KIMBERLEY SCIENCE AND CONSERVATION STRATEGY

PERFORMANCE REPORTING PROGRAM FOR BIODIVERSITY CONSERVATION AND LAND MANAGEMENT ACTIVITIES CONDUCTED AS PART OF THE LANDSCAPE CONSERVATION INITIATIVE

OPERATIONAL VERSION 1.0

DEPARTMENT OF ENVIRONMENT AND CONSERVATION

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KIMBERLEY SCIENCE AND CONSERVATION STRATEGY: PERFORMANCE REPORTING PROGRAM FOR BIODIVERSITY CONSERVATION AND LAND MANAGEMENT ACTIVITIES CONDUCTED AS PART OF THE LANDSCAPE CONSERVATION INITIATIVE (LCI)

1. INTRODUCTION

The Kimberley Science and Conservation Strategy (Kimberley Strategy) includes a commitment to the LCI, which aims to conserve the world class and unique biodiversity values of the Kimberley for current and future generations (DEC, 2009; Government of Western Australia, 2011).

The LCI recognises that the higher rainfall north-west Kimberley (Figure 1) in particular retains high conservation values, such as largely intact native fauna and flora assemblages, ecosystems and landscapes, and requires urgent management action in order to protect these values. While emergent threatening processes such as altered fire regimes and introduced plants and animals have had greater impacts on the flora, fauna and landscapes in the south-west, central and east Kimberley, the north-west area offers unique opportunities for landscape scale conservation and is the focus of initiatives established under the Kimberley Strategy.

The State Government, through the Department of Environment and Conservation (DEC), is implementing the LCI of the Kimberley Strategy. The LCI provides DEC with significant resources to protect the biodiversity values by managing the threatening processes across different land tenures in the Kimberley. The LCI program requires partnerships with pastoralists, indigenous communities and ranger groups and non-government organisations to achieve its wider outcomes. The LCI management actions are additional to the ongoing DEC conservation management programs conducted by the Kimberley Region to meet its statutory obligations.

2. LANDSCAPE CONSERVATION INITIATIVE (LCI) PROGRAM OUTCOME STATEMENT

The principle biodiversity outcome being sought under the Landscape Conservation Initiative is:

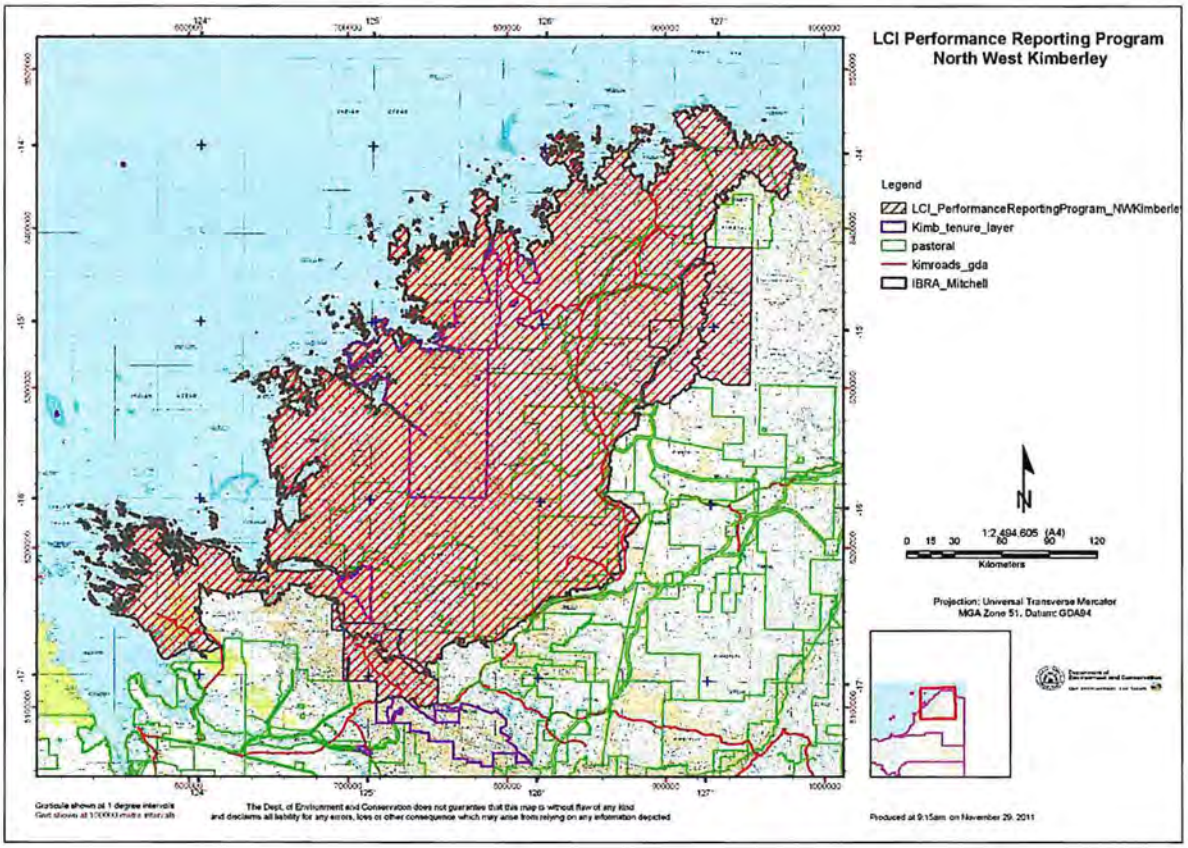
TO HAVE MAINTAINED, AND WHERE POSSIBLE ENHANCED, THE NATURAL TERRESTRIAL BIODIVERSITY VALUES OF THE KIMBERLEY AT A LANDSCAPE SCALE.

3. THREATS

The major threats to the biodiversity and landscape values of the Kimberley (i.e. those to be addressed under the LCI) are interconnected as follows.

- **Inappropriate fire regimes**, principally extensive fires that occur late in the mid-dry season and occur too frequently with high intensity.
  - *In recent years nearly half the Kimberley has been burnt each year which is seriously threatening many biodiversity values by simplifying the natural vegetation composition and structure, and resultant habitats, reducing productivity and altering soil profiles. The large area burnt each year increases the opportunity for introduced and native predators to locate prey and for weeds to establish and compete with native species.*

Figure 1. Map of north-west Kimberley for LCI performance reporting, based on North Kimberley IBRA Mitchell sub-region, Drysdale River National Park, part of King Leopold Range Conservation Park and proposed Conservation Corridor.



- **Introduced animals**, particularly feral and unmanaged cattle, donkeys, horses, pigs feral cats, and the introduced cane toad.
  - *Impacts from introduced grazing animals include altered vegetation composition, accelerated weed invasion, denuded soils, increased run-off and soil erosion, loss of nutrients and sedimentation of creeks and river systems. Cattle particularly cause significant degradation of sensitive rainforest patches, wetlands and riparian ecosystems by trampling vegetation, degrading soil and spreading weed seeds into these disturbed and productive sites. Cattle strongly favour recently burnt areas to graze on regrowth which exacerbates the damage to soils and the risk of erosion. Cane toads and feral cats prey on a wide range of native species and compete with them for food and habitat resources. The spread of cane toads is facilitated in heavily grazed areas, while feral cats are believed to focus on recently burnt areas.*

- **Introduced plants**, particularly species and weeds with high invasiveness potential and ability to smother and replace native species in a manner that alters and simplifies the vegetation structure and range of available habitats.
  - *Key species include Rubbervine (Crytostegia grandiflora), Gamba grass (Andropogon gayanus), Parkinsonia (Parkinsonia aculeata), Grader Grass (Themeda quadrivalvis), Stinking Passionfruit (Passiflora foetida), Rubberbush (Calotrpis procera), Prickly Acacia (Acacia nilotica), Giant Sensitive Plant (Mimosa pigra) and Horehound (Hyptis suaveolens). Non-native plants are mainly introduced by humans but are spread by a variety of vectors including vehicles and machinery, introduced and native animals and birds, water flows and wind. Introduced plants establish more successfully where the soil and native vegetation have been disturbed by fire and heavy grazing pressures.*

4. MANAGEMENT GOALS AND ACTIONS

The Kimberley Region has been divided into two sub-regions for the purposes of the LCI Monitoring Program. These are:

- **the north-west Kimberley** (see figure 1),
  - *which has, in many parts, a near intact natural landscape and where the management focus is primarily on protecting key intact habitats from the identified significant threats; and,*
- **the south, central and east Kimberley,**
  - *which has, in many parts, been impacted by significant landscape changes and the management focus is to reduce the impacts of current threats and undertake reconstruction and rehabilitation in the highest priority areas.*

The Performance Reporting Program will initially focus on the north-west Kimberley as shown on the map in Figure 1. However DEC will also be undertaking management actions and monitoring as part of the LCI in areas in the south and east Kimberley as resources permit and as joint management arrangements with native title holders are established.

4.1 North-west Kimberley

For this sub-region the management goal is:

To retain and enhance current natural biodiversity and landscape values by preventing significant new impacts from inappropriate fire regimes, introduced animals and plants, and other identified threats.

This will be achieved by undertaking the following management actions:

- Changing fire regimes in the north-west Kimberley to protect fire sensitive ecosystems (particularly rainforest patches and wetlands) and to prevent loss of habitat diversity from impacts of intense and extensive mid-late dry season bushfires.
    - *This will involve using prescribed burning early in the dry season (Jan-Jun) to create a patchy mosaic of burnt and unburnt land that will reduce the spread of large, intense bushfires later in the dry season. Prescribed burning aims to achieve a more sustainable burning pattern to counter current trends.*
    - *Cooperative fire programs will be implemented with a view to also reducing the overall area burnt each year, decreasing the proportion of the area burnt in the mid-late dry season (Jul-Dec), decreasing the size of burnt patches and increasing the proportion of vegetation in older age classes. Prescribed burning regimes (timing, frequency, intensity, patch size) will be sensitive to the vegetation type and rainfall region to ensure successful regeneration of native vegetation and habitats.*
- Eradicating so far as is possible, and in other areas minimising the impacts of, feral cattle and other introduced animals.
    - This will involve mustering cattle as well as aerial and ground culling and trapping of feral animals in and around conservation reserves and other specified high value ecosystems. A strategic approach will be used to concentrate on clearing areas of high conservation value assets under threat of significant detrimental impact from introduced animals. Some strategic fencing may be considered to prevent re-invasion of treated areas. Pigs will be trapped and eradicated where they are detected in specified pig eradication and control areas.
- Preventing the establishment and spread of high priority environmental weeds that have been ranked for their invasiveness and potential impacts in the Kimberley, and controlling the impacts of other important environmental weeds.
    - DEC will undertake priority site monitoring to locate and eradicate new populations of high priority environmental weeds in the north-west. There will also be control programs undertaken to reduce the impacts of those priority weeds with limited populations already in this area. Appropriate methods for eradication and control will be used with due consideration to sensitive wetland ecosystems. Known weed species have been prioritised for management in the Kimberley region (Appendix 4), and will be prioritised specifically for the north-west Kimberley. Mapping of new and priority areas for eradication and management in the north-west Kimberley will be based on protection of high biodiversity value assets and will follow DEC Standard Operating Procedures (SOP No. 22.1). Increased surveillance and quarantine measures will be part of the weed management plan, including boat landing areas, camping areas and roadsides. (Surveillance and Rapid Response Team).

4.2 South, central and east Kimberley

For this sub-region the management goal is:

To enhance biodiversity values at a landscape scale in the south-west, central and east Kimberley by reducing the detrimental impacts of inappropriate fire regimes, introduced animals and plants, and other threats on selected high value biodiversity ecosystems, including pathways for these identified threats that may impact on the north-west Kimberley.

This will be achieved by undertaking the following management actions:

- Implementing appropriate prescribed burning regimes (timing, frequency, intensity and patch size);
  - to promote recovery of habitat diversity and reducing the spread and impacts of intense and extensive, mid-late dry season bushfires on priority ecosystems and conservation reserves. Additional prescribed burning will be undertaken in partnership with pastoral and indigenous land managers to optimise the management of pastoral and conservation objectives.
- Reducing the impacts of feral cattle and other introduced animals in priority ecosystems and conservation reserves, and reducing the potential for re-invasion of introduced animals into the north-west Kimberley.
  - Some culling of feral cattle and introduced animals will be undertaken in partnership with pastoral and indigenous land managers as required to create low density buffers around priority biodiversity assets.
- Controlling damaging environmental weeds in high priority ecosystems and conservation reserves, where such control is identified as feasible and providing the potential for significant recovery of natural habitat and native species over the long term.
  - Management of weed vectors (e.g. horses and cattle) will be required in some areas to lessen the impacts from past and present pastoral activities. Weed control will be undertaken in partnership with pastoral and indigenous land managers as required to protect high priority ecosystems and to reduce the potential for spread of weeds into the north-west Kimberley. Known weed species in the Kimberley region have been prioritised for on-going management and mapping (Appendix 4). Increased surveillance will be part of the weed management plan to prevent new and damaging weeds becoming established in the region.

5. PERFORMANCE REPORTING INDICATORS

Performance reporting needs to provide high quality, robust and readily assessed information on both progress toward the overall LCI program outcome and on management performance.

The performance reporting program needs to be resilient to personnel changes and to be managed so that the information is collected, analysed and reported in a consistent manner and within specifications for timeliness and practice over the long term. The best long-term monitoring programs are those that are streamlined, implementable with available capacity and kept to a standard set of simple but meaningful activities. Given the need to assess overall performance of the LCI towards the desired long term outcome and management goals, as well as performance in

implementing management actions, the performance reporting program will have two components: Landscape Outcome or 'Health' Indicators; and, Management Action Effectiveness Indicators.

This program also has application for overall performance monitoring of DEC's Nature Conservation Program in the Kimberley Region, including other Kimberley Strategy initiatives such as the Conservation Corridor, the Kimberley Islands, and Conservation Linkages programs.

5.1 Landscape Outcome or Health

The LCI outcome statement, as applied to the north-west Kimberley can be interpreted as seeking to retain the 'naturalness' or landscape health of the sub-region. While landscape or ecosystem health can be defined and measured many ways, including detailed, complex and expensive biotic and abiotic measures, this reporting program identifies broad indicators of landscape condition. These indicators are surrogates for the overall condition of biodiversity at the landscape scale and are relatively straight forward to measure.

The following key indicators for the landscape conservation initiative outcome have been selected:

- **Rainforest patch extent**
  The key habitats across the north-west Kimberley that are most indicative of landscape health are the rainforest patches. These are thought to be remnants of the natural environment dating back millions of years and are known to be under threat from a combination of inappropriate fire, feral animals and weed invasion. These threatening processes are resulting in reductions in the extent of rainforest patch sizes and if unmanaged, will probably result in the loss of entire patches. Retaining the extent and quality (species diversity and vegetation structure) of rainforest patches by landscape-scale management of threatening process is fundamental to the desired LCI outcome and is indicative of healthy landscapes more broadly.
- **Small native mammal diversity and abundance**
  The second key indicator of the success of the LCI in retaining the landscape health is the extent to which the various native mammal species are retained, as the smaller mammal fauna (<5kg) are considered to be highly susceptible to local extinction through habitat degradation by inappropriate fire and introduced herbivores, and predation by introduced predators, as demonstrated elsewhere across northern Australia. Retaining this intact assemblage of smaller native mammals in the north-west Kimberley will be a key indicator of the success of this program.
- **Native vegetation condition**
  The third indicator of landscape health is a measure of long term changes in vegetation cover and structure, and substrate condition across selected landscape-scale vegetation units. Changes in vegetation cover and structure (including trees, shrubs and grass) and substrate condition (including litter and soil) will indicate changes in overstorey dominance, structural and floristic diversity, and site productivity which lead to changes in habitat condition. This measure is considered to be responsive to gross landscape vegetation changes through impacts of fire, feral animals and weeds, as well as rainfall trends, and will be monitored across the Kimberley, but with an initial focus on the north-west Kimberley.

In addition to the above, the pattern, frequency and quantity of rainfall are extremely important for natural environment and biodiversity outcomes across the Kimberley. In order to separate habitat condition and outcome trends from the effects of abnormal or extraordinary rainfall impacts it will also be necessary to collect and analyse rainfall data across the region. Mean annual rainfall in representative locations in the north-west, south-west, central and east Kimberley will therefore be a trend verification dataset.

Table 1 provides a framework for the LCI performance reporting program for the Kimberley region, outlining the landscape outcome 'health' indicators, condition targets, monitoring targets, methodology, reporting frequency and responsibility. These landscape outcome indicators are targeted at the north-west Kimberley even though many of the management actions will be applied across the broader Kimberley region.

5.2 Management Action Effectiveness

The management actions will be applied strategically over different spatial scales. Prescribed burning will be applied across the Kimberley by DEC on conservation reserves and unallocated Crown land (UCL), and in partnership with managers of other land tenures. Introduced animal and weed control will be more targeted to where these are threatening areas of high conservation value. Some threats such as feral pigs and new and high priority environmental weed populations will be targeted for eradication at a very local scale.

Similarly, monitoring of management actions will be at different scales appropriate to the actions and targets being monitored. Tables 2 and 3 provide a framework for the management action reporting plan for the LCI. They outline the threats, management actions, management action indicators, indicator targets, monitoring methodology, reporting frequency and responsibility. Direct action reporting of management activities completed (e.g. number of feral cattle culled, area of *Passiflora foetida* controlled) is the subject of a separate LCI reporting process.

5.3 Tables of Performance Reporting

The following tables detail the Outcome and Management Performance reporting arrangements in place for the LCI. They include advice on methodologies, frequency and work-group responsibility for each of the actions. Detailed information on sites and procedures is included in the appendices.

- Table 1. LCI Outcome Performance Reporting: Landscape Health Indicators across NW Kimberley.
    - This identifies three principal Outcome Condition Monitoring Indicators across the focal areas of Rainforest, Small Mammals and Natural Habitat as OCM1, OCM2 and OCM3. Targets for these indicators are also identified as OT1, OT2 and OT3. In addition, subsidiary indicators and targets are identified as OCM1a and OT1a, etc.
- Table 2. Management Action Effectiveness: NW Kimberley.
    - This identifies a series of three Management Action Targets (MAT1, MAT2 and MAT3) and sub-targets (MAT1a, etc).

6. BUDGET

An LCI performance reporting budget has been prepared for the next four years and is expected to continue in the foreseeable future. The budget figures may vary from year to year depending on logistical constraints of working in remote areas and will be reviewed annually to assess significant variation of expenditure from budget estimates. The LCI monitoring budget does not include the costs of monitoring the fire indicators which is covered under the regional LCI fire management program.

Performance reporting and evaluation will be undertaken through the Region, with external review from the Nature Conservation Division's Evaluation Assessor, part funded by the project, as identified in the Tables. The budget also does not include any costs involved with liaison with the AWC, pastoralists, native title groups, traditional owners and indigenous ranger groups.

TABLE 1: LCI OUTCOME PERFORMANCE REPORTING: LANDSCAPE HEALTH INDICATORS ACROSS NW KIMBERLEY

REGIONAL OUTCOME	FOCAL ASSET	INDICATOR	INDICATOR GOAL	EVALUATION				
				Condition Monitoring	Monitoring Targets	Methodology	Freq.	Work group
To have maintained, and where possible enhanced, the natural biodiversity conservation values of the Kimberley at a landscape scale	**Rainforest (1)**	**Rainforest patch extent**	Rainforest patches retained in both extent and condition. (i.e. No significant loss of rainforest patch extent or condition.)	**OCM 1** Extent to which monitored rainforest areas maintain their size/extent	**OT1** Stable or increasing trend in rainforest patch size/area.	Aerial transect count of rainforest patch size/area. Two flight transects parallel to coast and two perpendicular. Aerial photography of rainforest patches, with analysis of changes in areal extent compared with early photography (1980s and pre-1960).	At least every three years.	Regional Monitoring Team (RMT) and GIS staff/ Evaluation Assessor (EA)
				OCM1a Extent to which monitored rainforest areas maintain their vegetation condition (structure)	**OT1a** Maintenance of vegetation density/cover with no evidence of clearing by grazing or burning, or invasion of annual plant species.	Quadrats (50mx50m) at monitoring patch boundaries to measure changes in rainforest patch vegetation structure. .	Annually	RMT and GIS staff/ EA
	Small Mammals (2)	**Mammal species diversity and abundance**	Small mammal species (<5kg) diversity and abundance retained.	**OCM2** Changes in numbers of species detected.	**OT2** Stable or increasing trend in number of small mammal species detected.	Kimberley divided into sites by geology, landform and vegetation as per Appendix 1. Compare species numbers over time on average per site, with trend compared to 2004 data point.	Annually	RMT/ EA.
				OCM2a Specific species presence/absence rates	**OT2a** Trends in average abundance of monitor species stable or increasing.	Determine trends in approximate species capture/detection rates at above monitor sites.	Annually	RMT/ EA

TABLE 1 Continued

REGIONAL OUTCOME	FOCAL ASSET	INDICATOR	INDICATOR GOAL	EVALUATION				
				Condition Monitoring	Monitoring Targets	Methodology	Freq.	Work group
To have maintained, and where possible enhanced, the natural biodiversity conservation values of the Kimberley at a landscape scale	**Natural Habitat Condition (3)**	**Native vegetation canopy cover/ structure and soil, litter and organic layers**	Historic habitat values (vegetation densities, structure and litter/humus) retained, enhanced, or re-established.	**OCM3** Vegetation/habitat condition scores in six major vegetation types.	**OT3** Stable or increasing trend in retention of natural habitat condition.	Use 50mx50m quadrats in replicated sites in major vegetation types. Measure and compare changes in canopy cover of each vegetation strata for comparison with initial data points (2003/04).	Annually	RMT/ EA
				OCM3a Litter layers enhanced (through ecological burning and cattle control) to increase habitat resilience	**OT3a** Stable or increasing trend in leaf litter accumulation.	Assess changes in litter depth and soil erosion in quadrats (annually). Include at least six reference sites on selected NW Kimberley Islands (every five years).	Annually	RMT/ EA
				OCM3b Sub-region-wide vegetation canopy cover maintained or increased over the long term.	**OT3b** A reduction in the proportion of annual grasses to perennial grasses and an increase in the proportion of shrubs and younger age tree species.	VegMachine remote sensing analysis used to assess long term changes in overstorey canopy cover since 1990 in 100mx100m (4 pixels) sites around above quadrats and in at least 20 other sites per vegetation unit.	Annually	RMT/ EA
	Climate Trends (4)	**Rainfall**	Assess rainfall abnormalities as a possible complication impacting on biodiversity conservation success.	**Rf Monitoring** Rainfall quantity and timing by year compared to historic average and trend by site type (OM7).	**Rf Reporting** Monthly rainfall data is obtained for representative sites from BoM weather stations in the Kimberley and used in analysis of trends.	Rainfall performance variance from averages (as available).	Annually	RMT/ EA

TABLE 2: LCI MANAGEMENT ACTION EFFECTIVENESS : NW KIMBERLEY

THREAT	MANAGEMENT ACTIONS	MANAGEMENT EVALUATION			
		Methodology	Management Action Effectiveness Target	Freq.	Work Group
1. Inappropriate fire regimes	Reduce proportion of the sub-region burnt on an annual basis	Analysis of remotely sensed (Modis) fire scar imagery to compare total area burnt by end of December each year. Ground truth transects to check sensitivity of analysis.	**MAT1** Increasing trend in the proportion of the sub-region (area of vegetation) unburnt in a single year.	Annual	Regional Fire Coordinator (RFC) and GIS staff
	Reduce proportion of fires in late dry season	Analysis of remotely sensed (Modis) fire scar imagery, comparing total area burnt by end of June and December each year. Ground truth sites to check sensitivity of analysis.	**MAT1a** Increasing trend in proportion of fires that burnt in the early dry season.	Annual	RFC and GIS staff
	Reduce proportion of large aerial extent fires.	Assess fire scars across the Kimberley and LCI area, in particular CWR fauna and vegetation monitoring sites, determining average separation distances on an annual basis.	**MAT1b** Decrease the mean distance between unburnt patches.	Annual	RFC and GIS staff
	Increase habitat value through effective fire management.	Assess area of occupancy and age/dbh of predetermined fire sensitive species in the landscape around fauna and vegetation quadrat monitoring sites.	**MAT1c** An increasing trend in the proportion of fire sensitive vegetation in older age classes (>3yrs old).	Biannual	RFC and GIS staff
2. Introduced animal landscape impacts	**2.1 Cattle:** Exclude/eradicate feral cattle from high conservation value areas wherever possible and reduce their impacts in other identified high conservation value areas through management of cattle exclusion and control zones. *(Cattle impact control zones established across the sub-region, including sensitive areas (springs/rainforest). Cattle control impact objective for each, such as reduce area of cattle pad impact to zero hectares.)*	Take aerial photographs along set transects at standard flying heights immediately after the wet season and compare density (number and cumulative area) of cattle pads as an index of cattle impacts each year. Calculate proportion of 'effective eradication', 'significant impact reduction' and 'impact reduction' areas where the control objectives are met. Use impact measures or acceptable surrogates as objectives and not harvest numbers, e.g. reduce cattle pad area, state % cattle population reduction sought, or proportion of cattle remaining after control, or numbers of cattle seen less number shot/mustered, to indicate extent of problem remaining.	**MAT2** Reducing trend in cumulative area of cattle pads in monitored areas (i.e. area negatively impacted by cattle). **MAT2a** Increasing trend to 100% achievement of targets in 'effective eradication', 'significant control' and 'control' zones.	Annual Annual	Regional Monitoring Team (RMT) and Evaluation Assessor (EA) RMT/EA

TABLE 2, Continued

THREAT	MANAGEMENT ACTIONS	MANAGEMENT EVALUATION			
		Methodology	Management Action Effectiveness Target	Freq.	Work Group
(2. Introduced animal landscape impacts, continued)	**2.2 Other target species (donkeys, horses, pigs):** Reduce the detrimental impacts of these species sufficient to retain natural conservation values of the sub-region	Calculate proportional area of the sub-region where species control objectives are met.	**MAT2b** Increasing trend to 'control objectives met' across 100% of the sub-region'.	Annual	RMT/EA
	2.3 Cane Toads: Maintain priority identified Kimberley Islands cane toad free (proposed reserves?).	Monitor identified priority islands for presence of cane toads at least once every three years.	**MAT2c** Maintain 100% of identified islands cane toad free.	Every three years	RMT/EA
3. Invasive weed landscape impacts	Identify priority environmental weed exclusion and control zones. Detect and eradicate environmental weeds determined to have potential for significant detrimental impacts in exclusion zones and under control in control zones.	Calculate area monitored and effectively managed for priority environmental weed detection/eradication and control.	**MAT 3** Decreasing area occupied by priority environmental weeds (or area where weeds successfully controlled).	Annual	RMT/EA
	Implement early detection and rapid response protocols to meet eradication/control actions	Calculate proportion of weed eradication zones and control zones where objectives are met.	**MAT3a** Increasing trend to 100% of exclusion zone and control zones where objectives fully met.	Annual	RMT/EA

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APPENDIX 1

MONITORING SITE SELECTION AND METHODOLOGY

Primary LCI monitoring field sites have been selected in the north-west Kimberley to collect long term trend data for reporting on the three main landscape health indicators (rainforest patch, native mammal diversity and vegetation cover). Field sites are currently established in the Mitchell Plateau area on various land tenures, and in the King Leopold Range Conservation Park north of the Gibb River Rd. Additional sites are planned for the Drysdale River National Park and the Prince Regent River National Park, at each end of the Conservation Corridor area.

Monitoring field sites have been stratified into one of six major vegetation types (rainforest, riparian, dissected sandstone shrubland, sandstone savanna woodland, laterite savanna woodland, volcanic savanna woodland and laterite forest) although not all these are represented in each major conservation reserve. Table 4 outlines the expected monitoring field site coverage for the main LCI landscape health indicators, based on current resourcing in the Kimberley region. Additional sites will be selected during 2012 to increase the replication of vegetation types for assessing vegetation and substrate structural trends and to test predictions about impacts.

These sites were also positioned to represent the range of fire and cattle disturbance attributes expected in the north-west Kimberley. Fire frequency mapping from 2004 to 2010 accessed from the North Australian Fire Information (NAFI) website was used to classify sites as being burnt 0 to 7 times in the last seven years. This mapping is reasonably coarse scale with a pixel size of 100m x 100m with accepted inaccuracies with respect to quadrat information but does provide a useful indication of likely fire impacts.

Cattle impacts were more difficult to attribute to these sites as there has been no comprehensive survey of cattle or other introduced feral animals in the north-west Kimberley. Cattle have been occupying many areas of the Kimberley for decades and are often completely unmanaged. Even in many reserve areas, while cattle may be rarely encountered, it is virtually impossible to achieve an objective of keeping large areas totally free of all cattle given the proximity of pastoral stations to the reserves areas. Mapping of potential cattle carrying capacity according to land systems (Speck *et al.*, 1960) provided a basic level of information on the areas likely to be unsuitable, or sustain very low, low, moderate or high feral cattle densities and these have been considered in a context of protecting areas of highest biodiversity value. In addition, aerial transect survey and shoot data from the past five years has been considered to identify those areas more likely to be at high risk of cattle grazing and trampling impacts and where effective control operations could be mounted. DEC has grouped the overall monitoring sites for cattle impact risk into areas with targets of 'effective eradication', 'significant impact reduction and 'impact reduction'. These three groupings can be explained as follows.

- 'Effective eradication' areas are those where DEC's management target is to effectively exclude cattle impacts to the extent that evidence of cattle should be almost imperceptible.
- 'Significant impact reduction' areas are those where there is a high cattle risk and presence and the management objective is to significantly reduce measurable cattle impacts by 50% or greater.
- 'Impact reduction' areas are those where the management objective is to reduce measurable cattle impacts by up to 50% or prevent impacts increasing.

Over time the management intention for individual sites/areas may vary as a better understanding is developed of the significance of cattle impacts, the necessity for specific area control efforts and the impacts on cattle invasion risks of changes to burning regimes and other Kimberley strategy management actions.

The available fire frequency and cattle density information was used to select monitoring sites that were expected to have experienced a range of fire and cattle impacts from low to high. However, these impacts are correlated and it was not possible to have fully replicated sites for each impact separately.

It is important to recognise that there is no intention in the LCI program to leave any "untreated" areas to act as experimental controls. Also, due to these confounding factors and the high cost of monitoring mammals, mammals will not be sampled at all vegetation monitoring sites in the four conservation areas and only every second year in Drysdale National Park, Prince Regent River National Park and King Leopold Range Conservation Park.

Monitoring field sites were also selected where there was fauna and vegetation data from earlier surveys: 1974 (Miles and Burbidge, 1975), 1975 (Kabay and Burbidge, 1977), 1976/77 (Western Australian Museum, 1981), 1987/89 (McKenzie *et al.*, 1991) and 2003/04 (Start *et al.*, 2007). Prescribed burning on a large scale commenced in the north Kimberley around 2004, while culling of feral cattle and donkeys has been in operation in the north Kimberley since about 2003, so previous survey data will provide useful historical comparisons with current trends.

Other secondary field sites will be selected in appropriate locations to monitor trends in significant environmental weed populations and impacts from pigs and other introduced herbivores. Many of the performance indicators will be monitored using remote sensing and air photography that will require ground truthing of the imagery data, e.g. fire scar mapping, vegetation canopy cover, rainforest extent. These sites are in the planning stage and should be in place during 201/13. Appendices 2 and 3 provide greater detail for the methodology of vegetation and fauna monitoring, respectively.

TABLE 3. The number of sites selected at each location in the north-west Kimberley for the LCI performance reporting program, grouped according to site type.

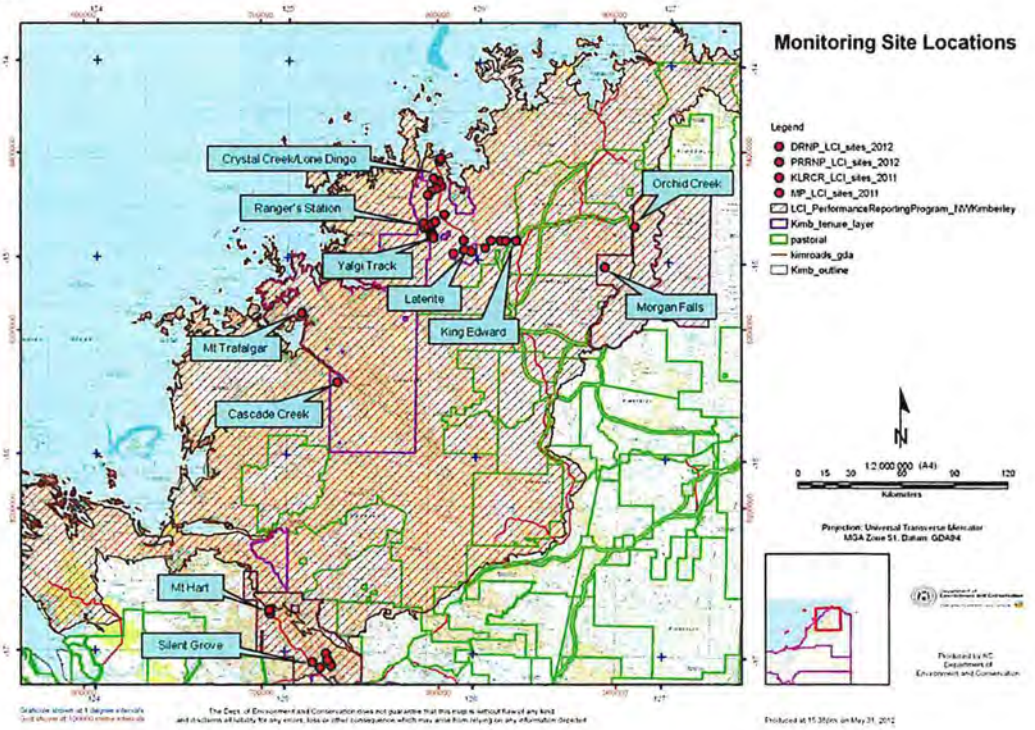
SITE TYPE			LOCATION AND NUMBER OF SITES				
Geology	**Landform**	**Vegetation Type**	**Mitchell Plateau**	**Prince Regent River NP**	**King Leopold RgeCP**	**Drysdale River NP**	**Total**
Laterite, Sandstone, Volcanics	Protected upper slopes and breakaways	Rainforest	5	4	2	2	**13**
Volcanics	Drainage lines and flats	Riparian /wetland woodland	5	6	4	4	**19**
Sandstone	Dissected upland	Hummock grassland and open shrubland	6	6	2	4	**18**
Sandstone	Sand plains	Savanna woodland	6	4	4	4	**18**
Volcanics	Lower slopes	Savanna woodland	6	4	4	2	**16**
Laterite	Plateau	Savanna woodland	9	0	0	0	**9**
Total			**37**	**24**	**16**	**16**	**93**

Note: The site numbers listed in the above table are all PRP sites sampled during the full monitoring program, including sites where mammals are and are not trapped. The vegetation and ecosystem process attributes (including substrate, i.e. soil, litter and organic layers), sampled at all 93 sites, will increase the level of replication and analytical power. See Table 4 below. Also, the above precise details may change as we gain more detailed understanding of trends and responses to management actions.

TABLE 4: Monitoring clusters, number of sites including ecosystem process sites and frequency of monitoring

Area and cluster name	**# Ecosystem process sites**	**Number sites trapped for mammals**
Mitchell Plateau, King Edward	8	4 (every year)
Mitchell Plateau, Laterite	8	4 (every year)
Mitchell Plateau, Yalgi Track	5	-
Mitchell Plateau, Ranger's Station	8	4 (every year)
Surveyors/Crystal Creek/Lone Dingo	8	6 (every year)
Prince Regent, Mt Trafalgar	8	4 (every 2nd year)
Prince Regent, Cascade Creek	8	4 (every 2nd year)
Prince Regent, Blyxa & Baxton Creeks	8	4 (every 2nd year)
Drysdale, Boiga Falls	8	4 (every 2nd year)
Drysdale, Orchid Creek	8	4 (every 2nd year)
King Leopold, Mt Hart	8	4 (half every year)
King Leopold, Silent Grove	8	4 half every year)
TOTALS	93	46

Figure 2: Map of LCI PRP Sites



APPENDIX 2

STAFFING AND COORDINATION

1. Introduction

The LCI performance reporting program and assessment will be undertaken by a DEC Kimberley Region team comprised of Regional Services and Science Division staff engaged in undertaking the various monitoring actions detailed in Tables 1 and 2. Coordination of the on-ground and initial analysis of the LCI performance reporting will be the responsibility of the DEC Regional Leader for Nature Conservation in the Kimberley, or a person specially appointed to this coordination role, in collaboration with the Science Division and Nature Conservation Division. This person will be responsible for coordinating all aspects of the performance reporting program and will work closely with the LCI implementation team to ensure that work programs are kept to schedule, data is entered and summarized within the nominated timeframe.

The LCI Program Coordinator is responsible for liaison with partner organizations, such as the AWC, Dunkeld Pastoral Company and various native title groups, where these organizations are contracted to deliver performance reporting information. Negotiation is required to ensure standard performance targets and protocols are followed and a core set of equivalent data is collated from each property that contributes to overall LCI evaluation. The LCI Coordinator must ensure that proposed monitoring sites are approved by the relevant Native title group, and liaise regarding attendance of traditional owners and training for ranger groups or fee for service contracts for monitoring. The regional scientist in the Kimberley will be responsible for maintaining animal ethics approval and reporting for this program.

The LCI monitoring staff will be mentored by two senior Science Division research staff (0.1FTE each) who will provide ongoing appraisal and support by travelling to the Kimberley three to four times per year to be fully conversant with monitoring activities. This level of scientific support will help to ensure that the LCI monitoring team has access to the necessary technical discipline and scientific rigor required to generate meaningful monitoring outcomes.

In addition, and to ensure adequate external accountability for the program, the Nature Conservation division will undertake the role of assessing and approving annual performance reports prepared by the Region, as well as coordinating periodic reviews of the LCI performance reporting program.

2. Data management and analysis

The coordinator must ensure the quality of data acquired is maintained and data is entered in a suitable format (database or spreadsheets) that can be validated and accessed for auditing purposes, including data from partner organisations. The data must be clearly set out with metadata attached to allow for smooth transition should staffing positions change. The coordinator will be responsible for undertaking the detailed analysis of all monitoring results (including projections and liaison with external experts as required) and preparation of annual performance reports and presentations detailing long and short term trends against the established targets. Standard data analysis and graphing templates should be used to ensure consistency in reporting formats from year to year. The coordinator will also identify and report on any problems encountered in undertaking required monitoring within established protocols, timelines and schedules and be able to recommend changes to LCI management and monitoring programs.

Full backup copies of all performance reporting data will also be lodged with DEC Science Division and Nature Conservation Division in Perth, to ensure adequate data and reporting security.

Intellectual property agreements must be completed with native title groups and partner organizations to ensure clarity of data ownership and sharing arrangements for publications.

3. Reporting timeframe, presentations, publications and peer review

Annual performance reports will be prepared by the coordinator and approved by the Director of Nature Conservation prior to presentation at an annual workshop during December for regional staff, LCI partners and Steering Committee, native title groups and interested public in the Kimberley. The results will also be reported in Perth for the Kimberley Strategy Steering Group, Department of Premier and Cabinet, and DEC Nature Conservation, Regional Services and Science Divisions. A written annual report with executive summary will accompany the presentations. Other media articles and scientific publications will be prepared from time to time as appropriate in collaboration with DEC media and Science Division staff, respectively.

The performance reporting program will be reviewed at the annual presentations and workshops with a major peer review every five years to assess information learnt for adaptive management purposes. This performance reporting program document will be updated to reflect any changes made to the management actions, indicators or monitoring methodology. The Director of the Nature Conservation Division will have the responsibility for approving the annual performance reports and five yearly reviews.

APPENDIX 3

SUMMARY OF BIODIVERSITY VALUES

The LCI program aims to protect significant terrestrial biodiversity values in the Kimberley at the landscape scale which are under greatest threat from inappropriate fire regimes, excessive grazing from introduced animals and competition from introduced plants. The biodiversity values are briefly described below, with a focus on the north-west Kimberley.

The highest priority ecosystems and threatened and priority fauna species (highlighted) will be targeted for monitoring under this performance reporting program. Other priority ecosystems and species are being monitored under existing regional conservation programs (e.g. monitoring of threatened flora, mound springs TECs, migratory shorebirds and turtle nesting), or will be monitored according to the level of threat and availability of resources in future years (e.g. Devonian Reef NP, Purnululu NP).

These biodiversity values have been based on various documents and the literature cited within them (Graham and McKenzie, 2004; DEC 2009; DEC 2010a; DEC 2010b; Government of Western Australia, 2011; Carwardine *et al.*, 2011). Priorities and monitoring protocols were discussed at a workshop held in November 2009 at Mornington Wildlife Sanctuary with pastoralists, the Australian Wildlife Conservancy, DEC and other land managers (DEC 2010b) which have been adapted for the current performance reporting program.

Ecosystems

1. High priority

- Tropical savanna woodlands characterized by specific tree and hummock or tussock grass communities, which vary in structure and floristics with geology and rainfall. Some of the rock formations include sandstones, volcanics, granites, limestones, mudstones and siltstones. The laterite savanna woodland on the Mitchell Plateau dominated by *Livistona eastonii* palms, and mixed open woodlands with tussock grasses, are unique in Western Australia.
- Dissected sandstone uplands with herbfields, triodia hummock grasslands and fire sensitive shrublands with high levels of species diversity and endemism. These rugged environments provide a level of protection from fire for obligate seeder plants, including cypress pine (*Callitris intratropica*) and many threatened and declining fauna species and their habitats.
- Rainforests with distinct flora and fauna species assemblages including many endemic and fruit eating species not found in the surrounding savanna (e.g. fruit pigeons, pittas and flying foxes), as well as many endemic camaenid land snails and earthworms. Rainforests occur as isolated patches on scree slopes, gullies and gorges, along rivers and swamps, and in the near tidal flats, with greatest representation in the high rainfall region. Cape Bougainville rainforest on laterite and volcanic soil is the largest rainforest patch in the Kimberley. Some inland swamp rainforests (e.g. Roe River, Theda and Walcott Inlet) are gazetted threatened ecological communities.
- Monsoon vine thickets are semi-deciduous rainforest ecosystems which occur in coastal sand dunes, drier inland rocky springs and limestone outcrops and provide dry season refuges for a variety of animals, plants and many endemic invertebrates, and many are gazetted threatened ecological communities. Devonian reef limestone ridges and gorges have important cave systems for bats (e.g. Windjana and Geiki Gorges, Mimbi Caves, Tunnel Creek, Ningbing Range, Napier Range).
- Riparian and gorge ecosystems (e.g. Prince Regent, Mitchell, Roe, Charnley, King Edward, Moran, Berkley, Hunter Rivers, Ord, Pentacost, Durack, Fitzroy) with fringing vegetation comprising closed forests of melaleuca and pandanus, tall melaleuca and eucalypt gallery forests, and rainforest patches which are all important dry season refuges for birds and fauna and contain a high diversity of fish and aquatic invertebrates. A number of rivers are classed as Ramsar Wetlands and Wetlands of National Significance.

- Freshwater wetlands and swamps, including Airfield Swamp and Glauert's Lagoon on the Mitchell Plateau, Le Lievre Swamp near the Fitzroy River, Beverley Springs, Lake Gladstone, Long Swamp, Munja Lagoon, Lake Gregory in the Tanami Desert and smaller sandplain seepages near sandstone ridges. Organic mound springs with sedgelands and melaleuca low forests include Mandora Marsh, Dragon Tree Soak in the Great Sandy Desert, Bunda Bunda and Black Spring, some of which are gazetted threatened ecological communities.
- Near coastal uninhabited islands with no known feral animals and few introduced plants represent intact ecosystems that are less exposed to fire and provide important refugia for native fauna species that are in decline on the mainland. Most of the major mainland ecosystems are represented on the islands. They also provide important habitat for migratory birds, shorebirds and nesting turtles.

2. Medium priority

- Extensive coastal mangroves (mangal) in estuaries and embayments are the only extensive, high productivity, closed-canopy community in the Kimberley with endemic fauna and important habitats for fisheries and saltwater crocodiles. These are some of the largest patches of mangroves in Australia and are among the most pristine in the world.
- Sandy coastal beaches are important for shorebird and turtle nesting, including Cape Dommett for Flatback Turtle (*Natator depressus*). Tidal mudflats, coastal swamps and grasslands are feeding grounds for thousands of migratory shorebirds (e.g. Eighty Mile Beach, Roebuck Bay and Roebuck Plains).
- Large alluvial floodplains and natural productive grasslands (e.g. Camballin, Parry Lagoons, Lower Ord and Lake Argyle) are nationally and internationally important wetlands for waterbirds and shorebirds feeding and breeding sites as well as crocodile nesting.
- Purnululu World Heritage Area with the imposing Bungle Bungle Range with the orange and black banded sandstone domes, steep gorges and creeklines supporting several endemic and threatened species, and the Osmond Range to the north with remnant rainforest patches.
- Semi-arid red sandplains with shrubland of acacia, hakea and grevillea species and grasses in the Tanami Desert and Dampier Peninsular, known habitat of the threatened Bilby (*Macrotis lagotis*).
- Vast natural tussock grasslands and herbfields on volcanic cracking black clay plains along the Ord River floodplain and throughout the Kimberley. Also extensive plains on dry calcareous soils with shorter tussock grasses.

Species

Mammals

- **Endemic terrestrial mammals in the north-west Kimberley include Scaly-tailed Possum (*Wyulda squamicaudata*), Monjon (*Petrogale burbidgei*), Kimberley Rock-rat (*Zyzomys woodwardii*)** and Yellow-lipped Cave Bat (*Vespadelus douglasorum*), while Narbarlek (*Peradorcas concinna* subsp. *monastria*) have limited distribution.
- **Threatened mammals in the north-west Kimberley include Golden Bandicoot (*Isoodon auratus*), Northern Quoll (*Dasyurus hallucatus*) and Butler's Dunnart (*Sminthopsis butleri*).** Other threatened mammals in the Kimberley include the Bilby (*Macrotis lagotis*), Crest-tailed Mulgara (*Dasycercus cristicauda*), West Kimberley Rock Wallaby (*Petrogale lateralis* subsp. WAM M151135), and Northern Marsupial Mole (*Notoryctes typhlops*).
- **Priority mammals in the north-west Kimberley include Golden-backed Tree-rat (*Mesembriomys macrurus*), Black-footed Tree-rat (*Mesembriomys gouldii*), Scaly-tailed Possum (*Wyulda squamicaudata*), Monjon (*Petrogale burbidgei*), Rock Ringtail Possum (*Petropseudes dahli*),** Northern Leafnosed-bat (*Hipposideros stenotis*), Yellow-lipped Cave Bat (*Vespadelus douglasorum*) and Ghost Bat (*Macroderma gigas*). Other Kimberley priority species include the Spectacled Hare-wallaby (*Lagorchestes conspicillatus* subsp. *leichardti*), Little North-western Mastiff Bat

(*Mormopterus loriae* subsp. *cobourgiana*), Water-rat (*Hydromys chrysogaster*) and Lakeland Downs Mouse (*Leggadina lakedownensis*).

- **Critical Weight Range (CWR) mammals (35g to 5.5kg) other than above including Brush-tailed Tree-rat (*Conilurus penicillatus*), Black-footed Tree-rat (*Mesembriomys gouldii*), Pale Field Rat (*Rattus tunneyi*), Northern Brown Bandicoot (*Isoodon macrourus*), Northern Brushtail Possum (*Trichosurus vulpecular* subsp. *arnhemensis*), Narbelek (*Petrogale concinna*), Short-eared Rock Wallaby (*Petrogale brachyotis*), Brush-tailed Phascogale (*Phascogale tapoatafa*), Pale Field Rat (*Rattus tunneyi*), and Sugar Glider (*Petaurus breviceps*).**
- **Smaller rodents and dasyurids (<35g) at risk including Grassland Melomys (*Melomys burtoni*), Common Planigale (*Planigale maculata*), Western Chestnut mouse (*Pseudomys nanus*), Red-cheeked Dunnart (*Sminthopsis virginiae*) and Common Rock-rat (*Zyzomys argurus*).**

Birds

- **Endemic birds in the north-west Kimberley include Black Grasswren (*Amytornis housei*), Western Partridge pigeon (*Goephaps smithii* subsp. *blaauwi*) and Kimberley Rainbow Pitta (*Pitta iris* subsp. *johnstoneiana*)**
- **Threatened birds in the north-west Kimberley includes the Western Partridge Pigeon (*Goephaps smithii* subsp. *blaauwi*), while other threatened Kimberley species include Gouldian Finch (*Erythrura gouldiae*), Northern Crested Shrike-tit (*Falcunculus frontatus* subsp. *whitei*), Red Goshawk (*Erythrotriorchis radiatus*), and Australian Painted Snipe (*Rostratula benghalensis* subsp. *australis*).**
- **Priority birds in the north-west Kimberley include Northern Masked Owl (*Tyto novaehollandiae* subsp. *kimberli*) and Chestnut-backed Button-quail (*Turnix castanota*). Other Kimberley priority species include Western Purple-crowned Fairwren (*Malurus coronatus* subsp. *coronatus*), Grey Falcon (*Falco hypoleucos*), Australian Bustard (*Ardeotis australis*), Star Finch (*Neochima ruficauda* subsp. *subclarescens*), Pictorella Mannikin (*Heteromunia pectoralis*), Bush Stone-curlew (*Burhinus grallarius*),** Eastern Curlew (*Numenius madagascariensis*), Flock bronzewing (*Phaps histrionica*) and Princess Parrot (*Polytelis alexandrae*).

Reptiles

- Endemic reptiles in the north-west Kimberley include Rough-scaled Python (*Morelia carinata*) and Kimberley deep-soil Blind Snake (*Ramphotyphlops howi*). Another three blind snake, four dragon lizard, seven gecko and ten skink species are endemic to the Kimberley which is recognised as a centre for reptile endemism.
- Threatened reptiles include the Flat-backed Turtle (*Natator depressus*) which nests along the north Kimberley coast and another five turtle species that may use the Kimberley coastline or islands for nesting.
- Priority reptiles include Rough-scaled Python (*Morelia carinata*), Dampierland Burrowing Snake (*Simoselaps minimus*), four blind snake and six skink species.
- Specially protected reptiles include Saltwater Crocodile (*Crododylus porosus*), Freshwater Crocodile (*Crocodylus johnstoni*) and Woma Python (*Aspidites ramsayi*).

Amphibians

- There are six endemic frog species in the Kimberley including two that are priority species, Marbled Toadlet (*Uperoleia marmorata*) and Small Toadlet (*Uperoleia minima*).

Fish

- There are two threatened fish species, Grey Nurse Shark (*Carcharias taurus*) and Green Sawfish (*Carcharodon carcharias*) and twelve priority inland freshwater fish species.

Invertebrates

- Endemic invertebrates include numerous species of camaenid land snails and earthworms associated with different rainforest and vine thicket patches.
- Threatened invertebrates include 32 species of molluscs.
- Priority invertebrates include another 19 species of molluscs.

Plants

- There are at least 100 endemic plants species in the north Kimberley region but these have not been formally listed.

- Threatened flora species in the Kimberley include five threatened species: *Eucalypus mooreana, Eucalyptus ceracea, Keraudrenia exastia, Pandanus spiralis* var. *flammeus* and *Typhonium* sp. Kununurra.
- Nearly 500 priority flora species are listed although many are poorly known and in urgent need of further survey effort which could change their conservation status. These include 261 Priority one, 106 Priority two, 120 Priority three and 8 Priority four species.

APPENDIX 4. Weeds recorded in the north Kimberley in Florabase and other records. Species highlighted in light yellow are the highest priority for management under the LCI program.

Scientific name	Common name	Declared	WONS	Regional priority	Distribution	Life Form
Acanthospermum hispidum	Goat's head, Star Burr	Prohibited			Widespread	Annual herb
Amaranthus viridis	Green Amaranth				Scattered	Annual herb
Antigonon leptopus	Coral Vine			Yes	Isolated	Perennial vine
Arundo donax	Giant Reed			Yes	Isolated	Perennial tall grass
Azadirachta indica	Neem			Yes	Scattered	Tree
Bidens bipinnata	Cobbles Peg				Scattered	Annual herb
Bidens pilosa	Cobblers Peg				Widespread	Annual herb
Calotropis procera	Rubber bush			Yes	Widespread	Perennial shrub
Cardiospermum halicacabum	Small Balloon Creeper				Widespread	Annual herb
Cenchrus biflorus	Gallon's Curse				Widespread	Annual grass
Cenchrus ciliaris	Buffel Grass				Widespread	Annual/perennial grass
Cenchrus echinatus	Mossman river Grass	Prohibited			Widespread	Annual/perennial grass
Cenchrus setiger	Birdwood Grass				Widespread	Annual/perennial grass
Chloris barbata	Purple Top Chloris				Widespread	Annual/perennial grass
Citrullus colocynthis	Pie Melon				Widespread	Perennial herb/vine
Citrullus lanatus	Pie Melon				Widespread	Annual herb/vine
Clitoria ternatea	Butterfly Pea				Widespread	Perennial herb/vine
Crotalaria goreensis	Gambia pea			Yes	Isolated	Annual/perennial herb
Echinochloa colona	Awnless Barnyard grass				Widespread	Annual grass
Euphorbia hirta	Asthma Plant				Widespread	Annual herb
Gomphrena celosioides	Gomphrena weed				Scattered	Annual herb
Hibiscus sabdariffa	Rosella				Scattered	Annual herb
Hyptis suaevolens	Mint Bush	Prohibited		Yes	Widespread	Annual/perennial herb
Ipomoea carnea					Isolated	Tall shrub
Ipomoea pes-tigridis				Yes	Isolated	Annual herb/vine
Jatropha gossypiifolia	Bellyache Bush	P1/3		Yes	Scattered	Shrub
Lantana spp.	Lantana		Yes	Yes	Isolated	Shrub
Leucaena leucocephala	Leuceana	Prohibited		Yes	Scattered	Tall shrub
Macroptilium atropurpureum	Siratro				Widespread	Perennial vine
Macroptilium lathyroides	Phasey bean				Scattered	Annual vine

Scientific name	Common name	Declared	WONS	Regional priority	Distribution	Life Form
Megathyrsus maximus	Guinea Grass			Yes	Isolated	Perennial tall grass
Melinis repens	Natal Red Top				Isolated	Annual/perennial grass
Passiflora foetida	Passionfruit vine			Yes	Widespread	Perennial vine
Pennisetum pedicellatum	Mission Grass			Yes	Scattered	Annual/perennial grass
Physalis angulata	Wild Gooseberry				Widespread	Annual herb/ perennial shrub
Senna occidentalis	Coffee Senna				Widespread	Shrub
Sida acuta	Spinyhead Sida	P1		Yes	Scattered	Perennial shrub
Stachytarpheta cayennensis	Snakeweed				Scattered	Perennial shrub
Stylosanthes spp.	Stylo				Widespread	Perennial shrubs/herbs
Themeda quadrivalvis	Grader Grass	Prohibited		Yes	Scattered	Annual grass
Tribulus terrestris	Caltrop				Widespread	Annual herb
Tridax procumbens	Tridax Daisy				Scattered	Perennial herb

APPENDIX 5.

LCI VEGETATION MONITORING SITE GUIDELINES – ALL SITES

(Note: MODUS and Veg Machine methodology to be attached)

Site Selection

Potential monitoring site locations are mapped prior to field work taking into consideration

- Tenure, vegetation data, geology, topography, aerial photography
- Locations of previous field work and historic data
- Representation of vegetation types to be sampled
- Accessibility and logistical considerations

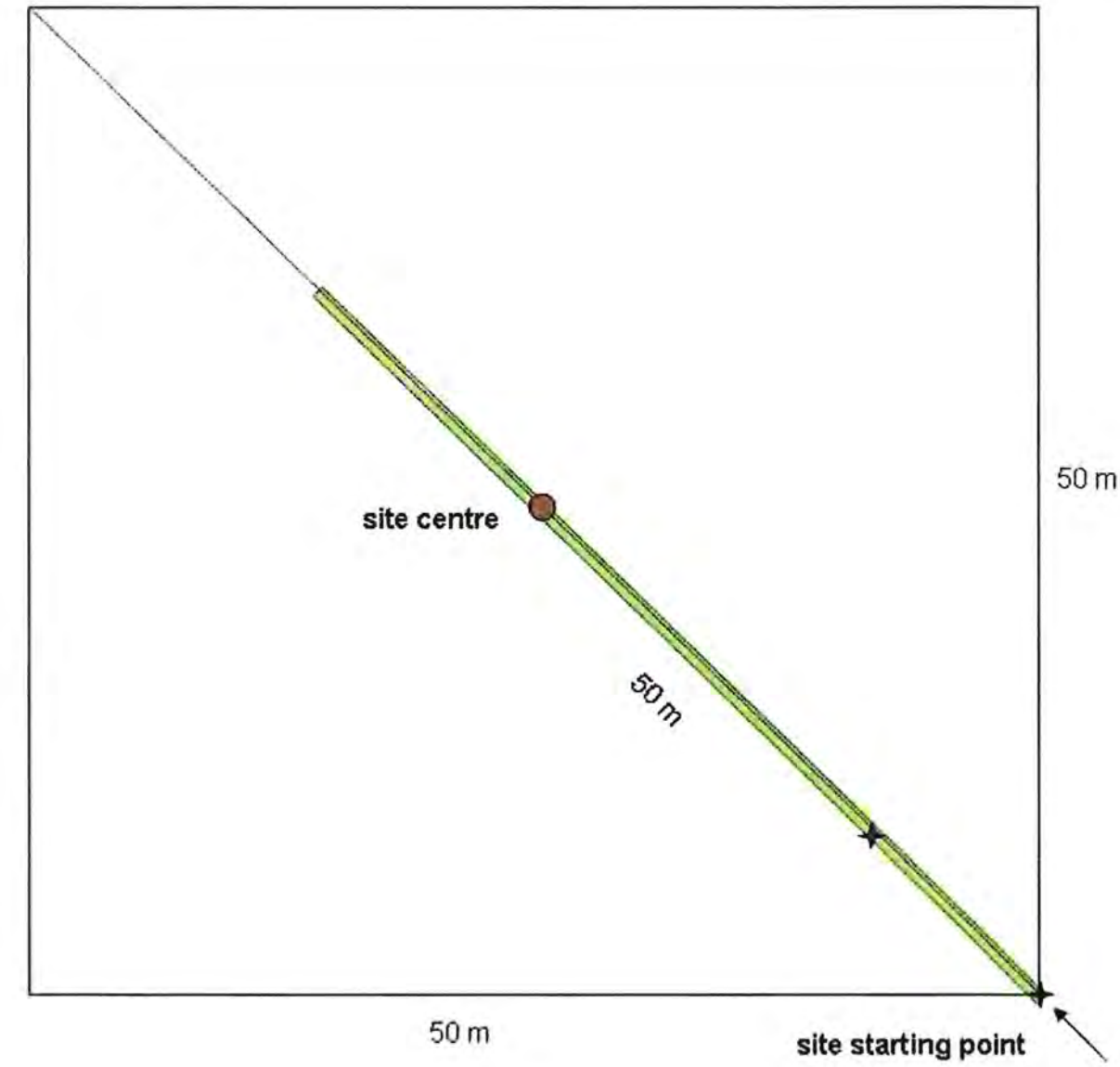
In the field, potential monitoring sites are assessed for their suitability and if necessary realigned.

Site set up

On the selected 50x50m site, a vegetation transect line is chosen to best represent the vegetation type and elements best suited to show up changes in fire and cattle management.

The start of the vegetation transect is marked with a star picket. The top of the picket is brightly coloured and a tag with site number is fastened to the picket. 10m along the 50m transect a second star picket is placed to align the monitoring photos. These 2 star pickets stay permanently in the ground.

Four soil pins are placed within the site following the transect (50m tape) and sitting to the left of the 20m, 30m, 40m and 50m points. These soil pins are entered into the ground leaving a distance of 40cm from the top of the pin to the ground surface.


50 m
site centre
50 m
50 m
site starting point
2 Star pickets
Photo monitoring
50m intersect transect

Site data collected during site set up

Site No

Each site is given a unique number with the prefix LCI. The sites within a cluster are numbered in consecutive order following the logical order in which sites are approached along the tracks.

- Mitchell Plateau sites are starting with LCI 001
- KLRCP sites are starting with LCI 201
- PRNR sites are starting with LCI 301
- DRNP sites are starting with LCI 401

Survey

Landscape Conservation Initiative (LCI)

Tenure

Coordinates

In decimal degrees (lat, long) using GPS to nearest 'second of arc' using WMG grid (= Google Earth)

Compass bearing of the vegetation transect

Collector name

Date of data collection

Date site is established

Photos taken

Number of photos taken for the photo monitoring

Underlying geology

This can be prepared in the office (maps, GIS) and verified in the field

Distance to closest water body

This can be prepared in the office (maps, GIS) and verified in the field

Type of water body

Relevant description in the provided list is circled

Additional comments can be made

Landform pattern

Relevant description in the provided list is circled taking into consideration the surrounding area of approximately 300m radius

Additional comments can be made

Landform element

Relevant description in the provided list is circled taking into consideration the area of the 50x50m site

Other terms (not listed) can be used to describe the landform element

Soil surface texture

A soil sample is examined in the field and the relevant description in the provided list is circled. There are five soil texture classes. There should be another substrate descriptor given (deposition, erosion, levee stripping etc).

Soil colour

Multiple terms of the list can be used to describe the soil colour

Soil attributes likely to indicate a response to disturbance management

- Positioning the transect tape so that it runs past the 'furniture' of the site (Hutchinson) – the variety of microhabitats present such as the litter patches under trees, rock outcrops etc.
- Record the depth of the soil organic layers (drt litter, fragmented litter, worm cast decomposition layer) point to point along the tape, rather than the areal % of litter cover
- Record soil-shear and other gestalt measures of A horizon with regard to animal ecomorphology
- Soil pins to measure average height of the soil surface and the litter surface over the surrounding square metre or so.

Four pins per site with permanent markings indicating the position of the litter's surface at the time the pin was driven into the substrate (averaged over the surrounding square metre). These points should be positioned at different edaphic settings within the site.

Leaf litter

Leaf litter depth and layering needs to be measured at 4 or more points per site. The points should be positioned in different edaphic settings within the site, including between tree canopies, under a tree canopy etc. Most likely layers in a tropical savanna ecosystem are:

- Intact litter
- Fragmented/decaying litter
- Decomposition/worm caste
- Organic mineral-A, including any macroinvertebrate tunnels.

Soil samples?

20cm bulk soil samples are to be taken at each site, these are to have soil chemical analysis completed (P, K, Ca) which will be useful in calibrating remote sensing work.

Photo monitoring

The photos are taken standing directly behind the star picket of the site starting point and looking along the transect towards the second star picket and the centre of the site.

Photo 1 is taken with the horizon just showing in the upper part of the frame and the second star picket in the centre.

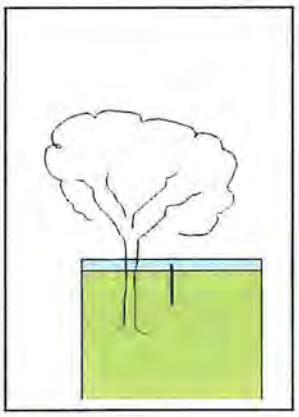


Photo 2 is taken with a standard setting of placing the horizon one third in from the top of the frame.

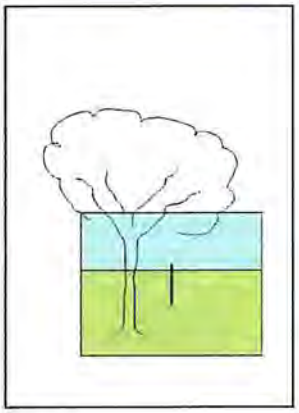


Photo 3 is taken with the horizon just showing in the bottom part of the frame.

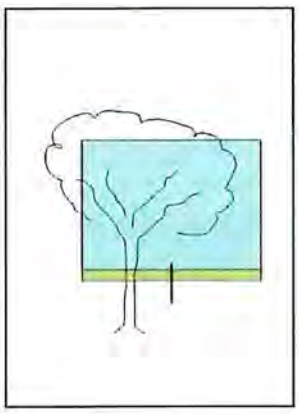
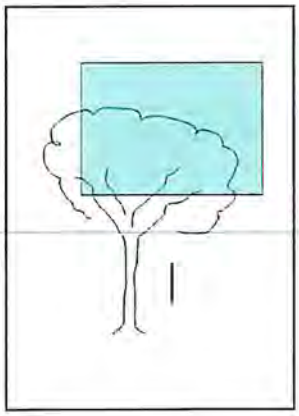


Photo 4, moving the frame even further up, is only taken if the tree branches are too high to be captured already in photo 3.



Vegetation data collected

Transect 50m intercept foliage

A 50m tape is laid out in a straight line from the star picket at the site starting point towards and beyond the second star picket and the centre of the 50x50m site.

Focusing on the line directly under the tape, a measurement in cm is taken of area taken up by any of the following categories: perennial grass, annual grass, herb, litter, logs >5cm, exposed rock and gravel, bare ground, termite mound, woody sub shrub, shrub and tree.

These measurements are taken down in a table for a tape length of 1, 2 or 5 meter at a time. At completion of the 50m transect, the measurements a totalled and converted into a percentage value.

Distinct changes along transect

If there are any distinct changes along the transect, the change and exact location on the 50m tape can be recorded for future reference. Distinct changes can be for example recently burned/unburned, a distinct change in vegetation type, location of a cattle pad, boundary of a rainforest patch and extent of grass intrusion into a rainforest patch.

Measurements taken from Site Centre

The site centre is at 37m along the transect (50m tape) from site starting point.

Basal area measurements are taken from site centre with a factor 1 glass wedge.

Bitterlich measurements are taken of all trees and all shrubs within sight from the site centre.

Vegetation stratum summary for 50x50m site

Growth form, percentage cover and average and maximum height are determined for each stratum present on the site. Each stratum is considered within one of the following categories: Upper stratum trees (U), mid stratum tall shrubs (M1), mid stratum low shrubs (M2) and ground stratum (G).

The percentage cover for each stratum is estimated looking at the whole of the site and taking into consideration the measurements from the transect and the Bitterlich measurements taken from the centre of the site.

Ground Cover summary for 50x50m site

The percentage cover for each listed element of the ground cover is estimated looking at the whole of the site and taking into consideration the measurements from the transect. The total of all elements is adding up to 100%.

Dominant Species in each Stratum

Up to three dominant species are recorded for each stratum present on the site.

For each species recorded the following information is entered: Species name, unique collector number if a sample is taken, height, percentage cover, basal area and Bitterlich value. It is also determined if there are any juvenile plants under 2m, juvenile plants over

2m, adult plants, mature plants at the height of their reproductive potential, health conditions and if the plant species is flowering, fruiting or seeding.

Species of special Significance or Indicators (Fruit trees, Heath species, Acacia species etc)

Need to include indicator species of overburning or burn damage, eg. Sorghum and opther grasses, and indicators of "healthy" or ecological burning, eg trees such as callitris etc.

In this table any species of special significance can be recorded with the same additional information entered as for dominant species.

Scoring of additional Indicators

Fire

Evidence of recent fire is judged within the site and scored by circling the appropriate category.

Fire intensity can only be scored for a recent fire or if intensity of a fire from the previous years left enough evidence of intensity of burn.

The percentage of vegetation burned within the site and the scorch height of the fire is only entered for a recent fire.

Cattle

Number of cattle sighted, grazing intensity, tracks and trampling and cattle dung are judged within the site and scored from zero to three, giving a maximum total score of 12. circling the appropriate category.

The percentage of vegetation showing damage caused by grazing or trampling is estimated for the site.

Other introduced animals

Any signs of other feral animals noted within the site are scored by circling the appropriate category.

Weeds

Any weed species noted within the site are entered into the table and scored for extent of infestation, density and invasiveness.

The percentage of vegetation consisting of weeds is estimated for the site.

Erosion

The distance from the top of the 4 soil pins to the ground surface is measured and entered into the table.

Indicators of biodiversity

Fauna habitat and shelter, food availability and tracks and traces are scored for the site by placing the appropriate number in the fields provided.

Litter and organic matter

By cutting vertically through the litter layer into the ground and examining the profile, four layers are identified and the layer depth measured in mm. These layers, if present, are:

- Intact litter
- Fragmented and decaying litter
- Worm cast layer with presence of macro-invertebrates or their traces
- Organic mineral layer

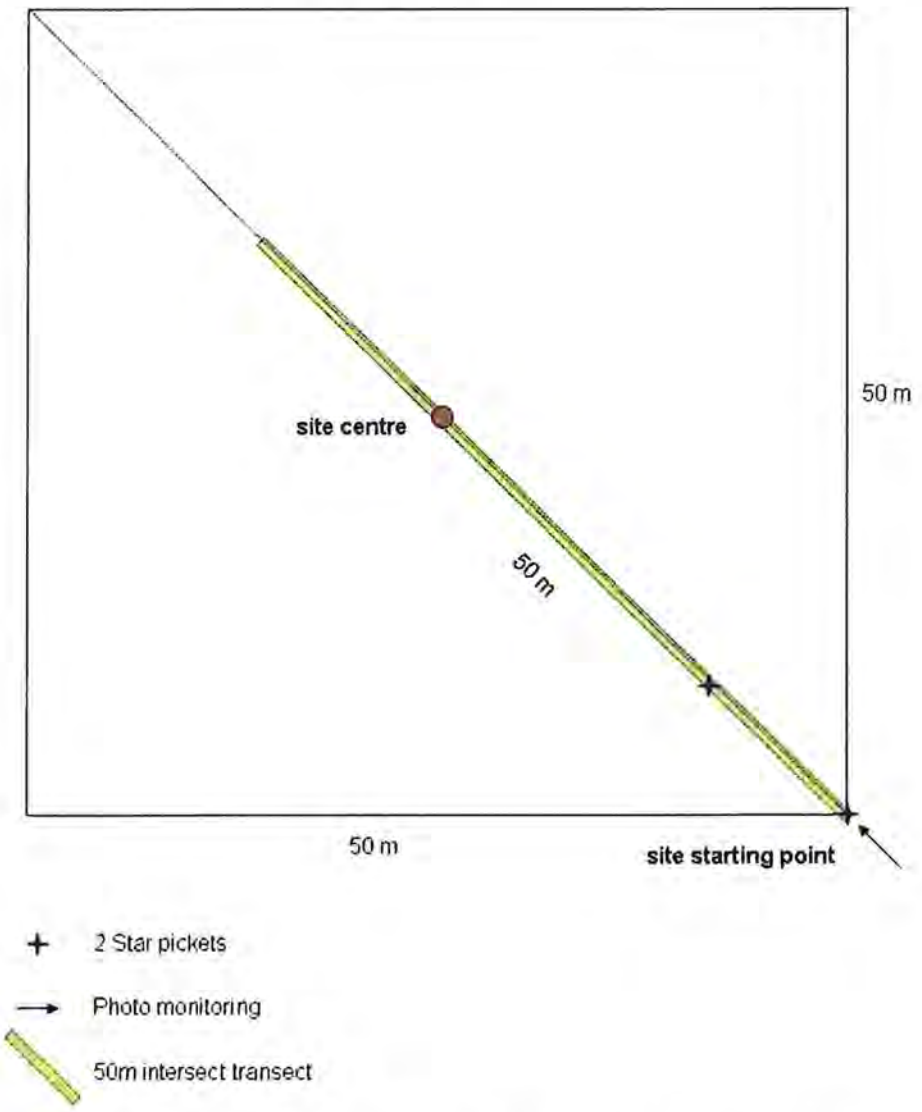
Two profiles are located under main habitat trees and two in the open.

APPENDIX 6.

LCI MONITORING SITE GUIDELINES - MAMMALS

Site Selection & set-up

Site selection, set-up, naming, description and vegetation measurement are described in Appendix 2. Quadrat design is presented below to aid in describing mammal trap set-up. Quadrat design is a variation on the Woinarski *et al.* (2010) plot used widely for biodiversity survey in northern Australia.



The start of the vegetation transect is marked by 2 star pickets placed 10 m apart. These mark the first ten metres of a vegetation transect (Appendix 2) which marks the diagonal of the mammal quadrat. The 4 corners of the mammal quadrat are unmarked.

Mammal trap set-up

Elliott and cage trap set-up and placement

Twenty elliott traps are placed at roughly 8 m intervals around the 50 x 50 m quadrat. Five traps are therefore placed along each side of the quadrat. Alternating large (15 x 15.5 x 46 cm) and medium (9 x 10 x 33 cm) elliott traps are used. Different sized traps allow capture of the full size-range of mammals, from small rodents (5-10 g) up to animals the size of quolls and bandicoots (200-1500 g). Four cage traps (c. 30 x 50 x 60 cm) are placed in each corner of the quadrat for larger mammals (2-5 kg).

Traps are placed in position by pacing out 8 m intervals. Quadrats are not precisely measured out or surveyed. Where possible, traps are positioned in sheltered/shaded micro-sites to avoid traps over-heating in the sun. Where there is high grass or rock cover, traps are placed in shade. Where grass is sparse, additional shade is provided either by placing traps under tree canopies, or by placing leafy branches on top of Elliott traps. Where little natural shade is available on-site, shade was provided by small hessian bags (e.g. sand-bags) over the top of traps.

Cage traps are covered in large hessian sacks to provide shelter from the sun and also to prevent stress on animals through exposure to predators. Hessian sacks are used to completely cover one side of the cage so that captured animals can retreat into a covered area. Cages also are placed under shrubs or in long grass to provide additional shelter/protection.

All traps should be clearly marked with a coloured tape or ribbon so that traps can readily be found each day. It is important not to miss traps as animals left in traps risk death from heat exhaustion.

Traps are baited with a mixture of peanut butter and rolled oats. These baits are renewed daily as used up by mammals or ants. Pieces of cut apple are placed in cage traps in addition to the peanut butter and rolled oat mixture to attract additional species including possums.

Timing of trap sessions

Traps are opened over five consecutive nights to quantify mammal abundance.

Traps are checked early each morning of the trapping session to ensure animals are measured and released before the heat of the day. Trap checking should be completed each day by 10am. Those undertaking the trapping must time getting up in the morning and travel to trap sites to allow this. Usually to check all traps by 10 am it would be required that checkers should leave camp by 6am.

Three to four trap sites can usually be run by 1 experienced worker. The exact number of sites that can be checked in a morning will depend on how long it takes each worker to process animals, the site terrain, how much travel there is between sites and how abundant animals are. During high abundance periods or at very good sites (trap success >10%) trap site number may have to be reduced.

We recommend that at a minimum of 2 experienced animal handlers, along with at least 1 less experienced helper, are needed to establish and service 6 to 8 trap sites during each trap session.

Regional trap sessions

In order to achieve current monitoring site targets in the Mitchell, Drysdale, Prince Regent, King Leopold and Island regions of the North Kimberley, we propose 4 two week field trips annually with 2 experienced workers and 1 or 2 volunteers/casual staff. Two of these 2 week field trips are needed for the Mitchell region with >24 sites.

King Leopold will be visited every year by 1 experienced worker with the help of additional west Kimberley staff. The annual target for this area is 8 sites. One 2 week field trip will be needed for this region.

Prince Regent and Drysdale National Parks will be serviced in alternate years due to logistical constraints. All sites in these regions are accessible by helicopter only. Each of region will need one 2 week field trip to service 8 sites in each region.

Mammal data collected

Animal handling

The emphasis when checking traps and handling animals is to reduce stress in animals as much as possible. When approaching Elliott and cage traps care should be taken to make little noise. Traps should be picked up and handled gently if it is suspected an animal is contained in a trap. It is a good idea to check what type of animal is present before handling in case the animal is dangerous (e.g. snakes, large predatory animals like cats). Noise should be kept to a minimum when handling animals to avoid causing stress.

Mammals can be emptied out of Elliott and cage traps into calico or zip-lock plastic bags for handling and identification. Zip-lock plastic bags should only be used for small rodents or dasyurids <150 g. Plastic bags are found to be less stressful for some rodents (e.g. the common rock rat) because measurements can be made without direct handling of the animal. Handling rodents has resulted in stress related deaths on a number of occasions and should be kept to a minimum.

In order to remove animals from traps into bags it is first necessary to position the animal in the end of the trap away from the door. This can be done by angling the door end upward. Place the bag over the door and fold and tighten it around the end of the trap so that it is sealed. Then open the door by pushing against it through the bag. At this point when the door is open, invert the trap and give a gentle shake. In this way the animal should fall down into the bag. Blowing through the cracks in the trap sometimes helps persuade the animal to move into the bag.

If animals will not move out of the trap, place whole trap into the bag and release the trap using the pin.

Larger animals are likely to bite if handled, so handling in the bag is designed to prevent this. Always handle animals firmly but gently through the bag. It is best to manoeuvre animals so that their nose and mouth are pushed into the corner of the bag away from where you are measuring.

Mammal measurements

Animal weight, head length, pes length, and in the case of rodent species, combined head-body and tail length, are measured to facilitate species identification.

Animal weight is measured using a pesola balance. Fifty gram, 100 g, 1 kg and 2.5 kg pesola balances are available and using the one that is most appropriate for the animal you have will ensure greatest accuracy. Gross animal weight including the bag, and bag weight after animal is released, are used to calculate net animal weight (g).

Head length is measured using callipers through the bag to avoid being bitten. Feel for the nose and measure to the back of the skull (mm).

Pes length is the distance from the end of the back toe (not including claws or nails) to the heal (mm). This can be measured by keeping the front of the animal covered in the bag while handling the back foot.

For rodents, combined head and body, and tail length are measured separately. This aids identification, as head/body to tail ratios are diagnostic for some rodents. This can be done through the plastic bag or a calico bag.

Mammals were identified using "A Field Guide to Mammals of Australia" (Menkhorst and Knight 2004). Where species identification was not clear from field examination of morphology, hair samples were taken and sent to Georgeanna Story (Scats About, PO Box 24, Majors Ck, NSW 2622) for examination in cross section to verify identification as per Lobert *et al.* (2001).

Animal numbers, identification of individuals and trap success

In order to get more accurate estimates of mammal populations, captured animals are marked to allow recaptures to be identified. Larger mammals, including quolls, large rodents (>150 g), bandicoots, small wallabies and possums, are all micro-chipped to allow identification of individuals. Micro-chips are inserted just under the top skin layer between the shoulder blades using a special syringe.

A micro-chip reader is used to check each captured animal to determine if they were a recapture from this or a previous trap session.

Smaller animals including rodents <150 g and small dasyuruds are marked using permanent marker pens on their ears. This allows identification of recaptured individuals from the current trapping session, but not for previous sessions as marks fade with time. Rodents including the common rock rat, are not micro-chipped as they are subject to stress related deaths when handled for extended periods.

The number of animals caught in each trapping session at each site, along with the total number of trap nights, is used to calculate trap success (trap success=animals caught/total trap nights).

Species richness, of the total number of species caught at a particular site is also recorded as a measurement of biological diversity.

Species of Special Significance

A number of mammal species are reported separately due to their national significance, and their threatened or iconic status. These include the northern quoll (*Dasyurus hallucatus*), the brush-tailed rabbit-rat (*Conilurus penicillatus*), golden bandicoot (*Isoodon auratus*), golden backed tree-rat (*Mesembriomys macrurus*), black-footed tree rat (*Mesembriomys gouldii*), scaly-tailed possum (*Wyulda squamicaudata*), Kimberley rock rat (*Zyzomys woodwardi*), northern brush-tailed possum (*Trichosurus vulpecular arnhemensis*), nabarlek (*Petrogale concinna*), monjon (*Petrogale burbidgei*), rock ring-tail (*Petropseudes dahlia*) and brush-tailed phascogale (*Phascogale tapoatafa*).

Post-session

Care should be taken to account for all traps at the end of the trapping session to avoid animal deaths with animals left in traps. All traps should be cleaned with detergent after field trips to avoid transmission of disease to animal handlers and to other mammals.

Remote camera trapping

Camera set-up

Two cameras are set up at each trap site to record additional species not captured in Elliott traps. Two cameras are placed adjacent to the trapping quadrat. Cameras are set up angled towards the ground approximately 5 m from the camera so that animals would be identifiable. Cameras are strapped to trees. Cameras are set up along animal foot pads if possible to increase the chance of recording animals. Cameras are set to be triggered automatically by animal movement in front of the camera. Cameras are set to video to record footage of the animal and to increase chance of identification.

Grass and low vegetation is slashed in front of camera to reduce the number of shots triggered by movement of vegetation in the breeze. Video footage allows detection of non-animal related triggering mechanisms so that removal of unwanted triggers can be done.

We use dried meat baits placed in a fixed wire cage in front of trap to increase camera interception of predatory species.

Camera records

Any animal recorded in cameras are identified to species based on Menkhorst and Knight (2011). Animals identified from camera traps are recorded as present, but no abundance value can be derived for small animals as individuals cannot

be identified. Low trap effort also reduces ability to derived abundance values for camera trapping with only 2 per site.

Predators are reported as animals of special significance due to their putative effect on mammal populations. These can more clearly be identified and are sometimes seen in groups. This allows predator numbers to be recorded.

Appendix 7

Cattle Pad Photo Monitoring

Aerial photo point monitoring of the density of cattle pads will be undertaken along selected creek flats and ephemeral swampy areas following each wet season. Data will comprise digital images of pre-selected photo points (using the same camera settings) in focal areas along fixed transects traversed by a helicopter at consistent altitude and speed in each monitored catchment.

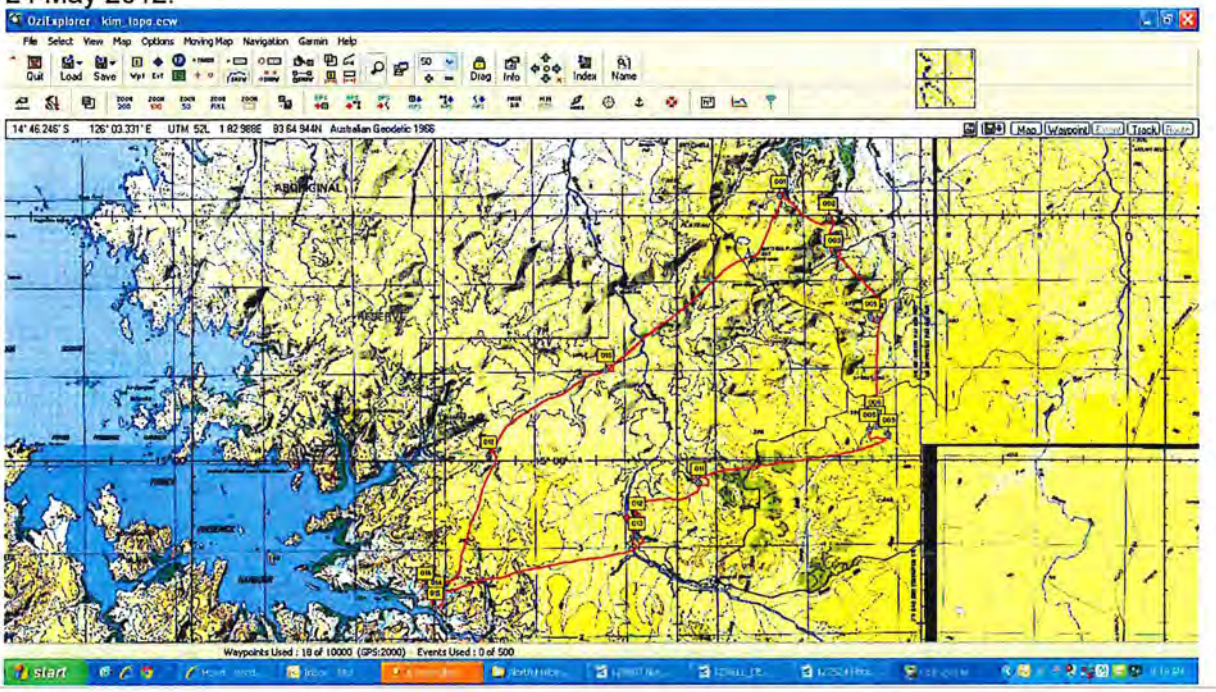
Photo point site selection

Sites will be selected during the first monitoring operation from a number of possible areas with an expected range in cattle density and impacts, and in the main vegetation types. Each site will have a recognizable landmark for future reference. The GPS coordinates of each transect will be recorded with the direction of the photograph, flying height and time of day.

Each cattle pad in each photo will be visually assessed as having nil, light or heavy impact and the length of each usage level assessed to derive a cattle impact score for that site, and contribute to the average score for that vegetation type and management zone. The management action target will be a reducing trend in average cattle pad scores. The categories for assessing cattle usage (Nil, Light and Heavy) will be standardized after the first assessment with allowances for different impacts and response times for different vegetation types, e.g. riparian tussock grass compared with sandstone spinifex.

Cattle sign is readily observed from a slow moving helicopter at 500 ft AGL – tracks, dung and dust wallows. Sites with obvious cattle sign will be selected across the area and aerial photographs taken to establish long term monitoring points.

The map below shows the route and photo point sites. Eighteen photo points were created on 24 May 2012.



Timing:

1. It is important that the photographs are taken before the early dry season aerial burning program has started to reduce the risk of tracks being burnt. When the vegetation on and along tracks is burnt it will be difficult to determine in the area has regenerated or if it is sustaining heavy use.
2. Monitoring will occur on an annual basis during May (wet season dependant).
3. The photo point monitoring can be completed while the fire operations helicopter is operating in the North Kimberley. This can occur in dialogue with the Fire Operations team.
4. The fire ops helicopter is authorised to fly below 1000ft. Authorization from the Aerial Operations Manager for flights below 1000ft must be gained, and justified. As the helicopter is required to hover momentarily for the photos to be taken, authorization was not granted for a Bell Jet Ranger to complete the work. This issue is likely to continue into the future.

Methodology:

1. Fly from Mitchell Plateau Ranger Station to selected GPS locations, the route is shown in the above map.
2. Photograph cattle pads at pre-determined GPS locations
3. Photographs are to be taken using an SLR camera set on wide angle, it is best to use the same camera where possible, see table below for camera details.
4. Photographs taken on a 45° angle, so that camera is not physically put outside the helicopter. This is done so that the camera can not be sucked into the tail rotor and because the doors are left on the helicopter for the flight it is too difficult to take photos at a greater angle.
5. The sun can obscure the cattle pads at certain angles, therefore the helicopter needs to be positioned in such a way that the pads can be shown clearly. This is usually with the sun positioned in front of the helicopter.
6. A minimum of 4 photos should be taken at each site at an average height above the ground of 500ft. As the helicopter is not able to hover in one position for too long at this height, it may be necessary to take more photos.
7.

EQUIPMENT:	GPS	Garmin 62s
	Camera	- Nikon D8 digital SLR - Lens 18 – 55 - Memory card 8GB (high capacity) - Quality RAW or Fine jpg (as a minimum) - Setting Autofocus, sports (zoom NOT used)

Helicopter arrangement + Equipment	**Seating** – Photographer should sit in front beside pilot, with navigator behind **Doors** – left on (photos taken out of open side window) **Camera use** - camera can not be used when wearing helmet. Wear headset and no hat (caps hit window)
Cattle pad visibility	Pads are clearest when looking in direction of sun. Same pads are barely visible with sun behind us (i.e. looking away from sun)
Helicopter orientation + Photo quality	Wind direction determines the safest orientation for helicopter to hover. Photo quality could be reduced if the wind is not coming from around the direction of the sun. Different positions will alter (cattle pad) visibility

Analysis:

The photographs are then analysed on computer looking at the density of vegetation along tracks, which can determine light or heavy use by cattle, the presence of dust bowls and wallows. These are then given a score from 1-3.

1 - No impact from cattle,
2 - Old or little use by cattle and
3 - Recent to heavy use by cattle.

APPENDIX 8. *Fire frequency mapping from Modis imagery (NAFI) for the north-west Kimberley from 2004 to 2010.*