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).

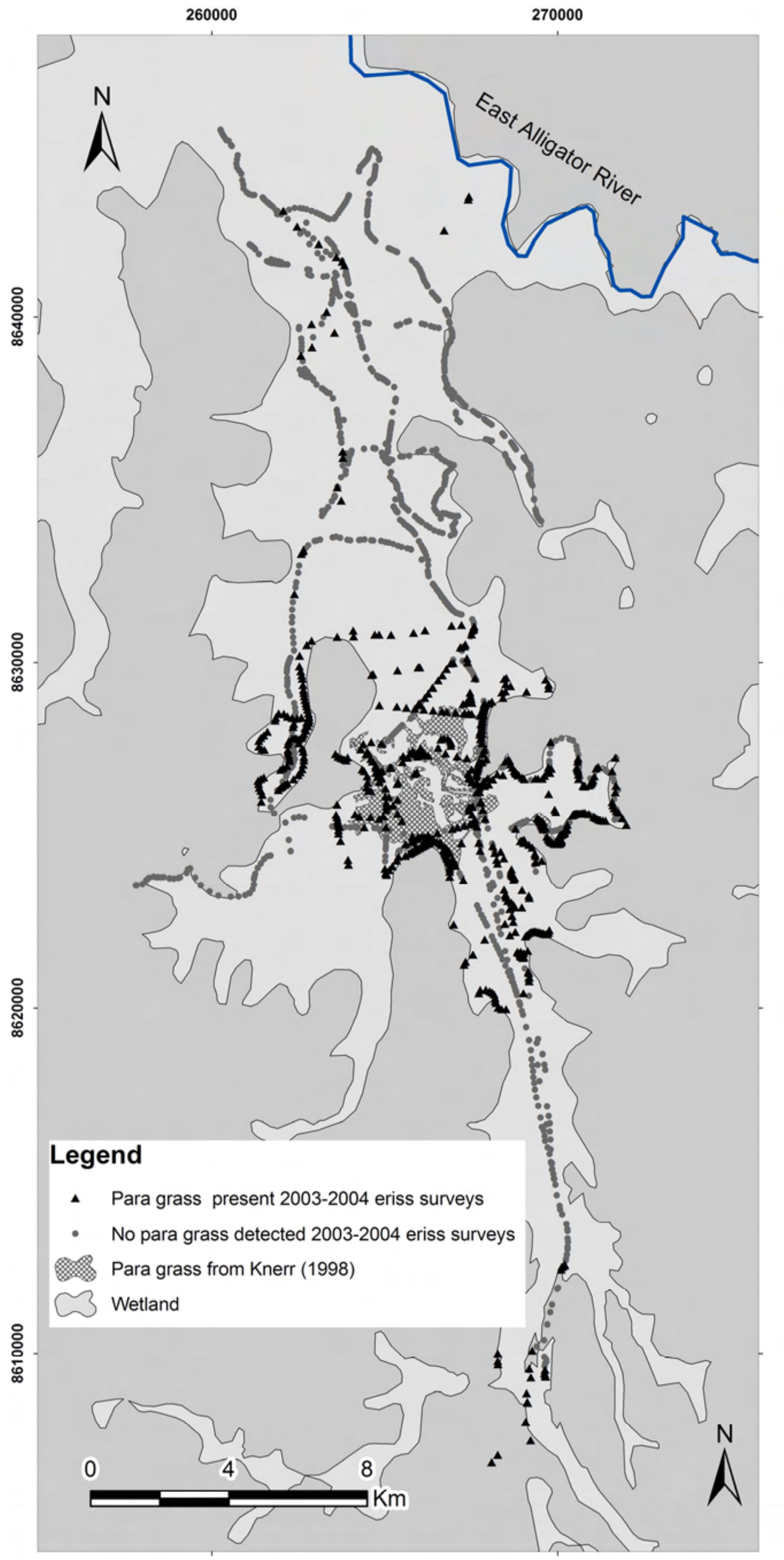

Figure 12 Para grass distribution on the Magela Creek floodplain from Knerr 1998 and point observation records by helicopter and airboat between 2003–2004 from ***eriss*** surveys and records from NT Government

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).

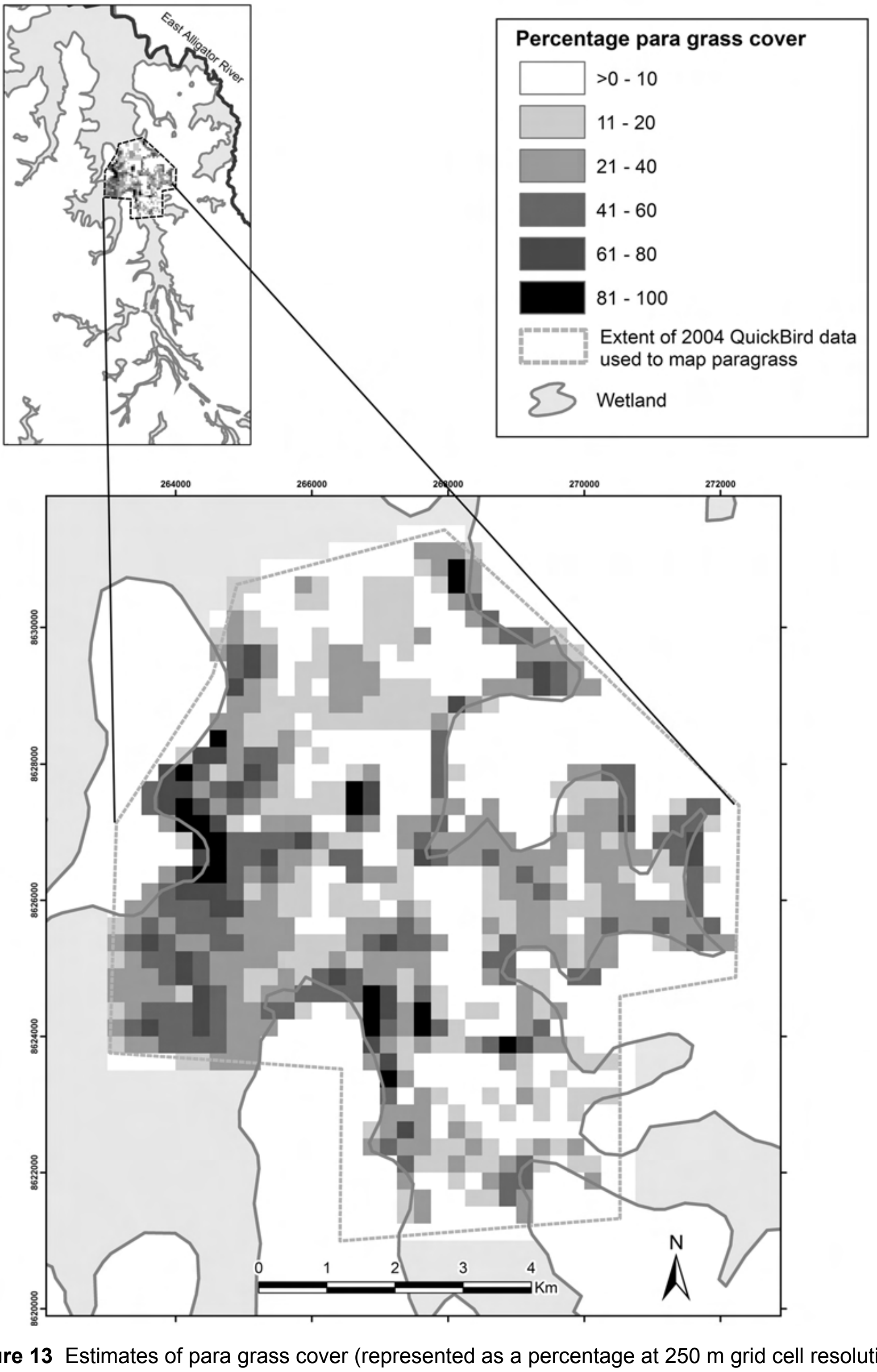

Figure 13 Estimates of para grass cover (represented as a percentage at 250 m grid cell resolution) derived from supervised classification of remotely sensed data collected in 2004

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.

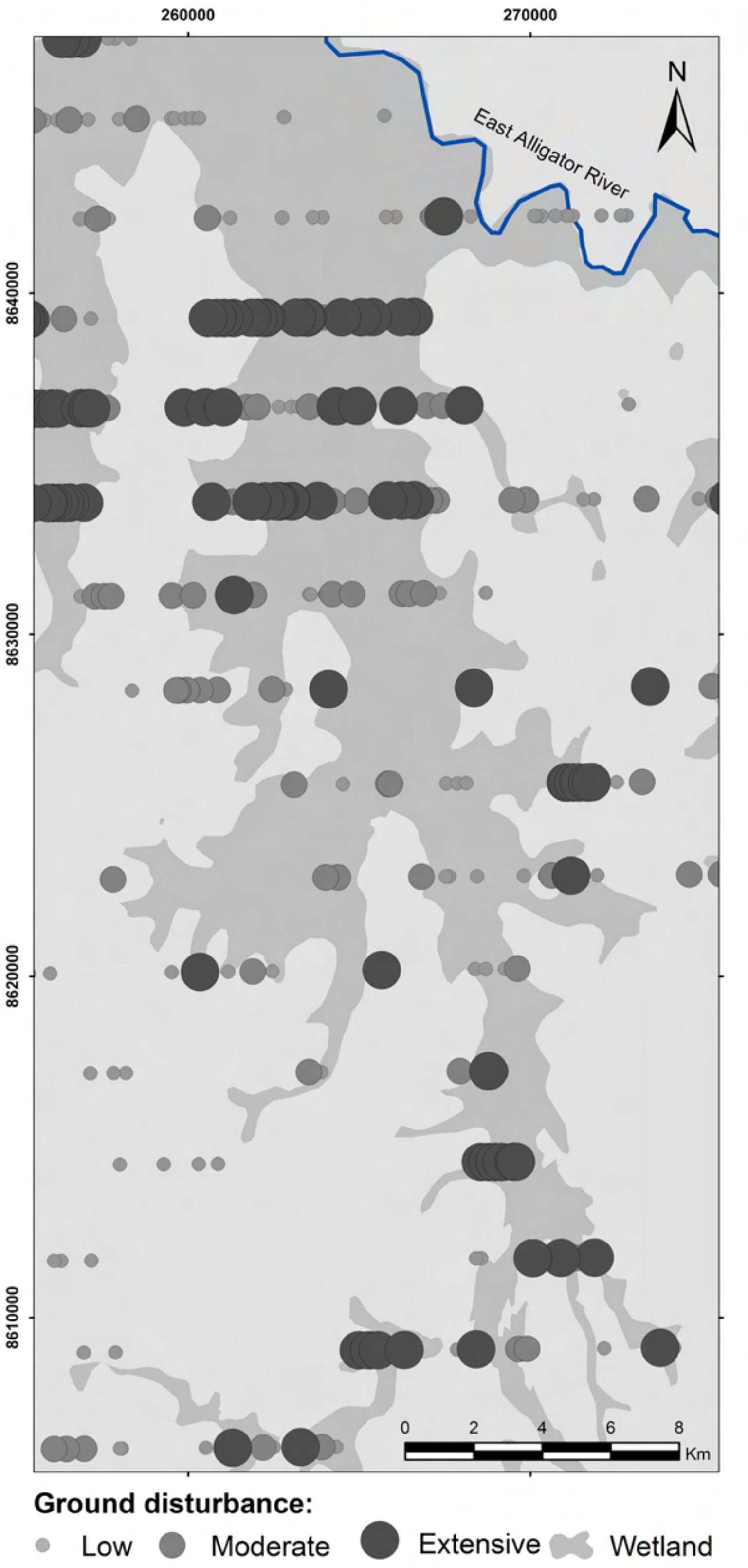

Figure 14 Estimates of ground disturbance by pigs and buffalo for the Magela floodplain region of KNP as recorded in the aerial survey conducted in November 2003

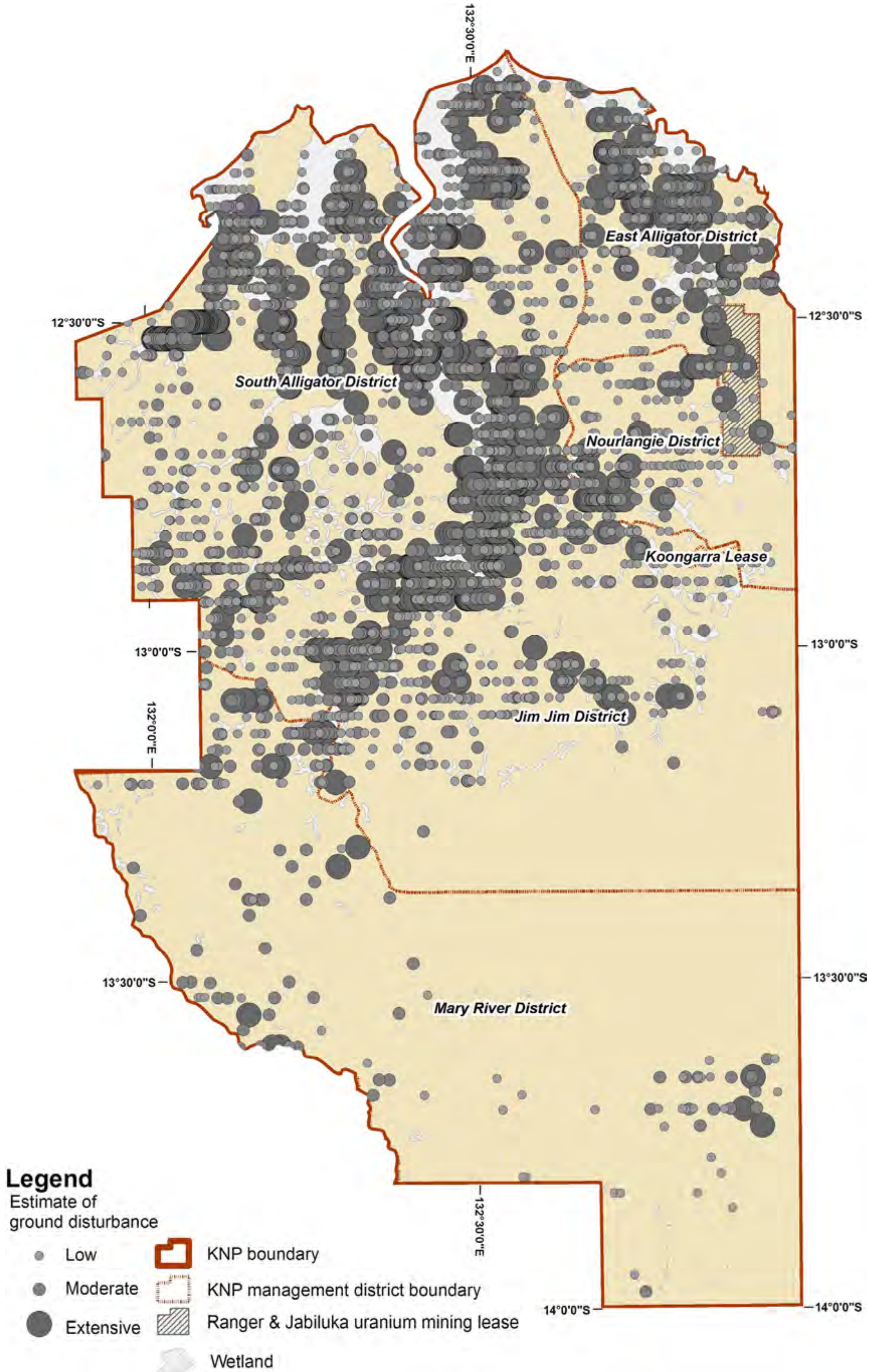

Figure 15 Estimates of ground disturbance by pigs and buffalo in KNP as recorded in the aerial survey conducted in November 2001 and November 2003

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.

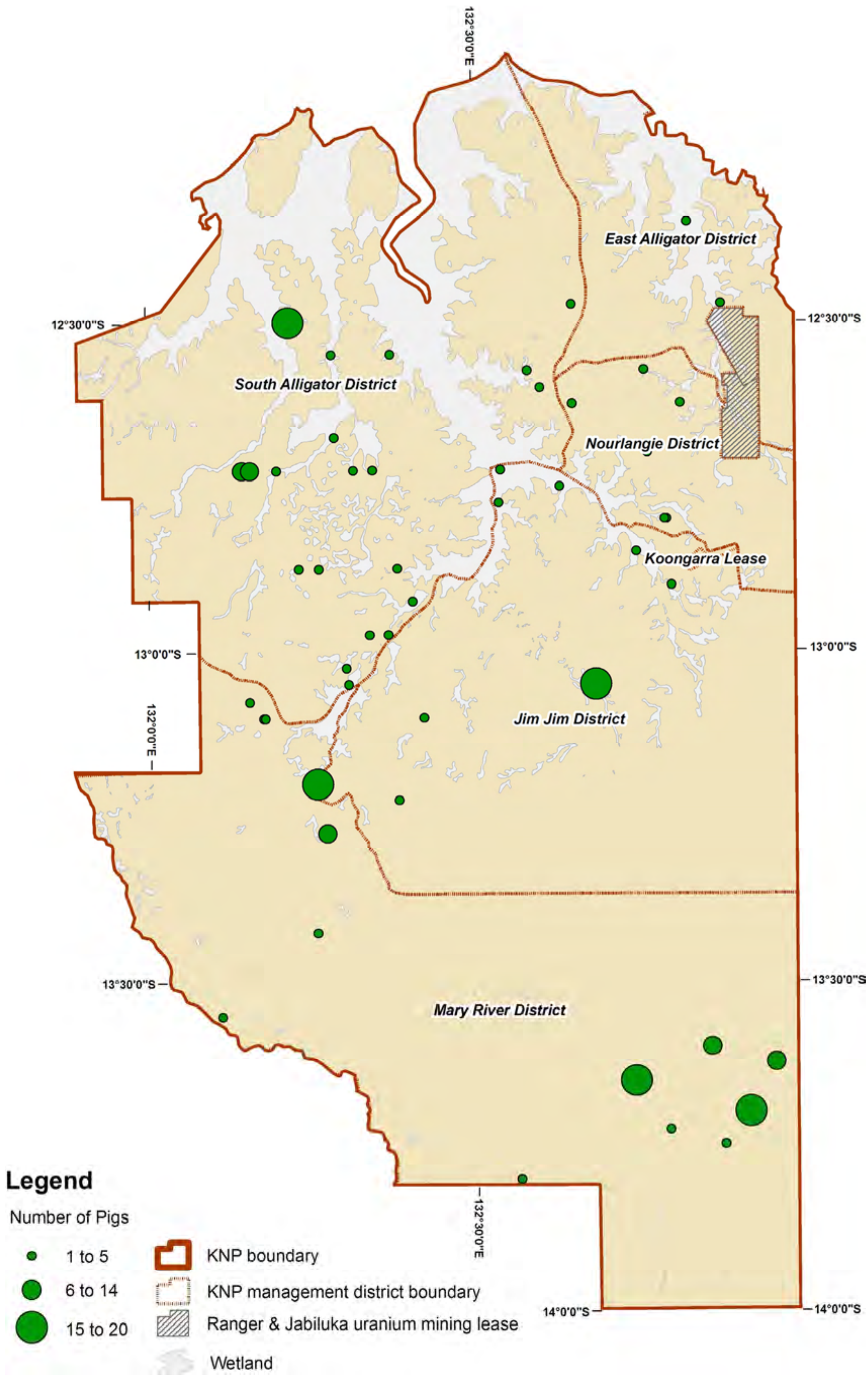

Figure 16 Distribution and number of pigs recorded during aerial surveys of KNP conducted in 2001 and 2003

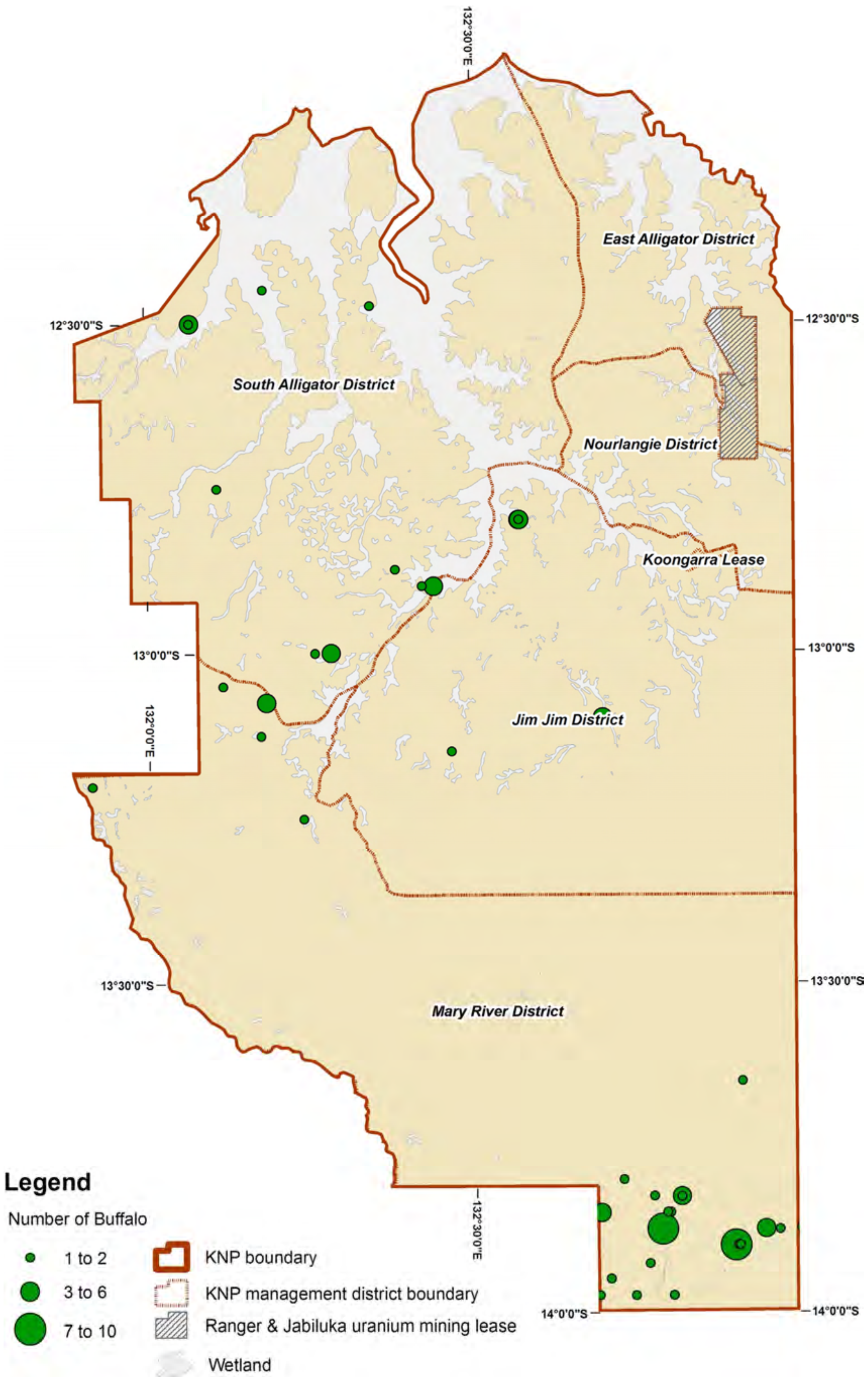

Figure 17 Distribution and number of Buffalo recorded during aerial surveys conducted in 2001 and 2003

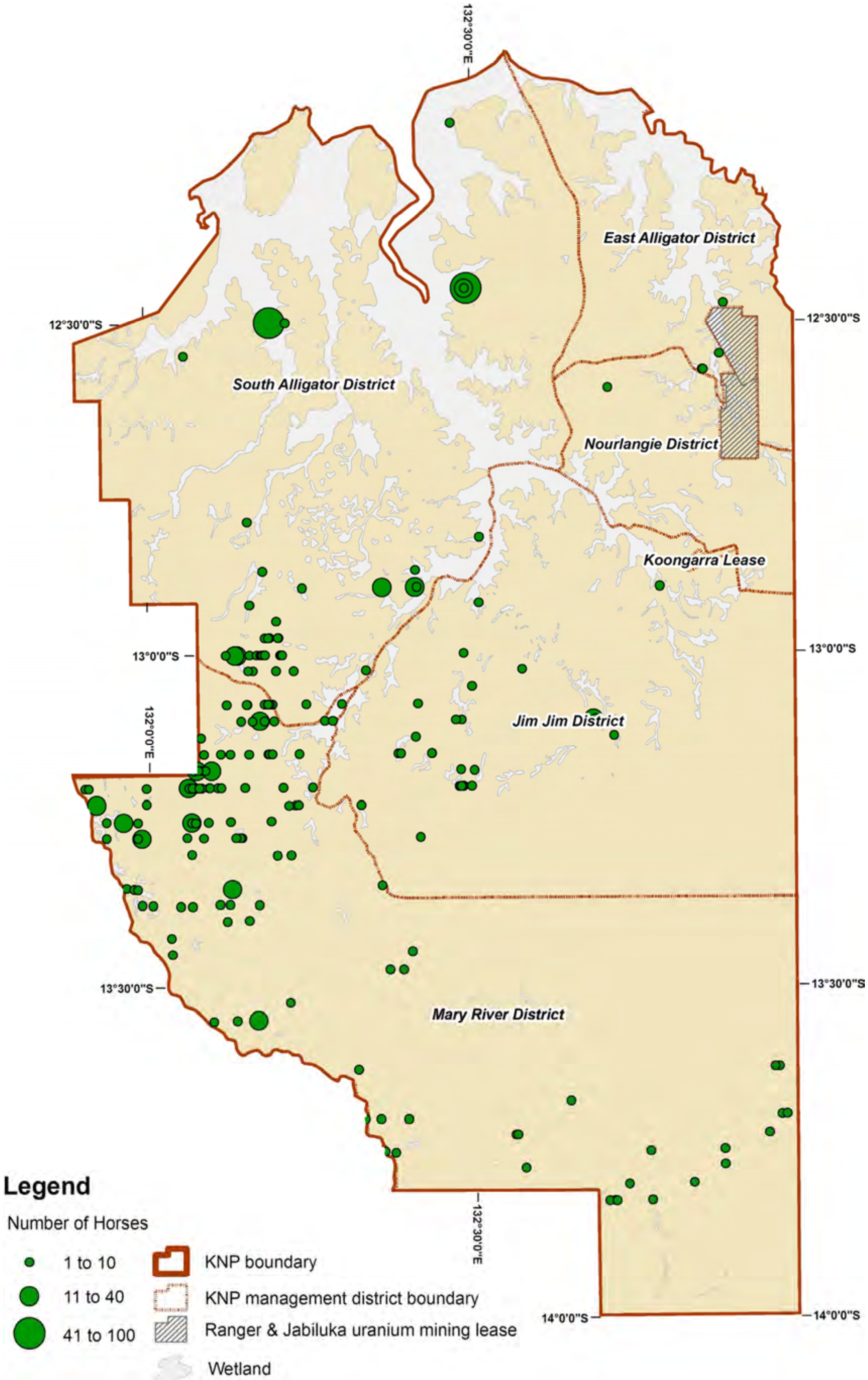

Figure 18 Distribution and number of horses recorded during aerial surveys conducted in 2001 and 2003

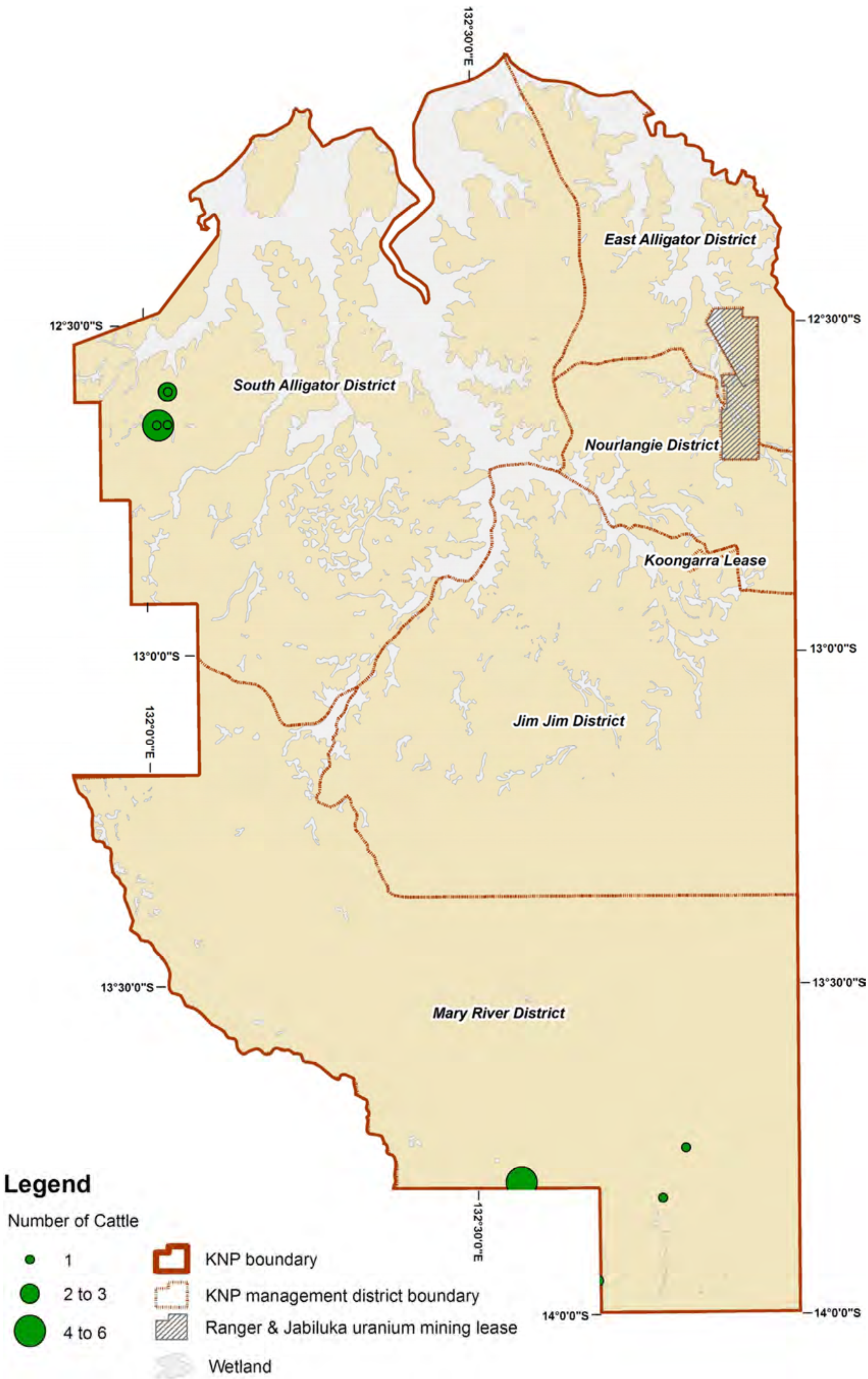

Figure 19 Distribution and number of Cattle recorded during aerial surveys conducted in 2001 and 2003

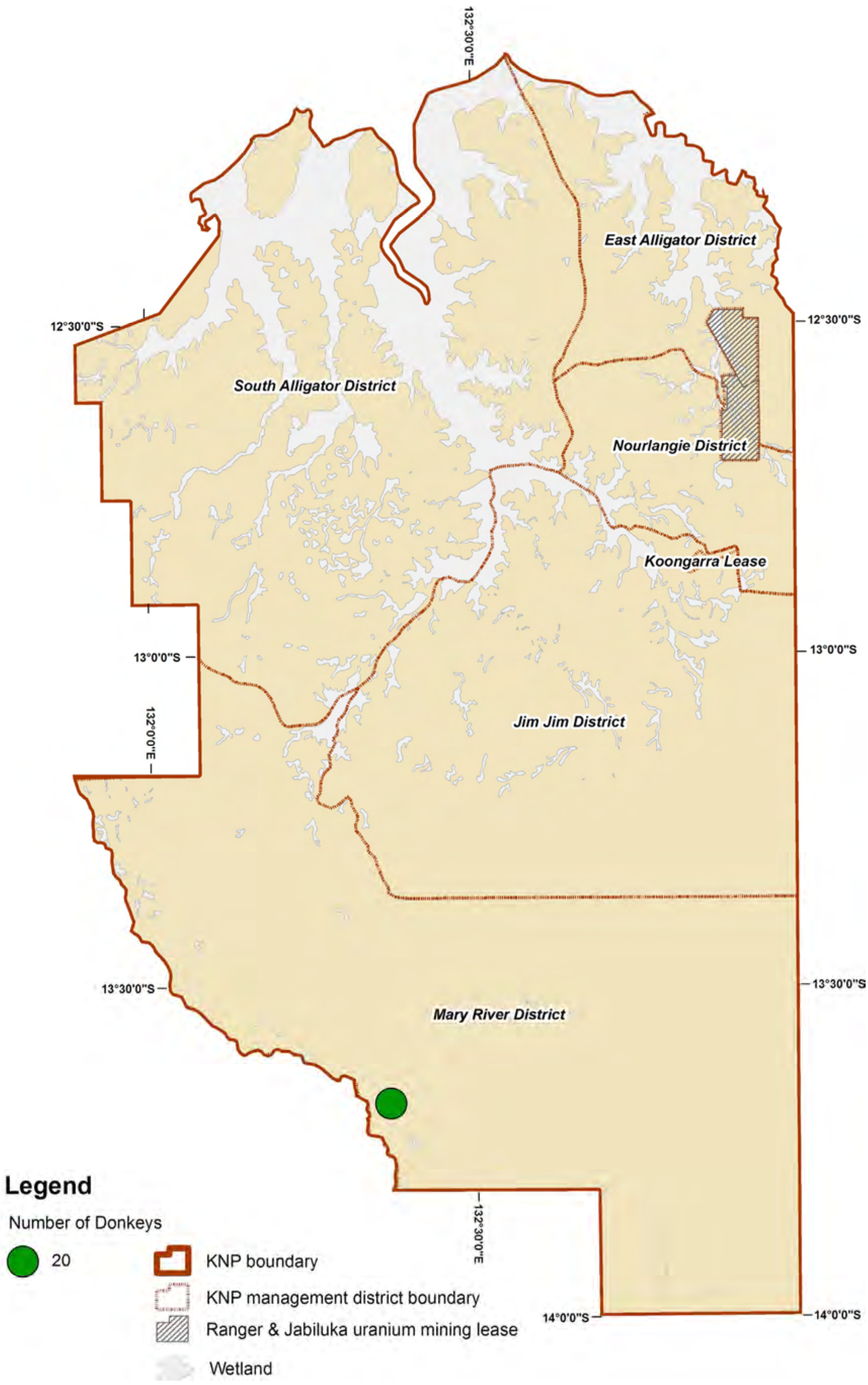

Figure 20 Distribution and number of Donkeys recorded during aerial surveys conducted in 2001 and 2003

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.

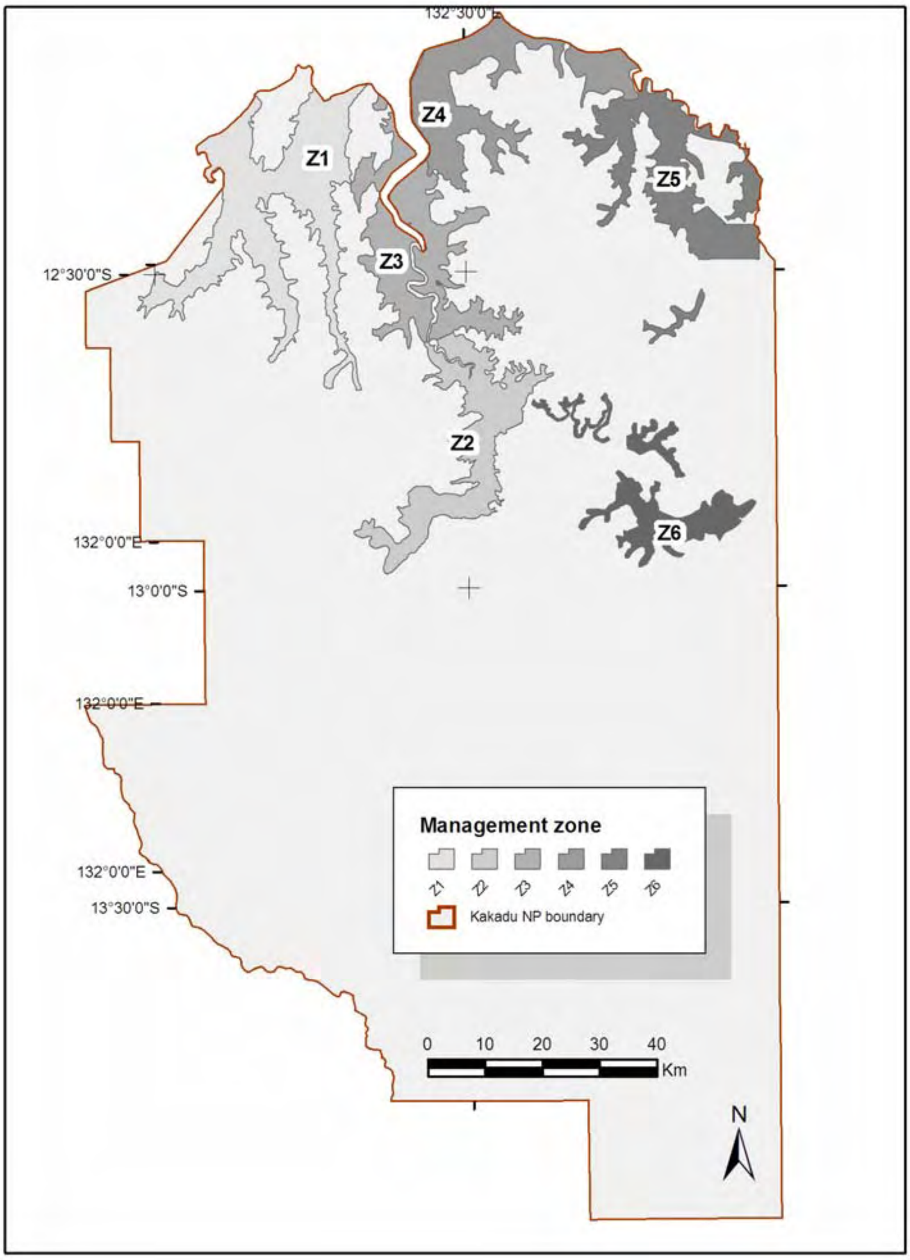

Figure 21 Preliminary feral animal management zones produced for the Natural Resource Management Unit of PAN to monitor and assess feral animal control programs in KNP