface was generated at 30 m resolution from point data using a fixed 40 m search radius to derive averages from surrounding point values. An absence of point data records within drainage channels resulted in a number of small gaps occurring along channels at the lowest heights on the floodplain. This was due to point height records being distributed only up to the edges of drainage channels (heights were taken from vegetation and not from water), therefore a channel wider than 40m would result in a gap in the DEM. In these cases each gap was substituted with the average value calculated from abounding raster values for each 'channel gap'. Averages were calculated using Spatial Analyst zone statistics, and a 30 m buffer zone generated from the boundaries of channel gaps. Derived values were then manually substituted by creating a polygon for each 'channel gap' using ArcGIS™ editor and working on a arc-shapefile created from the original Interpolated ESRI GRID file.

Positional accuracy

Accuracy of the 'high-resolution' data component is thought to be ±0.2 m vertical and ±2.0 m horizontal (pers com Mike Roberts at AUSLIG Darwin). However no metadata appear to have been compiled at the time of production.

For the 'low-resolution' component: accuracy statements are generally calculated for every DIGO product and provided in the file header metadata. However in this case no accuracy information was recorded or provided with header metadata. In general accuracy objectives for Level 2 data are : Absolute Horizontal- 50 metres circular error at 90%. Absolute Vertical- ±30 m linear error at 90%. The information content is approximately equivalent to a 1:50 000 scale resolution. Exploitation at larger scales must consider each individual cell's accuracy evaluation.

Attribute accuracy

Before DEM data were integrated (from the two sources) a number of data quality checks and comparisons were conducted to ensure the compatibility of the datasets for integration. While both datasets were known to be calibrated to AHD a comparison of corresponding z-values was made, where data overlapped spatially, using simple linear regression and some 80 randomly selected points. Regression confirmed that similarity was in the order of 95%.

A visual check of point data values (from the high-resolution dataset) revealed several records with 'zero' values that made no logical sense when related to surrounding point records (surrounding points had values several meters greater). A decision was made to omit these point values from the dataset before interpolating the raster DEM.

Logical consistency

Not relevant

Completeness: Complete

Contact information

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Metadata date

Date: 20070710

Additional Metadata

Native dataset environment is Microsoft Windows 2000 Version 5.0 (Build 2195) Service Pack 4; ESRI ArcCatalog 8.3.0.800

Supplementary information

http://www.defence.gov.au/digo/Products/Digital_Products/ProductsDTED2.htm

A1.13 Remote sensing fire-scar mapping of annual ‘early’ and ‘late’ dry season burning for Kakadu National Park (1980–2006) and adjoining West Arnhemland (1995–2006)

DATASET INFORMATION

ANZLIC identifier:	ANZCW0501002721 (assigned for Kakadu National Park component only)
Dataset name(s):	Remote sensing fire-scar mapping of annual ‘early’ and ‘late’ dry season burning for Kakadu National Park (1980–2006) and adjoining West Arnhemland (1995–2006)
Custodian(s):	Bushfires Council of the NT and Parks Australia North
Jurisdiction:	Kakadu National Park and West Arnhemland, Northern Territory

Description

Abstract

The full metadata report for this dataset is provided in Appendix 1.13. The fire history of Kakadu and adjoining west Arnhem Land provides broad scale annual mapping of both early (April-July) and late dry season (August-end of dry season) fire-scars as derived from satellite remote sensing. The two regions, Kakadu and west Arnhem Land, are kept as separate datasets. The Kakadu dataset provided continuous annual monitoring for the period 1980 to 2006, while the adjacent area in western Arnhem Land provides continuous monitoring for the period 1995 to 2006. The regional monitoring program continues at the time of this publication, and fire-scar mapping is compiled and updated annually by the Fire Research Unit of the Bush Fires Council of the NT. Detailed documentation of the datasets is provided in Russell-Smith and Ryan (1994), Russell-Smith, et al (1997), Gill et al (2000) and Turner et al (2002).

Fire-scar history is interpreted from satellite imagery captured at strategic times to determine the frequency and extent of early and late dry season burning. Fire scars were interpreted from Landsat MSS satellite imagery (56x78 m pixel resolution then re-sampled to 100 x 100 m) for the period 1980 to 1995. From 1996 to 2004 data are derived from Landsat TM/ETM (30 m x 30 m re-sampled to 25 m x 25 m). For the west-Arnhem Land component derivation of fire-scars was from Landsat TM, MODIS and AVHRR. Coarser resolution AVHRR (1.09 km^2) and MODIS imagery were substituted for the LDS captures for the periods 1995–2001, and 2002–2004, respectively. The resolution of these data is coarser (200 x 200 m pixels), although it can still be used to reliably detect areas where fire has occurred.

For any one year, mapping of ‘Early’ and ‘Late’ dry season burning is undertaken. Early fires (EDS) are defined as fires occurring from May to July. For this period imagery is captured at least twice to address the potential problem of under-sampling, where fire-scars can be missed, unless a suitable number image capture times are used (Russell-Smith et al 1997). Late burns (LDS) are defined as fires occurring from August onwards and are derived from a at least one capture time, preferably as late in the dry season as possible (before the onset of cloudy conditions). Cumulative probability estimates of early and late dry season fires for Kakadu and the Magela floodplain regions are illustrated in Figures 22–25.

Table A1.1 Summary of data sources and methods used to derive fire scar histories for Kakadu and West Arnhemland

Period	**source**	**Kakadu**	**West Arnhemland**
1980–90	Landsat MSS	1980–90 manual digitising and interpretation from FCC hardcopies (1:250000 & 1:500000) by Paul Ryan	Not obtained
1991–94	Landsat MSS	1991–94 Richard Durieu using TNTMips to perform interactive digital classification of scanned FCC hardcopies (1991,93,94) and original digital data (1992).	Not obtained. Some data exist but are of questionable quality (Edwards pers com)
1995–2005	Landsat TM/ETM	1995–2005 unsupervised classification in conjunction with interactive ground-truth validation by Andrew Edwards and BFC	1995–2005 unsupervised classification in conjunction with interactive ground-truth validation by Andrew Edwards and BFC AVHRR substituted for LDS mapping 1995–2001 MODIS substituted for LDS mapping 2002–2004

ANZLIC keyword(s)

HAZARDS Fire; PHOTOGRAPHY AND IMAGERY remote sensing, classification, mapping, monitoring

ISO category: Environment

Geographic bounding box (decimal degrees)

	Bounding Latitude		**Bounding Longitude**	
	North	**South**	**East**	**West**
Parent dataset (KNP)[1]	-12.05897	-14.01906	131.88661	134.14803
Parent dataset (West Arnhem Land)[1]	-11.53702	-14.73151	132.29499	134.55655
Combined dataset (ARR)[3]	-11.53702	-14.73151	131.88661	134.55655
Magela extent[2]	-12.225455°	-12.606458°	132.93636°	132.74936°

[1]Parent dataset obtained from BFC. [2]Derived subset for Magela ecological risk assessment [3]Dataset produced by combining parent datasets to derive complete coverage of ARR

Data currency

Beginning date: 1980

Ending date: Current, new monitoring data appended annually by BFC

Dataset status

Progress: In progress

Maintenance and update frequency: Annual

Access

Data representation: vector and raster

Stored data format(s)

Raster format is stored as ESRI grid, ASCII text and text layers in an Excel workbook. Vector format stored as ESRI polygon shapefiles.

Available format type

Data are provided as a polygon shapefile projected to the Geodetic Datum of Australia 1994 using the Map Grid of Australia, zone 53.

Access and use constraint(s)

Open. Parks Australia North and the Bushfires Research Unit of the Bushfires Council of the NT must be acknowledged as the source of the data. Contact the GIS Officer to discuss user requirements for citation etc.

Data quality

Lineage

From 1980-90 interpretation of fire-scars was undertaken using Landsat MSS false-colour composite (FCC) imagery (bands 4,5 and 7) produced as hardcopies at 1:250 000 and 1:500 000 scales. To minimise operator biases Paul Ryan performed all interpretations and digitisation of fire scars for the period 1980–90. The methodology he developed is outlined in Ryan et al (1995). For each year, clear acetate film printed with key geo-referenced linear features and was overlaid, aligned correctly using a 'best fit method', and then secured firmly onto hardcopy scenes. Fire scars were then interpreted and traced onto film with a fine-tip pen. The process was repeated using the same film for subsequent dry season images, which facilitated verification of preceding interpretations. The film was then manually digitised as separate EDS and LDS vector coverages using the PAN GIS, and then subsequently converted to 100m raster format.

From 1991–94 Richard Durieu was appointed as the new image processor. In 1992 digital Landsat MSS data were acquired, and processing and interpretation of fire scars was undertaken using the interactive classification procedure of TNTMips (Skrdla 1992). All other years in this period were also processed using interactive classification, however high-resolution scans of Landsat MSS geo-rectified hardcopy originals (as FCC) were substituted instead of original digital data in these cases.

As outlined in (Turner et al 2002), fire scar data for the 1995–2000 period were produced by the Fire Research Unit of the Bushfires council of the NT from Landsat TM digital imagery. Finer resolution TM data, with 30 m x 30 m pixels, approximates to a scale of 1:100 000. In these cases ER Mapper™ image processing software was used to a) co-register imagery to an initial set of July 1996 images, b) perform an unsupervised classification of each image; and c) select classes representing fire. The class selection step was performed in conjunction with ground staff and this often involved re-iterating the classification to separate mis-classified 'fire ' classes from spectrally similar features such as water or shadow. During this period ground-truthing information was collected chiefly from helicopter surveys where extensive GPS waypoint data were collected en-route to each monitoring plot. Records were typically taken every 30 seconds where the status of vegetation was recorded as: unburnt; fully burnt within a 100 m radius; or partially burnt (<20% burnt within 100 m radius).

Although the general principle for mapping has remained the same a number of modifications to methods have occurred over the years. It is assumed that the procedure outlined in the above paragraph is that currently used by BFC and PAN for fire scar mapping and validation, and includes all data from 1995 to 2004. Fire scars continue to be monitored by BFC for PAN using these methods.

Positional accuracy

From 1980–90 boundary positional errors constrained to pen thickness using 1:500 000 images is considered to be about ±150 m . Other positional errors of up to ±100 m are anticipated, associated with the rectification of interpreted fire scars. For the period 1991–94, positional errors are estimated to be of ±270 m on fire scar maps produced from 1:250 000 and ±200 m at 1:100 000 scales. As such positional errors may be in the order of 2–3 pixels when applied to a raster of 100 x 100 m.

Positional error may be considered smaller for data derived from 1:100 000 Landsat TM.

Attribute accuracy

Authors of this work have noted the potential for missing fire scar information due to rapid re-growth of vegetation after fire, particularly in the EDS where soil may still be moist. For the EDS this potential source of error was addressed by obtaining imagery at shorter intervals. Capturing at least 2 scenes during the EDS period has been considered sufficient to overcome this problem, however, it is probable that many small fire-scars remain undetected. Lack of detection of fire scars may also be apparent with floodplain fires. However, such fires occur late in the dry season when the floodplain is dry.

Cloudiness at the LDS-wet season interface adds a small but significant source of error, since fires occurring during this time cannot be mapped. While LDS imagery is obtained as late in the dry season as possible the authors are aware that in some years significant fires occurred after the date of image capture, especially on the floodplains, associated both with lightening strikes and traditional hunting/management practices. It has also been noted, given strategic wet-season burning practices to reduce annual Sorghum, the major grass fuel of the lateritic lowlands, that reliability of fire histories would also be further decreased due to the inability to capture images during cloudy periods.

No ground-truth data are available for the years 1980–92. Ground-truthing was undertaken in 1993 and 1994 by helicopter immediately prior to satellite overpass using a series of stratified, random-start transects flown over the Park to ensure that the northern, central and southern sectors of the Park were sampled relatively uniformly. Altitude and speed were held constant at 100m and 60knots, respectively. Every 30 seconds one observer recorded the GPS location, and another observer recorded the state of vegetation and fire history. This study confirmed a high overall agreement of 80% between mapped interpretation of fire scars and ground-truth data (Russell-Smith et al 1997).

Logical consistency

Files are named according to the period within each dry season, and the year. For example the files named E84, L04, and T80 represent fire scars layers for early dry season 1984, late dry season 2004, and total area burnt for 1980, respectively. Data have been designated logical values accordingly:

Burnt area = 1

Unburnt area = 0

Completeness

Complete for period specified.

Contact information

Contact organisation: Bushfires Council of the Northern Territory

Mail address: PO Box 30, Palmerston NT 0831

E-mail address: andrew.edwards@nt.gov.au

Metadata date

Date: 20070710

Additional metadata

Native dataset environment is Microsoft Windows 2000 Version 5.0 (Build 2195) Service Pack 4; ESRI ArcCatalog 8.3.0.800

Supplementary information

Gill AM, Ryan PG, Moore PHR & Gibson M 2000. Fire regimes of world heritage Kakadu National Park, Australia. *Austral Ecology* 25(6), 616–625.

Russell-Smith J & Ryan P 1994. *Long-term monitoring of the effects of management imposed fire regimes on old growth vegetation in Kakadu National Park : Fire history 1980–1993*. Department of Sports, the Environment and Territories, Canberra.

Russell-Smith J, Ryan PG, & Durieu R 1997. A LANDSAT MSS-derived fire history of Kakadu National Park, monsoonal northern Australia. *Journal of Applied Ecology* 34, 748–766.

Ryan P, Russell-Smith J, & Durieu R 1995. *Long-term satellite monitoring of fire regimes in Kakadu National Park, Northern Territory*. In *NARGIS 95: 2nd North Australian Remote Sensing and Geographic Information Systems Forum*, Darwin, NT, 18-20 July 1995 Darwin, Northern Territory, Supervising Scientist & Australasian Urban and Regional Information Systems Association Inc AURISA Monograph 11, AGPS, Canberra, 13–20.

Turner A, Fordham B, Hamann S, Morrison S, Muller, R, Pickworth, A, Edwards, A & Russell-Smith J 2002. Kakadu National Park fire monitoring plot survey and analysis. Kakadu National Park and Bushfires Council of the NT, Darwin.

A.1.14 Infrastructure of the Magela Creek floodplain region (June 2001)

DATASET INFORMATION

ANZLIC identifier: Not defined

Dataset name(s): Infrastructure of the Magela floodplain region (June 2001)

Custodian: Environmental Research Institute of the Supervising Scientist (***eriss***); Supervising Scientist Division; Department of the Environment, Water, Heritage and the Arts; Australian Government.

Jurisdiction: Kakadu National Park , Northern Territory, Australia

Description

Abstract

This vector dataset combines data available for roads, tracks, fence lines, and building boundaries from the DIGO 1:50 000 topographic map series and linear features digitised from IKONOS satellite imagery captured during June 2001 for the entire Magela floodplain region. The dataset was produced for the ecological risk assessment study of the Magela floodplain and covers this area only (Figure 26).

ANZLIC keyword(s)

HUMAN ENVIRONMENT Structures and facilities

Geographic bounding box

(decimal degrees) The following coordinates represent the bounding box chosen for each of the data layers developed for the risk assessment. This area incorporates the Magela floodplain and the immediate surrounds. These coordinates do not represent the extents of the actual data points sampled.

	Bounding Latitude		Bounding Longitude	
	North	South	East	West
Magela floodplain extent	-12.225455°	-12.606458°	132.93636°	132.74936°

Beginning date: unknown

Ending date: unknown

Dataset status

Progress: Complete

Maintenance and update frequency: Irregular

Access

Data representation: vector and raster

Stored data format(s)

Working dataset is stored as a ESRI polyline shapefile. Dataset size is approximately 170 Kilobytes.

Available format type

Dataset is supplied as a ESRI polyline shapefile projected to the Geodetic Datum of Australia 1994, Map Grid of Australia, zone 53.

Access and use constraint(s)

Contact the GIS Officer to discuss user requirements for citation etc.

Data quality

Lineage

The dataset was produced by John Lowry, GIS officer at the Environmental Research Institute of the Supervising Scientist . Vector data from the 1:50 000 topographic line map series for the

Magela region were combined from ‘sealed’ and ‘unsealed’ roads, ‘tracks’ and ‘buildings’ as a single shapefile (WGS84, MGA zone 53). Further vector data were gathered as a separate shapefile for fence-lines and other linear features using IKONOS imagery (captured during June 2001) as a base map for interpretation. Data from the two sources were then combined as a single shapefile.

Positional accuracy

No less than 90% of well defined detail within ±0.5 mm of map scale (25 metres) of their true position.

Attribute accuracy

Considered accurate at the time of map production.

Logical consistency

A visual check of maps in the preparatory stages of map production

Completeness

Considered complete with respect to the linear detail that could be discerned from IKONOS imagery (4 m pixel MS resolution & 1m pixel Panchromatic resolution).

Contact information

Contact organisation: Environmental Research Institute of the Supervising Scientist

Contact position: GIS Officer

Mail address: GPO Box 461, Darwin, NT, Australia 0801

E-mail address: john.lowry@environment.gov.au

Metadata date

Date: 20070710

Additional Metadata: Microsoft Windows 2000 Version 5.0 (Build 2195) Service Pack 4; ESRI ArcCatalog 8.3.0.800

Supplementary information

Metadata for the IKONOS satellite imagery used to derive linear features (captured during June 2001) is stored as a ‘readme.txt’ file on the SSD Oracle database, information explorer, and is located in the directory: \\Spatial Data Management and Storage\Raster\Satellite Imagery\IKONOS\Alligator Rivers Region/Kakadu National Park\Files\

Appendix 2 Descriptions of attribute data for aerial surveys of feral animals and waterbirds

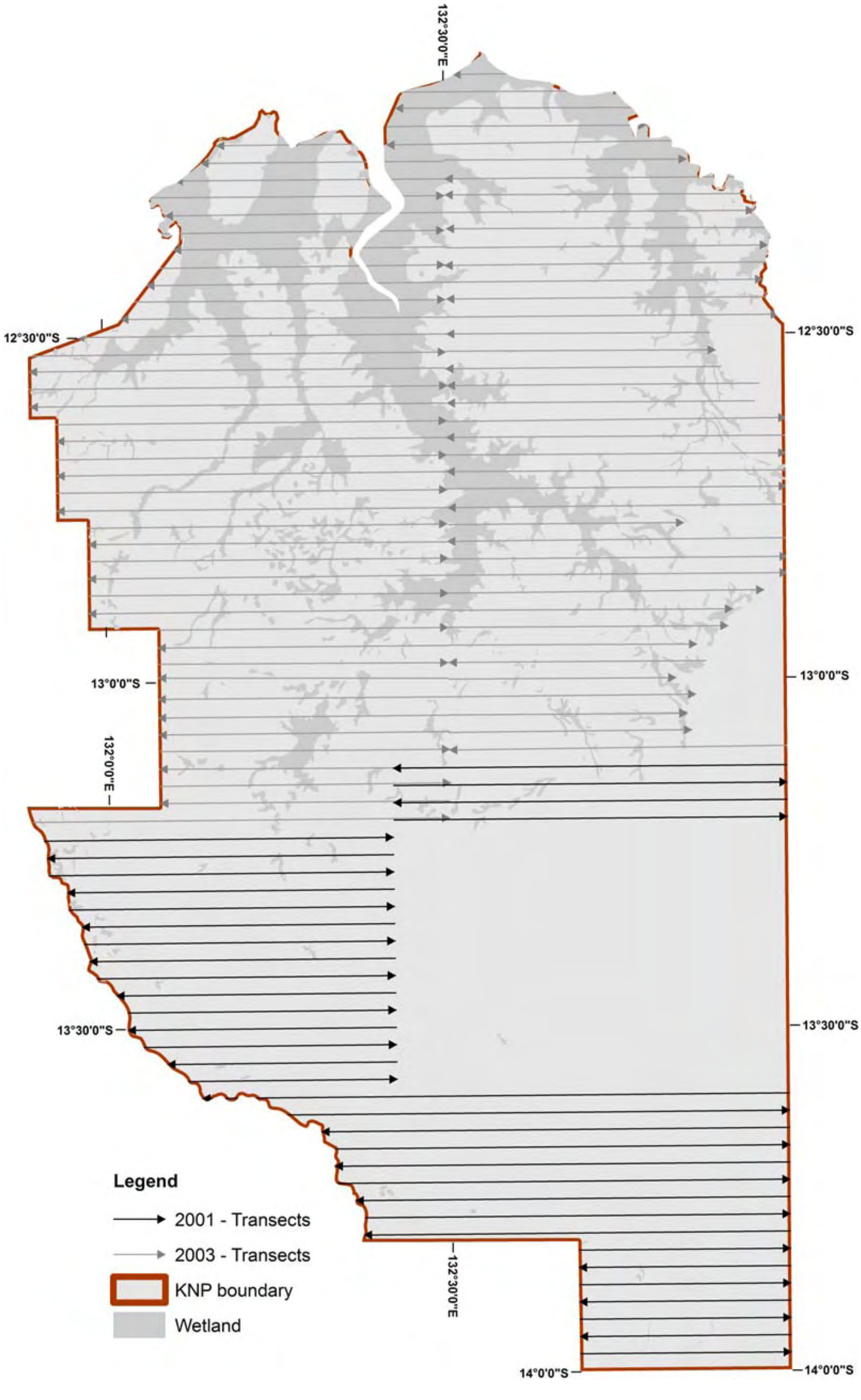


Figure A2.1 Location and extent of transects for aerial survey of waterbirds and feral animals conducted in 2001 and 2003 by Saalfeld and Bayliss

Table A2.1 Field definitions for the shapefile attribute tables for the feral animals and birds aerial survey data, 2003

Field Name	Description
Species	Code for species or primary type of damage (eg pd =pig damage, p = pig) OR description of key locations along flight (eg X track now). Refer to Excel file ‘ ‘ for a full list of code definitions.
Survey	Identifies which of the two surveys records are derived from (either Saalfeld_2001 or Bayliss_2003)
Transect	Relevant to 2003 data only. A transect code defined by the waypoint number at the start of the transect on the flight diagram followed by the direction (E= East, W = West).
Date	Date on which the transect was flown (DD/MM/YYYY)
Time	Relevant to 2003 data only. Relative time (MM.SS) along a transect line derived from the minidisk recording. Time zero roughly being the beginning of a transect.
Observer	Observers in the survey (PB = Peter Bayliss, PC = Peter Christopherson, KS = Keith Saalfeld, AF = Anne Ferguson, SO = Simon O’Connor, RS = Ross ‘Buck’ Salau, SH = Stefanie Hamann, JK = Jason Koh)
Position	The position of the observer in the plane (port or starboard, rear or front)
Seq #	Relevant to 2003 data only. A sequence number allocated to transect.
Number	Either the nominal score given to a level of feral damage (1= LOW, 2= MEDIUM, 3= HIGH) or the number of a particular species counted at one observation.
Type	Relevant to 2003 data only. A secondary description of the type of damage (e.g. wallow, track) or description on type of species count (eg in flight, flying, juvenile etc). This level of detail was not recorded consistently and therefore is incomplete across the entire dataset.
Habitat	A generalised description of habitat at which observations were made. This detail was not recorded consistently and is therefore incomplete across the entire dataset. Refer to Excel file ‘ ‘ for a full list of code definitions
Notes	General notes
Lat	Latitude coordinate provided as GDA94 decimal degrees
Long	Longitude provided as GDA94 decimal degrees

Table A2.2 Description of worksheets within the Excel workbook file ‘Aerial survey datat_11_03.XLS’, containing complete data for the aerial survey conducted in November 2003

Worksheet name	**Description**
Combined counts	Raw data for counts made by all observers (PB/PC/KS). See Table 1C for field definitions.
Transect summary	Indexed list summarising time, location and data storage source for each transect (Table 1)
Field definitions	Listing of field definitions for the ‘Combined counts’ and ‘Field Definitions’ worksheets (Table 1C + Table 1 B)
Species codes	Listing of codes used to describe each species under the ‘type’ field in the ‘combined counts’ worksheet
Feral_damage type codes	Listing of codes used for each species in the ‘Combined counts’ worksheet under the ‘type’ field in the ‘combined counts’ worksheet
Habitat codes	Listing of descriptions used to define the ‘habitat’ type
Keith Saalfeld counts	Raw count data for KS supplied by CC, before it was merged in the ‘combined counts’ worksheet

Table A2.3 Error corrections conducted on aerial survey data collected for the 2003 dry season for feral animals and waterbirds

Checks for positional anomalies of interpolated results imported into ArcMap shapefile were made against original waypoint and track log files in OziExplorer. A number of errors were found and corrected. The types of errors that arose can be summarised as:

– Incorrect location for start and end of transect arising from either ambiguous waypoint information or typo-errors and leading to incorrect position interpolation.

– Incorrect time-log transcription from recordings leading to incorrect position interpolation.

– errors associated with incorrect configuration of input text files leading to incorrect position interpolation. Note there are four general characteristics that define the role of metadata

Table A2.4 Field definitions for the shapefile attribute tables for aerial surveys of waterbirds on the Magela floodplain conducted by Morton and Brennan between 1981 and 1985

Field Name	Description
Transect	A unique code assigned to each transect on the Magela floodplain which is a cross reference to the transect location file (by a number at the start of the transect on the flight diagram followed by the direction (E= East, W = west).
Observer	A unique ID code assigned to each observer (1= Steve Morton, back-right position; and 7= Kym Brennan, back-left position)
Date	Date on which the survey was conducted (DD/MM/YYYY)
Time_Cat	The adjusted 30 second time category (estimated to be 1.2km ground distance along transect) in which a particular count record was assigned.
Species	Waterbird species name assigned to any particular record (egrets for all white egret species, combined, or MG for magpie geese).
Position	The position of the observer in the plane (port or starboard, rear or front)
Count	The total number of a particular species counted by one observer in a particular 30 second (1.2 km) transect unit.
Long	Interpolated geographic longitude generated as AGD66 decimal degrees
Lat	Interpolated geographic latitude generated as AGD66 decimal degrees

Appendix 2.1 Formatting of aerial survey data for correct transfer to ArcMap

Correct formatting of data was important to ensure all information translated to Arc. The following procedures were used:

a In Aerial survey data_11_03.XLS each field in the sight_ll output worksheet was formatted according to specifications in Appendix 6.1.4

b Missing data (blanks) were given the data tag '-99'. *Note: numeric fields in Excel do not transfer to correct format in Arc-shapefiles unless all cells are filled with a number.*

c Once formatting was completed the entire area of data was selected in Excel then saved in DBF (version IV) format for ArcMap.

Appendix 3 Attribute field descriptions for ESRI shapefiles

Table A3.1 Attribute field descriptions for shapefiles produced for aerial surveys of waterbirds and feral animals

Field Name	Format	Additional notes
SEQ	NUMERIC, integer	
TRANSECT	ALPHA-NUMERIC	Field width was expanded to include all text
OBS	ALPHA-NUMERIC	Field width was expanded to include all text
DATE	DATE	Date
E_TIME	NUMERIC, 2-decimal points	Elapsed time since commencement of transect
SPECIES	ALPHA-NUMERIC	Field width was expanded to include all text
SCORE	NUMERIC, 0-decimal points	Missing data tag = -99
TYPE	ALPHA-NUMERIC	Field width was expanded to include all text
HABITAT	ALPHA-NUMERIC	Field width was expanded to include all text
NOTES	ALPHA-NUMERIC	Field width was expanded to include all text
LAT	NUMERIC, 9-decimal points	Latitude were reassigned a negative sign to ensure data fell in the Southern hemisphere
LONG	NUMERIC, 9-decimal points	Longitude

Table A3.1a Attribute field descriptions for shapefiles produced for aerial surveys of feral animals

Field name	**Description**
SPECIES	Species or ground disturbance code, for example horse, pig, or pig damage (pd)
TRANSECT	Unique code for transect, including suffix noting direction of flight along transect (E)ast or (W)est
DATE_	Date DD/MM/YYYY
TIME	Elapsed time from start of transect
OBSERVER	Observer associated with particular count record (KS = Keith Saalfeld, PB = Peter Bayliss)
POSITION	Position of observer in aircraft (eg starboard rear)
NUMBER	recorded count or damage score (1= low damage, 2= moderate damage, 3= extensive damage)
TYPE	When damage score was recorded the 'type' of damage was sometimes noted (wal = wallow).
HABITAT	Code relating to the type of habitat noted when counting (0w = open woodland, rw = riparian woodland, wet= wetland, cw= closed woodland, rip= riparian)
NOTES	General notes
LAT	Latitude in decimal degrees
LONG	Longitude in decimal degrees
SURVEY	Identifies the survey (eg ‘ Bayliss_Saalfeld_2003’ = the survey conducted by Bayliss and Saalfeld during 2003)

Table A3.2 Attribute field descriptions for shapefiles produced for the para grass airboat survey on the Magela floodplain conducted 5–6 March 2003

Field name	Description
DATE_	Date of survey record (DD/MM/YYYY)
MAP_ZONE	Map zone of survey record (MGA)
X	Easting map coordinate from Garmin eTrex GPS (WGS84, UTM)
Y	Northing map coordinate from Garmin eTrex GPS (WGS84, UTM)
NAME	Unique name for survey record, number = waypoint code assigned by GARMIN GPS (A prefix indicates record collected on 5/03/2003 while B prefix indicates record collected on 6/03/2003)
CODE	Code indicating the general assemblage of plants observed at any one point in order of decreasing abundance, PA= para grass, H= *Hymenachne acutigluma*, PS = *Pseudoraphis spinecens*, E = *Eleocharis* spp, O = *Oryza* spp, OW= Open water, SE = *Aeschynonmene americana* or *A. indica* originally recorded as Sesbania, NY = Nymphaea & Nymphoides spp, LU = *Ludwigia adscendens*, ; eg PA_H_OW indicates dominant para grass followed by *Hymenachne* and then Open water where a single 'PA' indicated 100% para grass cover).
[1]HYMENACHNE	Notes on *Hymenacne acutigluma* (followed by percentage cover estimate.
[1]PSEUDORAPH	Notes on *Pseudoraphis* (followed by percentage cover estimate).
[1]PERSICARIA	Notes on *Persicaria* (followed by percentage cover estimate).
[1]NELUMBO	Notes on *Nelumbo* (followed by percentage cover estimate).
[1]ORYZA	Notes on *Oryza* (eg 'subdominant' followed by percentage cover estimate).
[1]NYMPHYAEA	Notes on *Nymphaea/Nymphoides* (eg 'subdominant' followed by percentage cover estimate).
[1]ELEOCHARIS	Notes on *Eleocharis* (eg 'subdominant' followed by percentage cover estimate).
[1]PARAGRASS	Notes on para grass (eg 'subdominant' followed by percentage cover estimate).
[1]LUDWIGIA	Notes on *Ludwigia* (eg 'subdominant' followed by percentage cover estimate).
[1]LEESIA	Notes on *Leersia hexandra* (eg 'subdominant' followed by percentage cover estimate).
[1]SALVINIA	Notes on *Salvinia* (eg 'subdominant' followed by percentage cover estimate).
[1]OPENWATER	Notes on Open Water (eg 'subdominant' followed by percentage cover estimate).
[1]MELALEUCA	Notes on *Melaleuca* (eg 'subdominant' followed by percentage cover estimate).
[1]SESBIANIA	Notes on *Aeschynonmene americana* or A. indica originally recorded as 'Sesbania' (eg 'subdominant' followed by percentage cover estimate).
NOTES	General notes relating to plant dominance, relative position, and growth form

[1] A zero value indicates species was not present.

Table A3.3 Attribute field descriptions for shapefiles produced for the para grass airboat survey on the Magela floodplain conducted 18–19 March 2003

Field name	Description
DATE_	Date of survey record (DD/MM/YYYY)
X	Easting map coordinate from Garmin eTrex GPS (WGS84, UTM)
Y	Northing map coordinate from Garmin eTrex GPS (WGS84, UTM)
NAME	Unique numeric waypoint name assigned by GARMIN GPS for survey record (A prefix indicates record collected on 5/03/2003 while B prefix indicates record collected on 6/03/2003)
CODE	Code indicating the general assemblage of plants observed at any one point in order of decreasing abundance, PA= para grass, H= *Hymenachne acutigluma*, PS = *Pseudoraphis spinecens*, E = *Eleocharis* spp, O = *Oryza* spp, OW= Open water, SE = *Aeschynonmene americana* or *A. indica* originally recorded as *Sesbania*, NY = *Nymphaea* & *Nymphoides* spp, LU = *Ludwigia adscendens*, eg PA_H_OW indicates dominant para grass followed by *Hymenachne* and then Open water where a single 'PA' indicated 100% para grass cover).
OPENWATER	Notes on Open Water (eg 'subdominant' followed by percentage cover estimate).
MONOCHORIA	Notes on *Monochoria* sp (followed by percentage cover estimate).
SALTWATER_	Notes on salt-water tolerant sedge observed adjacent to Mangrove channels at northern end of Magela floodplain (followed by percentage cover estimate).
PANICUM_TR	Notes on *Panicum trachyrhachis* (followed by percentage cover estimate).
LUDWIGIA	Notes on *Ludwigia* (eg 'subdominant' followed by percentage cover estimate).
PARAGRASS	Notes on para grass (eg 'subdominant' followed by percentage cover estimate).
LEESIA	Notes on *Leersia hexandra* (eg 'subdominant' followed by percentage cover estimate).
HYMENACHNE	Notes on *Hymenachne acutigluma* (eg 'subdominant' followed by percentage cover estimate).
PSEUDORAPH	Notes on *Pseudoraphis* (followed by percentage cover estimate).
ORYZA	Notes on *Oryza* (eg 'subdominant' followed by percentage cover estimate).
ELEOCHARIS	Notes on *Eleocharis* (eg 'subdominant' followed by percentage cover estimate).
PERSICARIA	Notes on *Persicaria* (followed by percentage cover estimate).
SALTWATER1	Empty field
NELUMBO	Notes on *Nelumbo* (followed by percentage cover estimate).
NYMPHYAEA	Notes on *Nymphaea*/*Nymphoides* (eg 'subdominant' followed by percentage cover estimate).
SESBIANIA	Notes on *Aeschynonmene americana* or *A. indica* originally recorded as '*Sesbania*' (eg 'subdominant' followed by percentage cover estimate).
MELALEUCA	Notes on *Melaleuca* (eg 'subdominant' followed by percentage cover estimate).
NOTES	General notes relating to plant dominance, relative position, and growth form

[1] A zero value indicates species was not present.

Table A3.4 Attribute field descriptions for shapefiles produced for the para grass airboat survey on the Magela floodplain conducted 16 June 2004

Field name	Description
DATE_	Date of survey record (DD/MM/YYYY)
MAP_ZONE	Map zone of survey record (MGA)
X	Easting map coordinate from Garmin eTrex GPS (WGS84, UTM)
Y	Northing map coordinate from Garmin eTrex GPS (WGS84, UTM)
NAME	Unique numeric waypoint name assigned by GARMIN GPS for survey record (A prefix indicates record collected on 5/03/2003 while B prefix indicates record collected on 6/03/2003)
CODE	Code indicates the general assemblage of plants observed at any one point in order of decreasing abundance, PA= para grass, H= *Hymenachne acutigluma*, PS = *Pseudoraphis spinecens*, E = Eleocharis spp., ED= *E. dulcis*, ES= *E. sphacelata*,O = *Oryza* spp., OW= Open water, SE = *Aeschynonmene americana* or *A. indica* originally recorded as Sesbania, NY = *Nymphaea* & *Nymphoides* spp, LU = *Ludwigia* adscendens, LS or L=*Leersia hexandra*; eg PA_H_OW indicates dominant para grass followed by *Hymenachne* and then Open water where a single 'PA' indicated 100% para grass cover).
Depth_M	Water depth in metres at waypoint location measured with a depth stick, nd= no data recorded at waypoint
OPENWATER	Notes on Open Water (eg 'subdominant' followed by percentage cover estimate).
PARAGRASS	Notes on para grass (eg 'subdominant' followed by percentage cover estimate).
HYMENACHNE	Notes on *Hymenachne acutigluma* (eg 'subdominant' followed by percentage cover estimate).
[1]ORYZA	Notes on *Oryza* (eg 'subdominant' followed by percentage cover estimate).
[1]LEESIA	Notes on *Leersia hexandra* (eg 'subdominant' followed by percentage cover estimate).
[1]ELEOCHARIS	Notes on *Eleocharis* (probably *dulcis*) (eg 'subdominant' followed by percentage cover estimate).
[1]ELEOCHARIS_	Notes on *Eleocharis* (probably sphacelata) (eg 'subdominant' followed by percentage cover estimate).
[1]NYMPHYAEA	Notes on *Nymphaea* (eg 'subdominant' followed by percentage cover estimate).
[1]LUDWIGIA	Notes on *Ludwigia* (eg 'subdominant' followed by percentage cover estimate).
[1]MELALEUCA	Notes on *Melaleuca* (eg 'subdominant' followed by percentage cover estimate).
[1]NYMPHOIDES	Notes on *Nymphoides* (eg 'subdominant' followed by percentage cover estimate).
[1]AESCHYNOME	Notes on *Aeschynonmene americana* or *A. indica* (eg 'subdominant' followed by percentage cover estimate).
[1]PSEUDORAPH	Notes on *Pseudoraphis* (followed by percentage cover estimate).
[1]SALVINIA	Notes on *Salvinia molesta* (followed by percentage cover estimate).
NN2	General notes relating to plant dominance, relative position, and growth form

[1]A zero value indicates species was not present

Table A3.5 Attribute field descriptions for shapefiles produced for the para grass helicopter survey on the Magela floodplain conducted 16 June 2004

Field name	Description
NAME	Numeric waypoint code assigned by Garmin eTrex GPS
X	Easting map coordinate from Garmin eTrex GPS (WGS84, UTM)
Y	Northing map coordinate from Garmin eTrex GPS (WGS84, UTM)
N4	Map zone (MGA)
CODE	Code indicating the general assemblage of plants or growth form of para grass observed at any one point: p (lowercase)= para grass present, P (upper case)= para grass on floodplain margins, PP= isolated patch of dense para grass, EH= *Eleocharis* patches surrounded by *Hymenachne*, OW= open water, L = *Leersia hexandra*, LP= *Leersia Hexandra* and para grass,
PARAGRASS	Blank field (not populated)
HYMENACHNE	Blank field (not populated)
NOTES2	General notes relating to plant dominance, relative position, and growth form

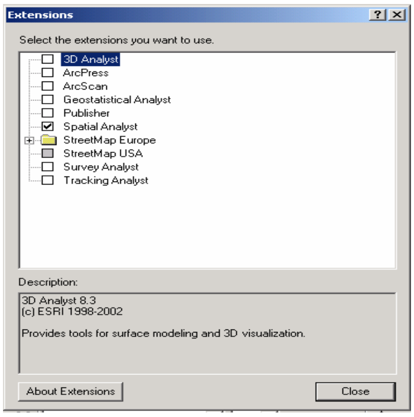
Appendix 4 Methods for developing raster layers in ArcGIS™

The following methods were used to create raster layers from shapefile point data records representing counts made in aerial surveys of birds and feral animals. Raster layers were produced using Spatial Analyst™. Output layers were produced such that any one cell represented the total sum of (point data) counts (for a particular species) falling within the specified grid-cell area (250 m and 500 m resolutions).

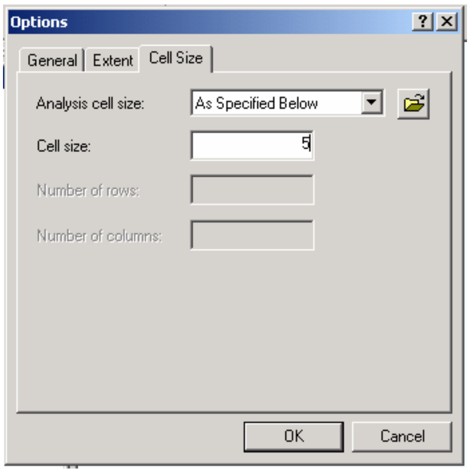
A4.1 Preparation and ArcGIS™ settings

1 Open Arc Map and display the **Spatial Analyst** Toolbar (menus: View>Toolbars>Spatial analyst)

2 If the Spatial analyst menu options are not functional, check that the Spatial Analyst extension has been activated: from the main menu select 'Tool' > 'Extensions' and select 'Spatial Analyst' as specified below.



3 Under the Spatial Analyst menu select '**Option**s' and then the '**Cell size**' tab as specified below.



4 Click on the drop-down list for '**Analysis cell size**' and select the '**as specified below**' option.

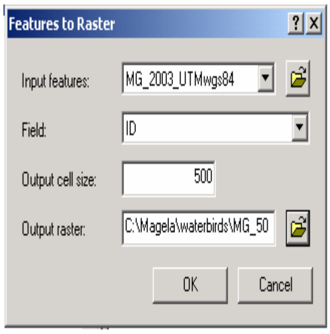
5 In the '**cell size**' box add '**5**' to set 5m as the minimum analysis cell size.

6 In **Layer Properties** set the Coordinate display to WGS_1984_UTM_Zone_53S.

7 Add the Shapefile layer containing the bird count data (projected in WGS_1984_UTM_Zone_53S).

A4.1.1 Creating a 'zone' grid for count data (Spatial Analyst™)

1. Open the Attributes Table for the shapefile.
2. From the Attributes Table select '**Options**' (lower right corner).
3. From the options menu select '**Add Field**'.
4. In the '**Add Field**' display, name the field '**ID**' and set '**field properties**' to '**short integer**' then click 'OK'.
5. Save the ArcMap project, close, and then open Excel.
6. In Excel open the DBF spreadsheet associated with the Attributes Table, above.
7. In Excel add a sequential reference number to the '**ID**' field in the **DBF** spreadsheet.
8. Save the **DBF** file, exit Excel, and then re-open the ArcMap project file.
9. Under the Spatial Analyst menu select '**Convert**' then select '**Features to Raster**'. *Warning: ensure that the correct resolution has been set in Spatial Analyst options (step 4 in A2.1).*
10. In the '**features to raster**' box specify the **input features** shapefile, the values **field** (ID), **output cell size** (500m) and output raster location as shown below.



11. Under the Spatial Analyst menu select '**Raster Calculator**…' and double-click on the new 500 m raster zone layer to add it to the Raster Calculator window then click on '**Evaluate**'. *This produces a new layer in ArcMap called 'Calculation'.*

Note: The output files produced in this Section produces a grid layer where every 500m grid cell is assigned an Identity code (ID). The field named 'ID' in the shapefile is, by default, renamed to 'Values' in the output raster file.

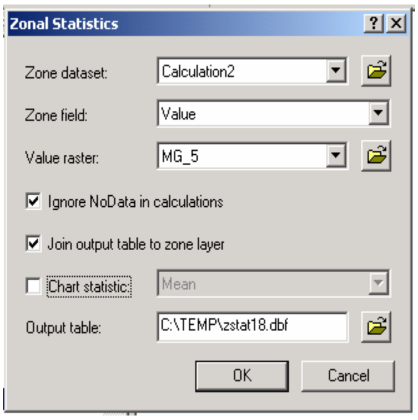
A4.1.2 Create a 5 m count-values raster layer

1. Under the Spatial Analyst menu select 'Convert' then 'Features to Raster'
2. In the 'features to raster' box define the input features shapefile, the count values field (eg. 'SCORE'), and set the output cell size to 5 m. Then click OK.

Note: This creates a grid containing the values for individual counts at 5 m raster resolution from which total counts may be summed at 500 m resolution. The field originally named 'Score' in the shapefile is, by default, renamed to 'Value' in the output raster file.

A4.1.3 Calculate 'zone statistics' for the 500 m zones to derive bird count summation

1 Under the Spatial Analyst menu select 'Zonal Statistics' dialogue box (displayed below)



2 In the Zonal Statistics box select the 'Zone dataset' from the drop-down list by adding the 'calculation' layer produced from the 500 m raster zone layer in Step 12 of section 4.

3 Set the 'zone field' to 'Value'

4 Select the Value raster file from the dropdown list. This will be the raster layer produced in section 3, above.

5 Ensure that the options- 'ignore No Data in calculations' and 'Join output Table to zone layer' – are both selected, and deselect the 'chart statistics' option.

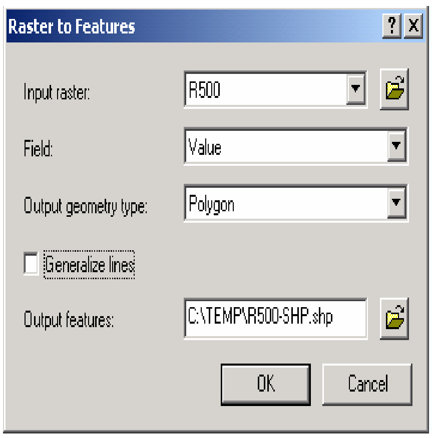
Note: The output statistics produced above are placed in a temporary 'zstat.DBF' Table (C:\Temp|Zstat.dbf).

A4.1.4 Embedding zone statistics (sum of point values) as the raster grid value

Note: The 'sum' value field from the Zstat Table must now be embedded in a 500 m raster grid as the value by linking the relational field from the Zstat Table ('Value') to the identical field in the 500 m zones raster zones Table. First the 500m raster zone Table must be converted back to a shapefile.

1 Convert the 500 m raster zones back to a shapefile: In Spatial Analyst select 'Convert' then select 'Raster to Features'.

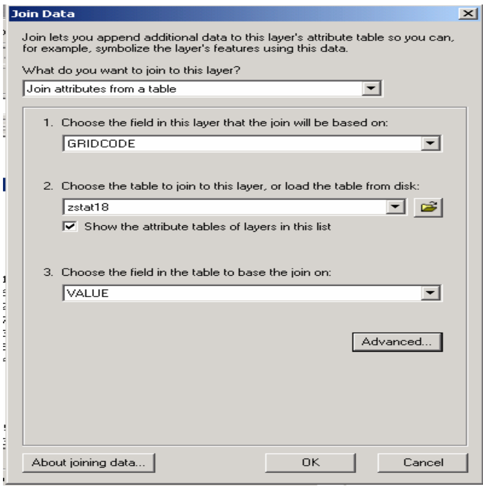
2 Complete the dialogue box settings as shown below, ensuring that the '**generalized lines**' option has been **de-selected**, then click 'OK'.



Note: The field called 'GRIDCODE', in this case, is the same as the original shapefile 'ID' field created in Section 2.

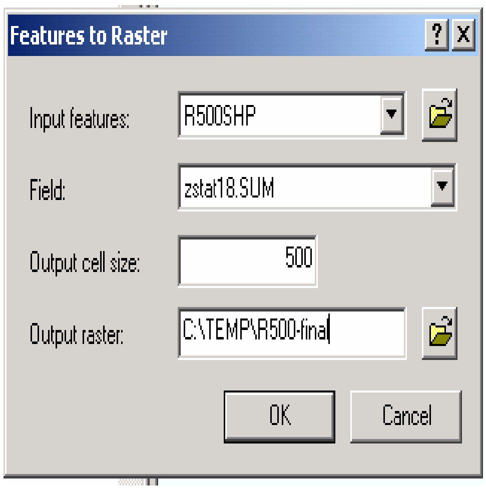
1 Now Right-click on the new shapefile and from the menu select 'Joins and Relates' then select 'Join'.

2 Complete the dialogue box as shown below, choosing the Zstat Table to link to 500 m zone shapefile. Note that 'GRIDCODE' (in the 500 m zone file) must be linked to 'VALUE' in the Zstat Table. Click OK.



Warning: *When fields are incorrectly joined between tables the result will be incorrect*

3 Under the Spatial Analyst menu convert this file back to a Raster grid by selecting 'Convert' then 'Features to Raster'. Complete the dialogue box (below) ensuring that the Zstat.SUM is the field designated to the raster value. Also ensure the Output cell size is set correctly.



4 Ensure that the values in the output raster files are checked against original point data to confirm a correct result.

Appendix 5 Error checking procedures

Table A5.1 Summary of error checking procedures

Error type	Checking/correction method
Unclear audio-recordings	• Uncertain records were tagged with a 'X' suffix. These records were removed from final outputs.
Typo errors in manual data entry of counts data to Excel:	• Data were sorted by 'species' and 'score' to look for outlier values in the 'score' field. • Possible errors were then corrected against written transcriptions
Typo errors in manual data entry of spatial coordinates for transects used in interpolation of position of counts.	• Coordinates were imported to ArcMap and checked against waypoint data for transects
Errors produced in VB-Macro output from incorrectly formatted data:	• Format of input files was checked against a template file with correct format. • Output positions were then visually checked in Arc-Map
Position outputs from VB-Macro are positive numbers:	• Latitude was changed to a negative sign so that data were projected in the Southern hemisphere
Incorrect field formats in final shapefiles:	• Ensure fields are correctly formatted in Excel before saving as a DBF input file for Arc • Ensure that missing data (blanks) are tagged with a missing data value (-99) • Check field formats of shapefiles in ArcCatalog
Incorrect values in raster outputs generated from original shapefile data (This type of error arose when incorrect fields are assigned in rasterisation procedure):	• Check several raster cell values against original point data values

Appendix 6 Description of attribute fields associated with the vegetation and land unit classification maps

Table A6.1 Description of attribute fields associated with the Vegetation classification map for KNP produced by Schodde et al 1987

Field name	Description
Area	Area in hectares calculated for individual map polygons
Perimeter	Perimeter in kilometres calculated for individual map polygons
Shoveg_ID	A unique numeric code assigned to each vegetation map class
Veg_Type	A brief written description of the vegetation map class. A full description of map class units is proved in Schodde et al 1987.

Table A6.2 Description of map codes associated with the land unit classification of Magela Creek catchment (Wells 1979)

Surface features	Land unit code	Slope	Description	Typical vegetation	Distinguishing features
Plateau surface	1a	<10%	Massive sandstone outcrop, rare shallow lithosols, sparse grassland with low shrubs	Sparse grassland with low shrubs	Mainly rock outcrop, minor soil occurrences
Escarpment/ plateau side slopes	2a	>40%	Slopes greater than 40%, shallow lithosols and rock outcrop, grassland to low open woodland	Grassland to low open woodland	Includes scarps and cliff faces
	2b	15-40%	Slope 15 to 40%, shallow lithosols and rock outcrop, grassland to woodland	Grassland to woodland	Large boulders and scree debris common
	2c	5-15%	Slope 5 to 15%, shallow sands and skeletal soils with rock outcrop, low scrub to open forest	Low scrub to open forest	Common rock outcrop
	2d	<5%	Discrete areas of rock pavement on gently sloping rock outliers, rare shallow sands	None recorded	Rock pavement areas
Undulating upland terrain	3a1	<1%	Deep sandy red massive earths and minor gravelly red massive earths, tall open woodland to open forest	Tall open woodland to open forest	Tall open woodland to open forest
	3b	<2%	Moderately deep to deep red earth soils, tall open woodland to open forest	Tall open woodland to open forest	Tall open woodland to open forest
	3c1	<3%	Moderately deep to deep gravelly red massive earths, tall open woodland to open forest	Tall open woodland to open forest	Upper wash slope areas
	3c2	<1%	Shallow to moderately deep gravelly red massive earths and minor red earthy sands, woodland to open forest commonly with dense scrub under-storey	Woodland to open forest community with dense scrub under-storey	Lower wash slope areas, less well drained

Surface features	Land unit code	Slope	Description	Typical vegetation	Distinguishing features
Undulating upland terrain	4a	<2%	Shallow to moderately deep gravelly yellow massive earths and minor brownish sands, open forest	Open forest	Open forest on gentle colluvial slopes
	4b1	<3%	Shallow to moderately deep gravelly yellow and brown massive earths and minor brownish sands, woodland to low open woodland	Woodland to low open woodland	Woodland to low open woodland
	4b2	<4%	Shallow gravelly yellow and brown massive earths, dense scrub with emergent trees	Dense scrub with emergent trees	Dense scrub with emergent trees
	4c1	<3%	Moderately deep to deep sandy yellow massive earths and minor brownish sands earthy sands and pale sands with colour B horizons, open forest	Open forest	Wash slopes and flats near drainage lines
	4c2	<3%	Shallow sandy yellow massive earths and minor brownish sands, earthy sands and pale sands with colour B horizons, woodland to low open woodland	Woodland to low open woodland	Generally closer to drainage lines than 4c1
	4d	<3%	Shallow to moderately deep loamy yellow massive earths commonly on upper wash slopes, woodland	Woodland	Upper well drained wash slopes
	4e	<2%	Moderately deep to deep loamy yellow massive earths commonly on upper wash slopes, woodland.	Woodland to low open woodland	Lower, less well drained wash slopes
Low lying drainage floors, slopes and creeks	5a	<2%	Deep earthy sands, brownish sands and pale sands with colour B horizons, woodland to open forest	Woodland to open forest	Generally associated with upland terrain
	5b	<2%	Variable depth siliceous sands, pale sands with a colour B horizons and brownish sands, woodland intermixed with areas of grassland	Woodland intermixed with areas of grassland	Lower wash slopes commonly beneath 5a

Surface features	Land unit code	Slope	Description	Typical vegetation	Distinguishing features
Low lying drainage floors, slopes and creeks	5c	<1%	Moderately deep to deep brownish sands or earthy sands and alluvial soils (clay loams over sand), grassland with patches of low open woodland	Grassland with patches low open woodland	Very low lying poorly drained areas
	5d		Deep colluvial siliceous sands and brownish sands with minor pale sands of colour B horizons, tall open woodland to scrubland	Tall open woodland to scrubland	Colluvial slopes adjacent to sandstone plateau outliers
	5e	<4%	Alluvial soils (sand over clays) siliceous sands and minor brownish sands, grassland with scattered trees	Grassland with scattered trees	Drainage line areas
	5f3	<2%	Alluvial soils siliceous sands and earthy sands frequently occurring on upland margins to alluvial clay plains, closed Melaleuca forest with areas of grassland	Closed Melaleuca forest with areas of grassland	Melaleuca forest areas adjacent to the clay pans
Alluvial plains on freshwater sediments	6a2	<4%	Grey cracking clays, grassland	Grassland	Grassland
	6b2	<1%	Hard pedal and apedal mottled yellow duplex soils and gley duplex soils (solodized solonetz solodic soils and gleyed podsolics) rare structured earths with rough ped fabric, grassland with scattered trees.	Grassland with scattered trees	Grassland
Alluvial clay plains	7a1	<1%	Black cracking clays and hard pedal black duplex soils (acid swamp soils) with minor mottled yellow duplex soils, grassland with emerging Melaleuca occasionally in clumps	Grassland with emergent Melaleuca, occasionally in clumps	Grassland with emergent Melaleuca, poorly drained
	7a2	<1%	Black cracking clays, non cracking clays (acid swamp soils) and alluvial soils, closed Melaleuca forest	Closed Melaleuca forest	Closed Melaleuca forest, less poorly drained than 7a1

Surface features	Land unit code	Slope	Description	Typical vegetation	Distinguishing features
	7a3	<1%	Black cracking clays, non cracking clays and hard pedal black duplex soil, grassland	Grassland	Grassland, more poorly drained than 7a1
	8b	<1%	Alkaline black and grey cracking clay, grass and sedgeland	Grass and sedgeland	Grass and sedgeland, seasonally dry
Alluvial clay plains	8d	<1%	Alkaline black and grey cracking clay in ill-drained areas, sedge and grassland	Sedge and grassland	Sedge and grassland, lower more & poorly drained than 8b
	9a	<1%	Grey gleyed saline clays, saltwater mangroves.	Saltwater mangroves	Saltwater mangroves
Littoral areas		<1%			

Appendix 7 Procedure used to geo-register and reproject the land units classification for the Magela catchment

The Magela Land Units map was re-registered in ENVI™ to a standard Landsat TCC scene (Datum: AGD 1966; projection AMG zone 53) as visual inspection of the original file against registered base images indicated a spatial error-shift of about 400m (in both AGD66 and GDA94 datums'). The aim was to develop a method that delivered a product with optimal accuracy whilst also retaining the complete coverage area.

Using two different methods in ENVI™, triangulation, and RST (rotation, scaling an translation) the map was re-projected twice to produce two output files. Triangulation produced the most accurate result, however, an artefact of this process is that peripheral areas of the image are clipped. The second method, RST, reproduced a complete coverage, however, the resulting registration is not as accurate (although better than the original).

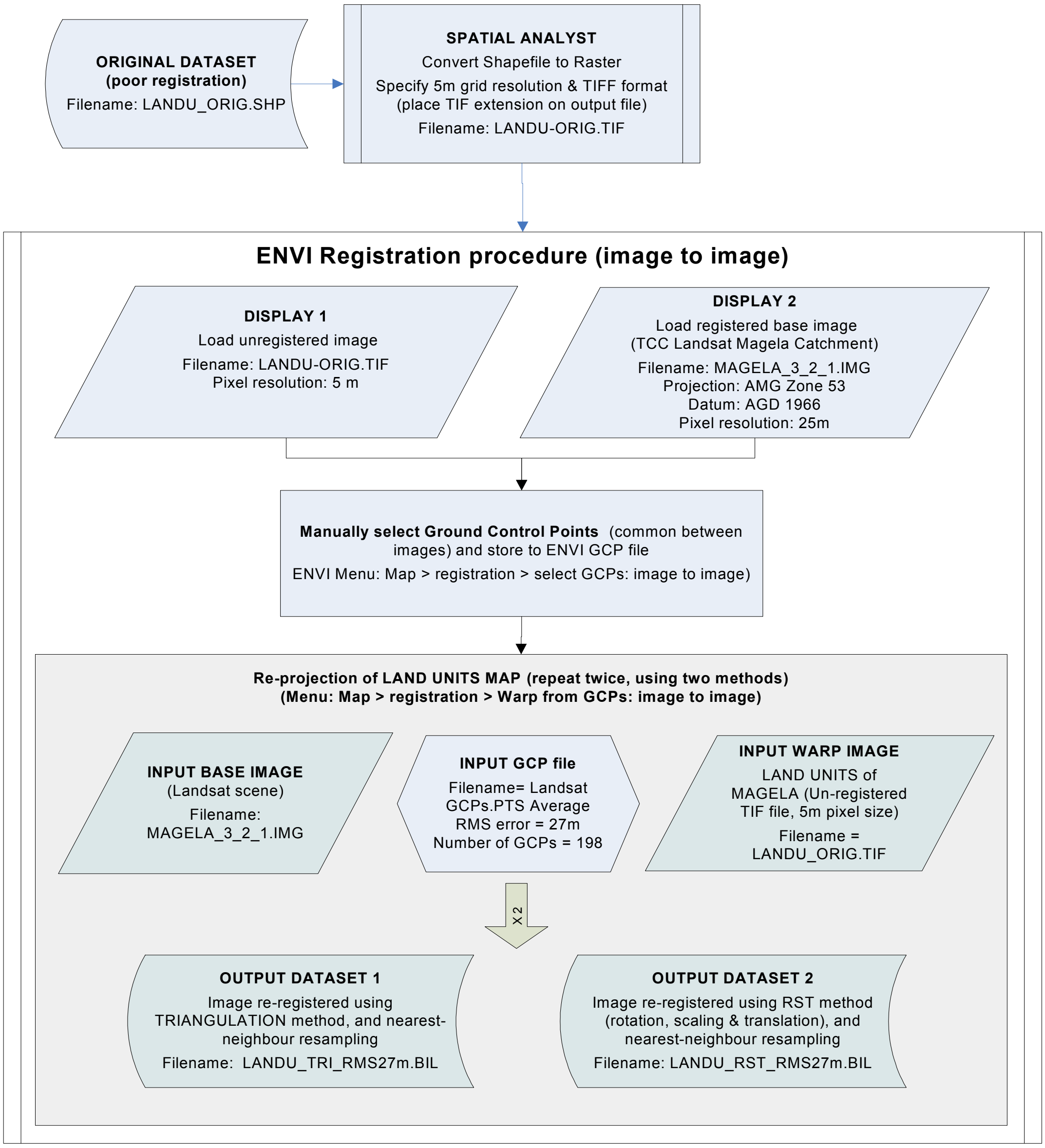


Figure A7.1 Procedures used in ENVI™ to re-project the land unit classification of the Magela catchment

The file produced using triangulation was used as a core dataset. The deleted peripheral zones in this dataset were then substituted with the same spatial zones produced from the RST re-projection. The following flow diagram (Figure A7.2) describes the methods used to amalgamate data produced from the two re-projections (Figure A7.1), resulting in a complete coverage with optimal accuracy.

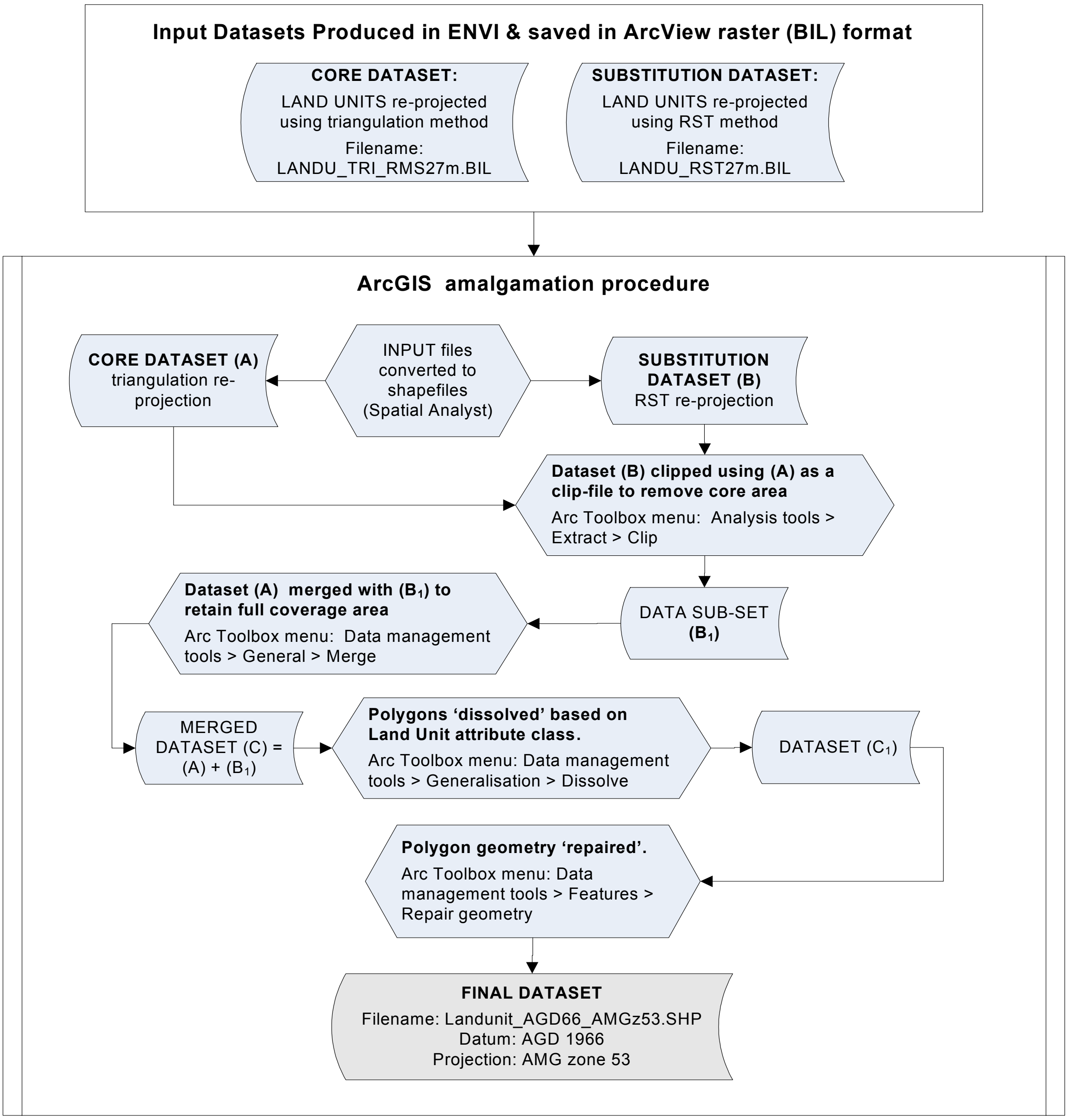


Figure A7.2 Procedures used in ArcGIS™ to amalgamate re-projected data files produced in ENVI™ (Figure A7.1)