Part 5: General Alligator Rivers Region

Contents[1]

[1] List of papers grouped by Key Knowledge Need.

Changes in Melaleuca distribution on the Magela floodplain 1950–2004

G Staben, J Lowry & G Boggs[1]

Background

In September 2001, concerns were raised by the media that the spread of *Melaleuca* spp observed in Papua New Guinea and the Mary River Floodplain in the Northern Territory may be occurring in the wetlands of Kakadu National Park. It was suggested that the spread of *Melaleuca* spp could displace herbaceous vegetation communities in the wetlands of Kakadu. An initial desktop study was undertaken using GIS software to map changes in Melaleuca distribution on a section of the Magela floodplain between 1975 and 1996 (Riley & Lowry 2002). This found that while there had been an overall decline (21%) in tree density on a 41 km^2 section of the Magela floodplain, the spatial distribution of woody vegetation had increased. However, there were recognised problems with the accuracy of some of the analysis, owing to limitations in image pre-processing techniques and human error using manual classification methods. The conclusions from this initial study emphasised that future technological developments in image analysis and classification software may help to overcome these problems.

The report by Riley and Lowry (2002) formed the basis for further research, which was undertaken as a Bachelor of Science Honours project at Charles Darwin University during 2005. This project has applied both remote sensing and GIS technology to investigate the change in *Melaleuca* spp canopy cover for a 4.9 km^2 section of the Magela floodplain.

The Honours project had two primary aims:

1 To assess the use of object-based classification for distinguishing between *Melaleuca* spp. cover and other floodplain communities using aerial photographs.

2 To track changes in the spatial and temporal distribution of *Melaleuca* spp. cover over the period 1950–2004, for a representative portion (4.9 km^2) of the Magela Creek floodplain.

Progress to date

Current advances in multi-scaled object-based classification techniques have enabled the successful classification of very high resolution satellite data (Laliberte et al 2004). The use of a multi-scaled approach has enabled the development of classification methods resembling the way humans interpret an image (Baatz et al 2004). It was found that environmental conditions at the time of acquisition of the photographs influenced the success of the classification. In particular, the 1975 image was significantly easier to classify due to the absence of other vegetation, allowing greater contrast between water and *Melaleuca* spp Typically, vegetation studies using automated classification techniques rely heavily on areas of the electromagnetic spectrum such as the infrared region, as it able to best discriminate between different vegetation species (Ahmad et al 1998, Harvey & Hill 2001). However, the

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spectral properties of panchromatic and true colour aerial photographs (as used in this study) are derived from the visible range of the electromagnetic spectrum (0.30–0.72 um). Consequently, these are unable to differentiate between different vegetation types as well as the infrared spectrum (Campbell 1996). This limitation of the visible range of the electromagnetic spectrum was found to affect the quality of the segmentation process, as extraction of meaningful objects (at the scale used in this project) still relies heavily on the spectral properties of an image. Specifically,this study found that the reduced spectral properties of the visible part of the electromagnetic spectrum were not able to discriminate well between *Melaleuca* spp and other vegetation.

It should be noted that the scale and quality of the 1950 aerial photograph may have led to a bias in the classification process. Specifically, small individual examples of *Melaleuca* spp may have been omitted, whilst tree shadow may have been classified as *Melaleuca* spp.

Applying a low-pass filter over the 1996 image greatly reduced the heterogeneity of the pixels in the image, and increased the contrast between *Melaleuca* spp and other vegetation types. The combination of smoothing the image and incorporating a scale level classified on the different brightness levels across the image helped to increase the accuracy of the automated classification process. The ability to incorporate objects at different scale levels into a single classification knowledge base helped to compensate for the limited spectral properties of aerial photographs and enhance the overall classification process.

Accuracy assessment was undertaken using reference datasets generated from digitised manual interpretation of 250 random points across each aerial photograph; additionally ground truthing data was collected to assess the 2004 classification. The final 1950 and 1975 classified images recorded an overall accuracy estimated at 89%, and 90% respectively. The overall accuracy of the final 1996 classification was estimated to be 82%. Estimated accuracy of the final 2004 classification using the digitised referenced data was 85% and for the ground truthing data 81%.

Change analysis

Change analysis was undertaken using a GIS platform. The extent of *Melaleuca* spp estimated to cover the 4.9 km^2 study area in 1950 was 118.9 ha; by 1975 the extent had increased by 14.4 ha to 133.4 ha. In 1996 *Melaleuca* spp. cover again increased slightly by 2 ha to 135.4 ha and in 2004 there was a slight decline in cover of 15.4 ha to 120.4 ha (Fig 1). Taking into account the error margins present in each classified datasets, these results indicate that the overall canopy cover of *Melaleuca* spp has not varied greatly over the 54 year period.

To identify spatial change in canopy cover over the 54 year time period, datasets representing percent of canopy cover for 392 m^2 areas across the whole image were produced using the block statistics function and the raster calculator in ArcMap. This was done to compensate for geometric distortions and misregistration between the different aerial photographs which would over estimate the level of change. Image differencing was then performed to produce data revealing levels of ± % cover change. Although the estimated percentage of canopy cover datasets indicate large variations in spatial distribution of *Melaleuca* spp. cover across the study area as a whole, coverage has been consistently expanding in the lower eastern region of the study area over the 54 year period. While this study shows there has been little overall change in canopy cover in the study area, the change in spatial distribution appears to have been large. The use of historical aerial photographs has enabled the floodplain to be studied at a scale not available in other forms of historical imagery.

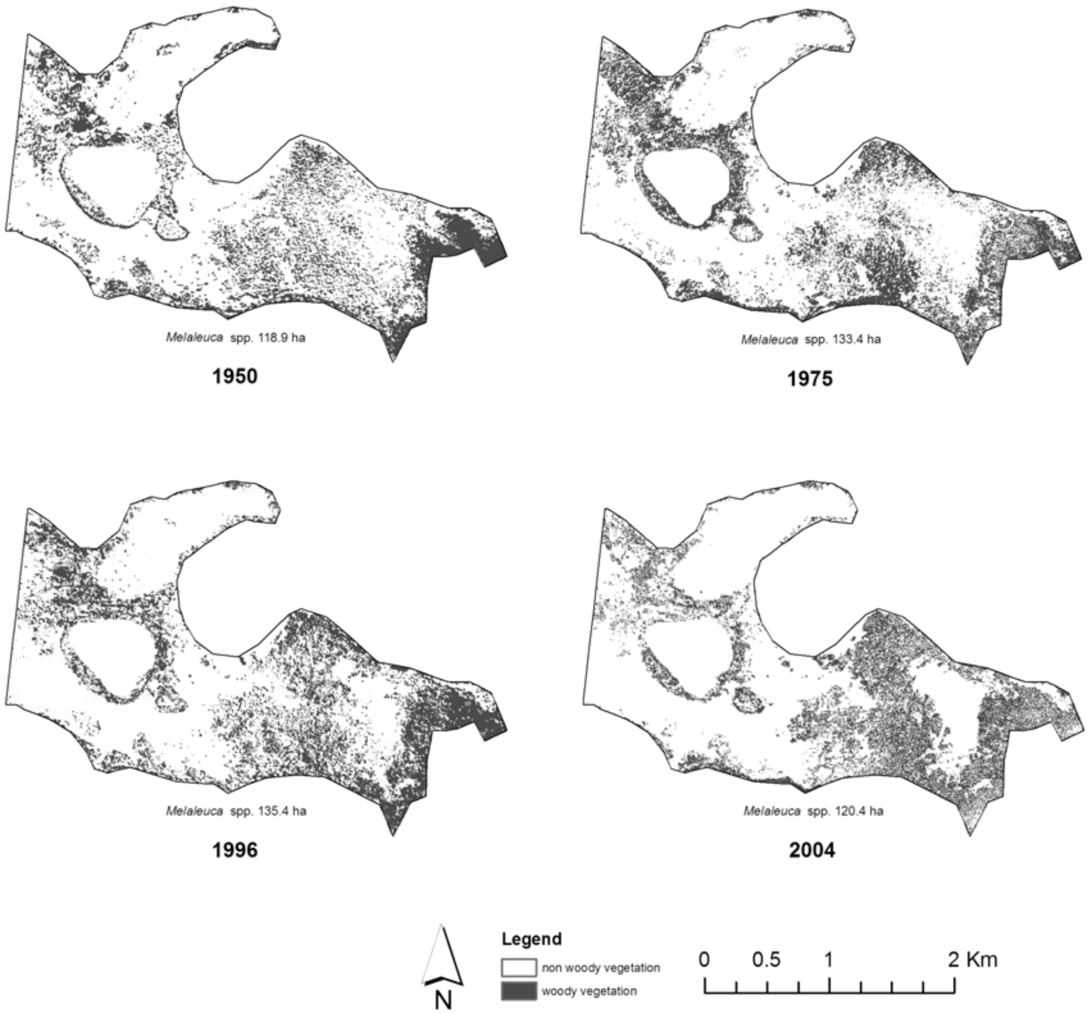

Figure 1 Classified images showing the spatial extent of *Melaleuca* spp. cover for the study area for each time period, with darker colours indicating increasing density of woody vegetation

Identifying the reasons for this change was beyond the scope of this study. However, the impact of fire and feral pigs was very apparent during the collection of ground truthing data in August 2005. Fire occurs regularly throughout the region, and mature *Melaleuca* stands have been identified as fire sensitive communities (Gill et al 2000, Russell-Smith et al 1997). While *Melaleuca* spp are generally a fast growing pioneer species (Morris, 1996) and their seedlings regenerate well in the ash bed of fires (Cowie et al 2000, Roberts 1997), new forests may take between ten and twenty years to develop (Morris 1996). Areas of juvenile regrowth of *Melaleuca* spp, and burnt out patches of *Melaleuca* spp were both observed along the margins of the study area. The observed impact of fire on *Melaleuca* spp may account for the spatial changes in distribution found in this study.

There was also significant soil disturbance (as a result of pig rooting) along the margins of the floodplain within the study area. In south-eastern Australia, pig rooting can change the species composition of native vegetation (Hone 1995). Outside of Australia they have been shown to modify soil nutrients, reduce plant cover, alter plant species composition, and effect soil erosion (Mitchell & Mayer 1997). Research on the effect of native pigs (*Sus scrofa*) on woody understory vegetation in a lowland rain forest in Malaysia has shown that native pigs play an important role in plant dynamics at the understory level (Ickes et al 2001). It is also possible that changes identified in this study could be representing intra species changes in distribution of *Melaleuca* spp., due to changes in rainfall patterns or succession due to sediment accumulation. Identifying and understanding the complex relationships between the various causal factors driving vegetation change is complex and requires further research (Banfai & Bowman 2005).

The honours thesis (Staben 2005) written for this project was submitted on schedule in November 2005. A poster was also presented at NARGIS 2005. An important output of the project is a number of datasets which would be invaluable for further analysis of woody vegetation communities on the Magela floodplain.

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Significant habitats and species in the Alligator Rivers Region

C Humphrey

Background

This project is being conducted in response to a specific recommendation of the IUCN and the World Heritage Committee. Their concern was that there might be endemic species of animals that, while not at risk from direct contaminant pathways associated with any development at Jabiluka, could be affected by indirect secondary pathways.

Surveys have been conducted on the aquatic fauna of seeps and springs in the stone country of KNP including in the vicinity of Jabiluka. Particular attention is being paid to the crustacean groups, the isopods (family Amphisopodidae), freshwater crabs (family Parathelphusidae) and prawns and shrimps (families Atyidae and Kakaducarididae) that occur in these habitats. The results obtained in these surveys are being provided to taxonomists to distinguish and describe new species collected from the sites. If species are identified that are only found in the vicinity of Jabiluka, consideration will be given to pathways for potential impact and possible monitoring programs.

This work could be of direct relevance to any possible mining developments in Western Arnhem Land. In addition, these endemic species may be vulnerable to the invasion of cane toads and their life stages, through either toxicity (direct contact or from consumption) or competition with tadpoles for food and space.

Progress to date

Current work is taxonomic, with southern collaborators from Griffith University, BioAccess Australia and The Australian Museum conducting morphological and molecular genetic studies on the samples. Work to date is confirming that the macro-crustacean groups from seeps and springs are very diverse, with very localised endemism.

One of these crustacean groups is an endemic genus of phreatoicidean isopod (*Eophreatoicus*) that has exceptional species-level diversity. Dr George Wilson from the Australian Museum and ***eriss*** received a research grant from the Australian Biological Resources Study (ABRS) in 2004 to describe isopods of KNP and western Arnhem Land. Dr Wilson has made particular note about the results he has recently acquired from the Jabiluka region – collected from Catfish, North Magela and 7-J creeks, Ngarradj and 3 small tributaries draining the Jabiluka outlier itself. It appears that there is a ‘species flock’ around the Jabiluka region with a number of these small creeks returning 2 or 3 co-occurring species, restricted just to these streams.

It has been postulated that this diversity and endemism is a consequence of the extreme age and persistence of the stone country and its associated fresh waters, and isolating mechanisms including fragmentation of habitat (long-term climate changes, erosion) and the generally poor dispersal characteristics of the crustacean groups. One model being proposed is that climatic variation over the Neogene (broad period of geologic time starting 23 million years ago to the present) has promoted speciation during both periods of aridity (when populations become isolated) and wetter periods (when animals are able to disperse). This ‘species pump’ model has also been used to explain diversity of vertebrates in the wet tropics of Australia.

To complete the isopod work and publish the findings, some additional sampling is required in 2006-07 from Jabiluka sites from which there is presently too little material. The results have profound implications for the conservation values of the sites and resident faunas. The extent of connectivity between surface and deep aquifers will need to be well understood to be able to predict the near surface effects of mine dewatering operations, in the event that mining does proceed. If significant lowering of the near surface groundwater table did occur in the habitat locations of these ispopods then their dry season habitat (sub-surface groundwater) would be compromised.

Ecological risk assessment of Magela floodplain to differentiate mining and non-mining impacts

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Background

The Ecological Risk Assessment (ERA) project is the final project of the 'Landscape-scale analysis of impacts' Program established in 2002 to help differentiate mining and non-mining impacts on the World Heritage and Ramsar listed Magela Creek wetlands downstream of the Ranger mine. Ecological risk assessment allows the level of risk to the 'health' of ecosystems exposed to multiple stressors to be quantified in a coherent, robust and transparent manner. A high protection level for the biodiversity of aquatic ecosystems was used as the assessment endpoint, so conclusions here can be regarded as being appropriately conservative.

Two key results from the initial ERA of the Magela floodplain reported at ARRTC17 (February 2006) were that: (i) diffuse landscape-scale risks were several orders of magnitude greater than point source risks to Magela surface waters from the Ranger mine; and that (ii) of the landscape-scale risks, damage from pigs > para grass > unmanaged fire. However, the current huge difference between non-mining and mining related risks may reduce when on-site water management systems and some of the potential exposure pathways at Ranger change in the transition between mine production and mine closure and rehabilitation. For this reason the decommissioning and closure periods will require their own detailed and explicit risk assessment.

Progress

Whilst the Landscape Program has basically concluded more advanced risk analysis and modelling is still underway in the lead up to publication of results. For example, use of recently revised estimates of para grass (*Urochloa mutica*) cover and distribution across Magela floodplain shows that it is currently the major ecological risk because of its extent, adverse effects and rapid spread rate (see below). However, damage to biodiversity values from pigs in the initial ERA was assumed to be 100% (i.e. effects probability = 1.0) because they are declared a Threatening Process under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). The influence of this 'maximum' assumption on the overall landscape ecological risk value and, hence, on the importance rank of each landscape threat, was examined by sensitivity analysis where the ecological effect of pigs was varied between 0.25 and 1.00. Results (Table 1) show that: the overall landscape risk value does not reduce significantly over a wide range of assumed pig effects. Para grass still ranks first in importance regardless of the effect of pigs; and, not surprisingly, fire became the second ranking risk when the effect of pigs was reduced. Since para grass contributes most to the overall landscape risk value (now para grass > pigs > unmanaged fire) it has been examined in greater detail by further study as outlined below.

In the early 1980s para grass was present in very small areas of the Magela Creek floodplain, and by the mid 1990s it had spread from 132 to 422 ha in five years (1991–1996, Knerr 1998). This core patch of para grass occupies the centre of the floodplain (see Figs 2 & 3) and is expanding on average at 14% p.a. (Fig 1a), or doubling in extent on average every 5 years (Bayliss & Walden 2003). The increase in area of para grass between 1991 and 1996 showed a corresponding decrease in area of a community of wild rice and *Eleocharis* spp sedge, important food resources for pre-fledging magpie geese and nesting material for adults, respectively. Para grass currently occupies about 1250 ha or 10% of the floodplain with 100% cover, and new outbreaks are occurring in inaccessible dense Melaleuca woodland.

Table 1 Summary of sensitivity analysis undertaken to examine the influence of variable pig effects on the overall ecological risk assessment value for landscape threats, and how this influenced the importance rank of each threat

Pig effects	Landscape ERA	Rank importance		
		Para grass	Pig damage	Unmanaged fire
0.25	0.18	1	3	2
0.50	0.19	1	3	2
0.75	0.20	1	2	3
1.00	0.21	1	2	3

Data obtained from sample plots in 2003 show that the percentage of native vegetation (eg wild rice, *Eleocharis*, *Hymenachne*, open water/lilies & *Leersia*) 'lost' to para grass rapidly increased with increasing weed cover and, importantly, that there was a 'threshold' effect for each plant group (Fig 1b, minus *Leersia*). Hence, for most floodplain plants measurable impacts did not occur until para grass reached 15–20% cover, suggesting that this extent may represent a pragmatic, cost-effective and justifiable control target.

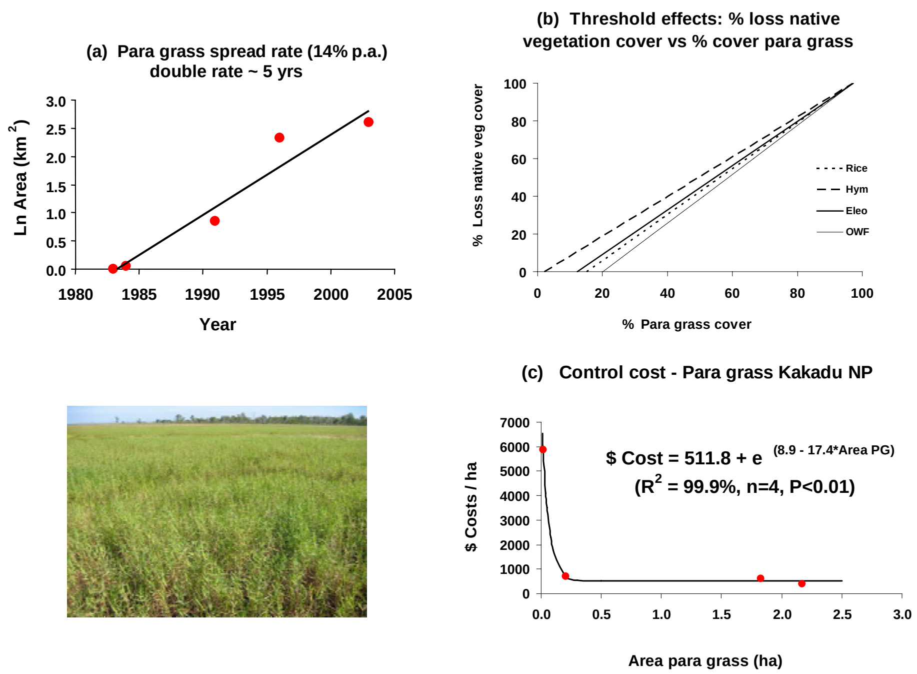

Figure 1a–c (a) Linear regression between Log_e extent (km^2) of para grass and time (years) (R^2 = 69%, P<0.04), (b) Relationship between loss of native vegetation cover (%) of four key wetland plants and increasing cover of para grass, (c) Negative exponential control-cost curve for para grass (Noulangie floodplain, Kakadu National Park)

Cost-of-control functions have been derived for mimosa and para grass (Fig 1c), and are critical for evaluating the benefits and costs of any invasive species management program using a risk management framework. The cost-curve for para grass shows that a 15-20% control target would avoid exponentially increasing control costs generally associated with unachievable eradication objectives, or cost-prohibitive 'trace level' objectives. However, this reasoning may not apply to mimosa because of its massive seed set.

A Bayesian Habitat Suitability Model (HSM) was developed in collaboration with Charles Darwin University to predict current and future distribution (or exposure, see Ferdinands 2006) of para grass and, hence, potential impacts on native wetland vegetation. The methodology has been successfully applied to the Mary River floodplain (Ferdinands et al 2001). The risk-based exposure map (Fig 2) incorporates test data from high resolution QuickBird™ satellite imagery (validated by helicopter & airboat surveys) to provide more reliable information on para grass extent over different temporal and spatial scales. The methodology developed to date in the core para grass area of central Magela provides a cost-effective monitoring and assessment tool for Park managers.

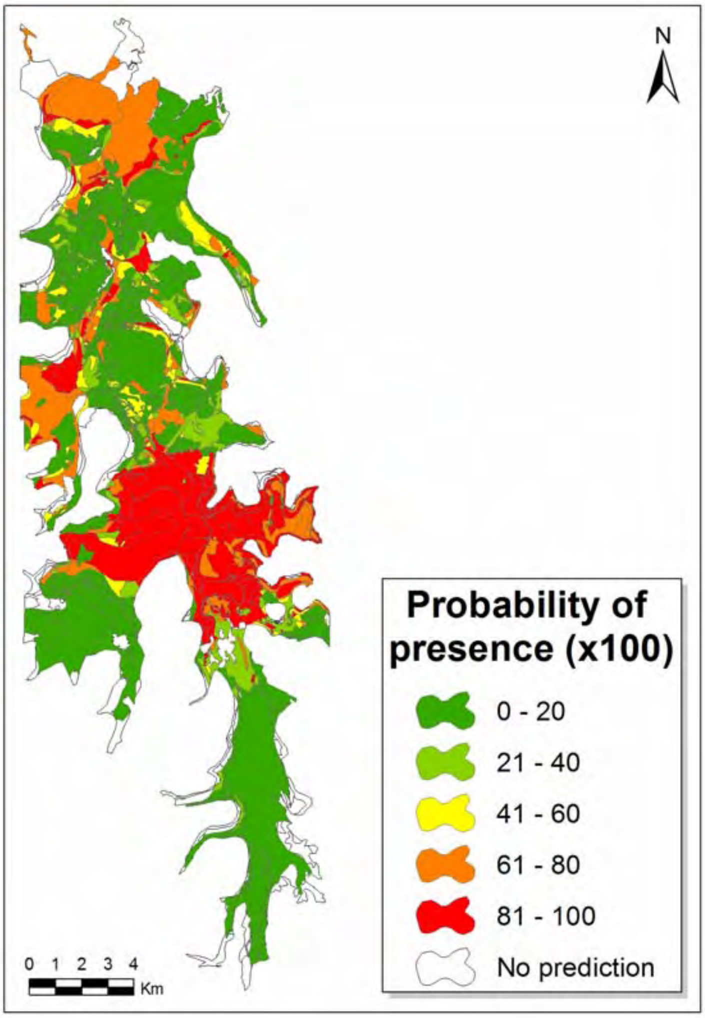

Figure 2 Bayesian habitat suitability model for para grass showing exposure probabilities (dark area is high exposure risk or present, dark grey is low exposure, light grey is absent). The exposure risk map was derived from a QuickBird™ satellite data capture, helicopter and airboat validation surveys and GPS observations by park staff.

Additionally, a spread rate model was developed to predict para grass extent and, hence, potential ecological impacts over time. Management scenario simulations were undertaken ranging from ‘do nothing’ to a range of initial and maintenance control investments. Initial simulation results suggest that with no control 50% or more of the floodplain will be lost within 20 y (Fig 3). However, this time frame may be the ‘best case scenario’ because satellite patches of para grass are now spreading along the entire length of the Magela floodplain, representing nascent foci for expansion.

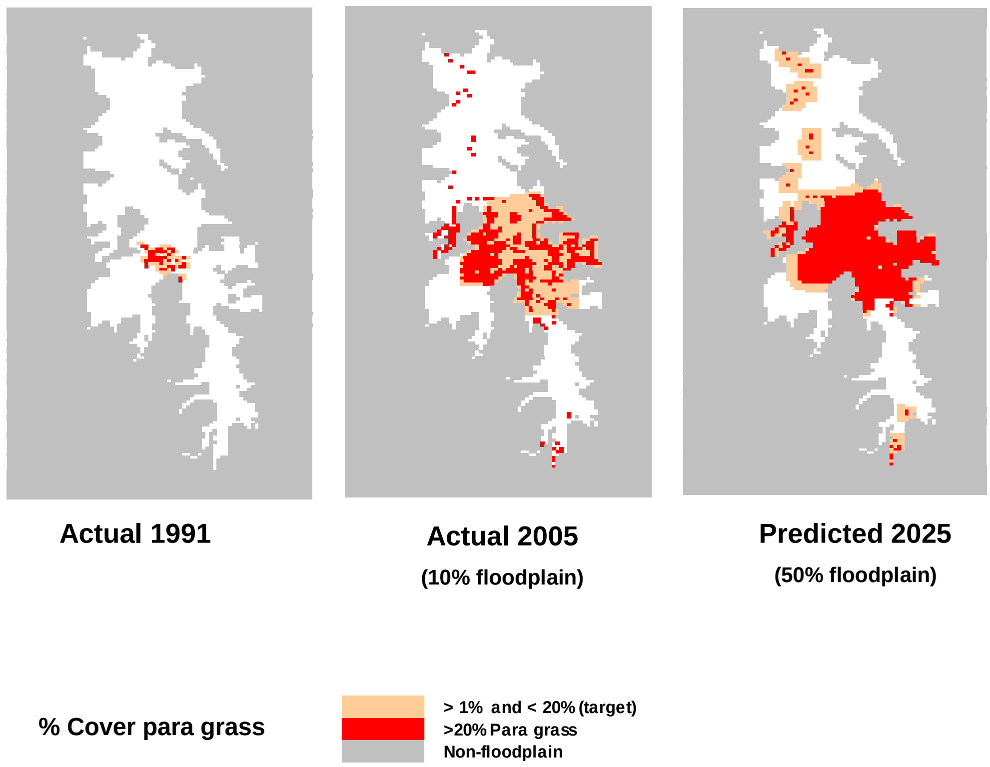

Figure 3 The extent of para grass on Magela floodplain in 1991 and 2005, and the predicted extent in 2025 based on habitat suitability, spread rates and location of known infestations

Future work

In June 2006 additional QuickBird™ multispectral satellite imagery over the entire Magela floodplain was obtained opportunistically as part of a broader assessment by ***eriss*** of damage caused to native vegetation by Cyclone Monica. At the same time intensive helicopter and airboat surveys of native vegetation and para grass communities were undertaken in order to calibrate spectral information from the QuickBird™ captures. Standard pixel-based spectral analysis combined with object-based image analysis (eg using pattern recognition software such as Ecognition) will be used to assess the capability of QuickBird™ imagery to map and monitor para grass distribution across the Magela, and to determine the condition of native wetland vegetation. Additionally, the 2004 and 2006 time series will be used in conjunction with future captures to provide Park managers with key information such as: what habitats are more susceptible to para grass colonisation; habitat-specific spread rates; and the cost-effectiveness of future control programs.

Para grass is currently the key threat to the World Heritage and Ramsar values of Magela floodplain and, hence, further work will be undertaken in collaboration with Parks Australia

North-Kakadu to finalise a more comprehensive risk assessment, and to help initiate an active control program. Additional field work has been completed this wet season, and detailed analysis and reporting is expected by December 2007.

More comprehensive risk assessment analyses have commenced on both minesite and landscape threats in the lead up to publication of results (eg Bayesian Nets & Influence Diagrams, sensitivity analyses, distance to target concepts), and this will involve collaboration with Dr Keith Hayes (CSIRO Marine & Atmospheric Research).

Major conclusion

The overall findings of the landscape ERA to date suggest strongly that non-mining landscape-scale risks to Magela floodplain should be receiving a level of scrutiny commensurate with their dominant risk ranking including an assessment of what appropriate level of investment would be needed to manage these risks.

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