Vertebrate monitoring and re-sampling in Kakadu National Park

Year 3, 2003-04

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Department of Infrastructure, Planning and Environment

TROPICAL SAVANNAS CRC
Cooperative Research Centre for Tropical Savannas Management

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Project RS19
Report to Parks Australia: March 2004.

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May 2004.

Cover photograph: Black-footed Tree-rat (Photo: Alaric Fisher).

SUMMARY

This report provides information on a range of studies undertaken in 2003, that involve aspects of monitoring and re-sampling of the terrestrial vertebrate fauna of Kakadu National Park. These comprised:

(i) continuation of a monitoring program (for terrestrial vertebrate fauna) which will contribute to the assessment of impacts of cane toads;
(ii) assessment of vertebrate fauna at existing fire monitoring plots (and hence establishment of baseline for ongoing monitoring of the impacts of fire upon fauna at these plots);
(iii) investigation of change in vertebrate (and especially mammal) species composition at sites sampled in historic surveys, notably in the north of the park;
(iv) surveys of rare and threatened plants and assessment of current status;
(v) investigation of censusing and trapping methods for feral cats and dingos;
(vi) training for Parks Australia staff in fauna survey through a field based training camp; and
(vii) compilation of data bases and GIS layers showing existing and current fauna records.

This report describes mainly items (ii), (iii), and (v) of the above list. The remaining items on this list either do not lend themselves to detailed analysis and documentation and/or have been described in separate reports delivered previously in 2003/04.

Baseline sampling of fauna at fire plots

During 2003/04, a total of 44 fire plots were baseline sampled for fauna. This is the largest annual tally of fauna samples on fire plots to date. The 2003/04 sampling brings the total number of fire plots now sampled to 114 out of the total 134 fire plots established. The sampling is now relatively even across Districts (minimum 79% of plots sampled in Jim Jim District to maximum of 93% sampled in Mary River District) and environments (minimum of 64% in lowland rainforest to maximum of 100% in sandstone heath). The 20 unsampled fire plots are mainly in remote lowland areas. For archival purposes, all fauna records from all sampled fire plots are here collated and appended as a CD. A total of 250 terrestrial vertebrate species have now been recorded from the fire plot sampling.

Re-sampling of mammals at historic survey sites

Re-sampling was undertaken in 2003 at two sites, Jabiluka lease (previously sampled between 1979 and 1981) and Kapalga (smaller studies undertaken by Gordon Friend and Anne Kerle between 1979 and 1983). At Jabiluka, 40 sub-sites (at 15 main sites) were re-located and re-sampled in the same manner and at the same time of year as the baseline sampling. In contrast to other recent re-samples, current mammal numbers were generally higher than at the time of the baseline sampling: total trap success increased from 6.95% in 1979-81 to 8.10% in 2003, and the mean number of species reported per sub-site increased

from 1.75 to 2.20 (although neither of these changes was statistically significant). Three individual species showed significant increase in abundance: northern quoll from 0.6% to 1.6% trap success, pale field-rat from 0 to 0.93% and northern brown bandicoot from 0.33% to 2.58%. Notably, all three of these species were found to have declined significantly at Kapalga in previous re-sampling. In contrast, the abundance of brushtail possums declined significantly, from 1.98% to 0.15% trap success, and there were near significant ($p<0.10$) declines for sandstone antechinus and Arnhem rock-rat. As with our previous studies, there was substantial "noise" in the pattern of changes in abundance at individual sites. Part of the variation in changed abundance appeared to be related to fire histories of individual sites. The Jabiluka study area was notable in having relatively few late dry season fires over the period between baseline sampling and subsequent re-sampling.

In contrast, the 2003 re-sampling of a smaller set of sites at Kapalga indicated substantial reductions in populations of the three species targeted in the original baseline studies, Black-footed Tree-rat, Fawn Antechinus and Northern Brushtail Possum. The success rate (from cage traps) at the Possum site (Kapalga Billabong) was 0.8% compared with a comparable success rate of 33% in 1981 (and 18% in 1980). The 2003 capture rates for all mammals at the two other sites sampled was 0 and 0.3%; although direct comparisons are hampered these results appear to be dramatically down from counts of 34 Fawn Antechinus and 17 Black-footed Tree-rats known to be alive on these sites in 1981. Both these species declined at these sites over the course of the previous studies.

Sampling for feral cats and dogs

A specific study was undertaken to assess a range of methods for survey, and to assess the relative abundance of cats and dingoes/wild dogs in selected areas of Kakadu NP. The survey methods comprised a wide range of procedures used elsewhere in Australia, including vehicle-based spotlight transects, unbaited soil plots, trapping and soil plots with a range of attractants (including foodstuff, visual and aural attractants). No cats or dogs were trapped. There were few visits to the baited and/or attractant stations, and there was no single or combination of baits and attractants that was more effective. Baits and attractants found to be very successful elsewhere were relatively ineffective in this study.

Spotlight counts and (unbaited) soil plots were used to provide some indices of abundance of cats and dogs. The indices derived for cats were higher that the only previous estimate for Kakadu NP, and fell within the range of estimates from a range of areas around Australia (although notably lower than some sites with high abundance of rabbits, a principal prey item for cats elsewhere). Estimates for dingo/wild dog abundance, in at least some of the study sites here, were appreciably higher than comparable estimates from other locations in Australia. There was no significant relationship between the abundance of cats, dingoes and potential native mammal prey, but such non-significance may not have been unexpected given a relatively low number of sampled sites for this component of the study.

CONTENTS

1. INTRODUCTION

This report describes results from the third year of a project that focuses on the state of terrestrial vertebrate biodiversity in Kakadu National Park ("KNP"), and the development of a program that monitors that fauna.

Results from the first year of the project (2001-02) were detailed in Woinarski *et al.* (2002). These results are not re-presented in detail here. In summary, that report described:

- changes in the mammal fauna in the Mary River district ("Stage 3"), based on re-sampling during 2001 of 263 quadrats originally sampled between 1988-90. Of 18 native mammal species recorded from at least 10 quadrats in either or both sampling periods, five species showed significant decline (antilopine wallaroo, common planigale, Arnhem rock-rat, delicate mouse and lakeland downs mouse), whereas one species (northern brown bandicoot) showed significant increase. Two exotic species (water buffalo and cattle) declined significantly over this time period, and one (pig) increased significantly;
- a range of relationships between changes in abundance of individual mammal species over the period between 1988-90 and the fire history of the quadrats over that period;
- the baseline fauna sampling of 21 of the 135 previously established fire monitoring plots, as a contribution to an integrated fauna, flora and fire monitoring program for KNP;
- the survey of native mammal fauna in 12 large grids selected to represent lowland eucalypt forest that had been subjected to contrasting fire histories. Brushtail possums and black-footed tree-rats showed a pronounced association with infrequent but fine-scale fire, and the total native mammal fauna increased at sites subject to the most patchy fire regimes;
- the establishment of monitoring sites suitable for the assessment of the impacts upon terrestrial vertebrate fauna of the colonisation of cane toads; and
- the aggregation of diverse data sets relating to the occurrence of terrestrial vertebrate species in KNP.

Results from the second year of the project (2002-03) were detailed in Watson and Woinarski (2003). Again, these results are not re-presented in detail here. In summary, that report described:

- changes in the mammal fauna in the Mary River District of the Park from 2001 to 2002, as related to invasion of part of this area by cane toads. There were clear declines for some species, and in particular for the northern quoll;
- an assessment of the change in abundance of native mammals at the sole stone country site with prior explicit quantitative data (Little Nourlangie Rock *Nawurlandja*; which was sampled previously between 1977 and 1979). This study reported significant declines

for northern quolls, sandstone antechinus and Arnhem rock-rat, and for all mammals combined; but significant increase for common rock-rat;

- an assessment of the change in abundance of native mammals at a series of eucalypt forest and woodland sites originally sampled in the CSIRO Kakadu Stages 1&2 Fauna Survey of 1980 to 1983. This study reported no major change in mammal populations across these sites, with the possible exception of a slight decline for northern brown bandicoot;
- baseline sampling of a further 36 fire monitoring plots;
- an analysis of trends in the abundance of birds, reptiles and frogs in the 263 re-sampled quadrats of the Mary River district. This study reported relatively little directional change in the reptile, bird and frog faunas, with the most substantial change being the reduced abundance in 2001 of a set of irruptive bird species (including banded honeyeater, bar-breasted honeyeater, varied lorikeet and red-backed button-quail) that were abundant during the baseline sampling. Such change is presumed to be a cyclical response to climatic conditions and/or unusual flowering conditions, rather than indicative of long-term decline;
- compilation and archiving of all monitoring data. All accessible monitoring data was compiled and distributed as a CD;
- compilation of data bases describing the distribution of terrestrial vertebrate fauna in KNP.

Following on from that work, activities undertaken in 2003 comprised:

(i) continuation of a monitoring program (for terrestrial vertebrate fauna) which will contribute to the assessment of impacts of cane toads;
(ii) assessment of vertebrate fauna at existing fire monitoring plots (and hence establishment of baseline for ongoing monitoring of the impacts of fire upon fauna at these plots);
(iii) investigation of change in vertebrate (and especially mammal) species composition at sites sampled in historic surveys, notably in the north of the park;
(iv) surveys of rare and threatened plants and assessment of current status;
(v) investigation of censusing and trapping methods for feral cats and dingos;
(vi) training for Parks Australia staff in fauna survey through a field based training camp; and
(vii) compilation of data bases and GIS layers showing existing and current fauna records.

These activities are described in Sections 2 to 8 of this Report. Note that analysis and substantial documentation is not relevant for some activities undertaken during this year's project (e.g. ranger training and baseline sampling of fire plots); and that reports have already been provided elsewhere for some components of this work (surveys of threatened plants, and training camp).

The formal brief for the overall project is detailed in Appendix A.

Previous reports:

Watson, M., and Woinarski, J. (2003). *Vertebrate monitoring and resampling in Kakadu National Park, 2002*. Report to Parks Australia North. (Parks and Wildlife Commission of the Northern Territory: Darwin.)

Woinarski, J., Watson, M., and Gambold, N. (2002). *Vertebrate monitoring and resampling in Kakadu National Park*. Report to Parks Australia North. (Parks and Wildlife Commission of the Northern Territory: Darwin.)

2. CONTINUATION OF A MONITORING PROGRAM THAT WILL CONTRIBUTE TO THE ASSESSMENT OF IMPACTS OF CANE TOADS

No specific sampling was undertaken within this project during 2003-04 designed specifically to measure the impacts upon wildlife of the arrival of cane toads. However, the fauna in a large number of plots was sampled, and this sampling will contribute to subsequent assessment of cane toad impacts. This sampling included:

(i) 14 fire plots in lowland areas (September-October 2003) (all in sites not yet invaded by cane toads);
(ii) 30 fire plots in stone country in the Mary River and Jim Jim Districts (February 2004) (all in sites invaded by cane toads);
(iii) an additional 26 quadrats sampled at the same time as, and within 500 m of, the above set (all in sites invaded by cane toads);
(iv) a set of 40 sites sampled around Jabiluka (August-September 2003) (all in sites not yet invaded by cane toads); and
(v) a large grid and 5 quadrats around Gunlom (September 2003) (invaded by cane toads).

Systematic analyses of the impacts of cane toads upon terrestrial vertebrate fauna would require repeat sampling of some of these (and/or the now numerous other) quadrats.

However, one less precise and relatively weak assessment of impacts can be provided by comparing the stone country sampling (ii and iii above) undertaken in toad-invaded areas in February 2003, with analogous sampling undertaken (before toad arrival) of 13 stone country fire plots in the East Alligator and Nourlangie Districts in June 2003. This analysis is weak because of (a) there were few plots in the pre-toad sample, (b) the time of year was different, and (c) the locations differ (although the environments were comparable).

A total of 193 vertebrate species were recorded in these two sampling episodes. Of these, 15 were recorded in the June 2003 samples but not in the February 2004 samples, and 87 were recorded in the February 2004 samples but not in the (far fewer) June 2003 samples. The proportion of samples in which species were recorded differed significantly between the two sample groups for 21 species (Table 2.1). Of these species, most were recorded in a higher proportion of quadrats in the first sample. Many of the observed differences are probably attributable to seasonal differences (such as frogs being more abundant and active in the wet season sample, whereas some bird species are dry season migrants to Kakadu). The study design used in our previous report (the repeat sampling (at the same time of year) of plots in the Mary River District before and after cane toad arrival) provides a more robust assessment of toad impacts than the opportunistic comparison summarised in Table 2.1. Nonetheless, the currently considered data are consistent in recognising a significant (post-toad arrival) decline for northern quoll. These data also provide some suggestion for decline in sandstone antechinus and black-footed rock-monitor, but the sample size for these is low, and both were still present in toad-invaded areas. In general, there were too few records in either pre- or post-toad invasion for testing for snake and goanna (other than black-footed rock monitor) species.

Table 2.1. Species recorded from significantly different proportion of sampled quadrats between June 2003 (pre-toad, East Alligator & Nourlangie) and February 2004 (post-toad, Jim Jim and Mary River) sandstone fire plots. Significance tested with Fisher exact test. Species marked in red were recorded at a higher proportion of sites in the first sample; species marked in blue were more frequent in the second sample.

species	no. sites from which recorded in 2003 (out of total possible 13)	no. sites from which recorded in 2003 (out of total possible 56)	prob.	possible reason
cane toad *Bufo marinus*	0	34	<0.0001	invasion; season
masked frog *Litoria personata*	0	14	0.035	season
carpenter frog *Megistolotis lignarius*	0	14	0.035	season
sandstone toadlet *Uperoleia arenicola*	0	18	0.011	season
black-footed rock-monitor *Varanus glebopalma*	5	4	0.0092	
bynoe's gecko *Heteronotia binoei*	4	4	0.036	
green-backed gerygone *Gerygone chloronata*	3	4	0.0203	
leaden flycatcher *Myiagra rubecula*	5	4	0.0092	season
little wood-swallow *Artamus minor*	7	3	0.0001	?season
rainbow bee-eater *Merops ornatus*	9	1	<0.00001	season
red-tailed black-cockatoo *Calyptorhynchus banksii*	3	1	0.0194	?season
rufous whistler *Pachycephala rufiventris*	5	7	0.041	season
sandstone shrike-thrush *Colluricincla woodwardi*	7	11	0.0178	
striated pardalote *Pardalotus striatus*	9	20	0.0296	season
whistling kite *Haliastur sphenurus*	3	2	0.0429	season
white-lined honeyeater *Meliphaga albilineata*	10	23	0.0206	
wedge-tailed eagle *Aquila audax*	3	1	0.0194	
northern brown bandicoot *Isoodon macrourus*	2	0	0.034	
northern quoll *Dasyurus hallucatus*	3	0	0.0055	
sandstone antechinus *Pseudantechinus bilarni*	3	2	0.0429	
black flying-fox *Pteropus alecto*	5	1	0.0006	?season

3. BASELINE SURVEY OF VERTEBRATES AT FIRE MONITORING PLOTS

Over the period July 2003 to June 2004, a total of 44 fire monitoring plots were sampled (for the first time) for vertebrate fauna. This sampling was undertaken in two episodes: (1) a set of lowland sites in the late dry season of 2003; and (2) a set of sandstone plots in the wet season of early 2004. The latter sampling was designed to coordinate with the scheduled sampling of vegetation at these fire plots. More fire plots were sampled in 2003/04 than for any other year of sampling (Table 3.1).

Table 3.1. Number of fire plots sampled for fauna, per year.

Year	no. plots baseline sampled	no. plots re-sampled	cumulative no. of plots sampled
1995/96	15	0	15
2000/01	5	15	20
2001/02	36	0	56
2002/03	14	0	70
2003/04	44	0	114

This 2003/04 sampling brings the tally of fire plots sampled to 114, from a total of the 134 fire plots established. As indicated in our previous report (Watson and Woinarski 2003), the 2003/04 sampling redresses the main previous sampling bias, of relatively sparse representation of sandstone fire plots. The distribution of sampled and unsampled fire plots, by district, by broad habitat type and by sampling date, are summarised in Figures 3.2 to 3.4. Details of site visits are summarised in Table 3.5.

Table 3.2. Number of fire plots sampled for fauna, by District

District	No. of plots sampled to date	% plots sampled to date
East Alligator	23	82.1%
Jim Jim	23	79.3%
Mary River	28	93.3%
Nourlangie	18	90%
South Alligator	22	81.5%

Fire plots have been sampled relatively evenly across Districts. The remaining unsampled fire plots are mainly in remote lowland sites.

Fire plots in different vegetation types have also been reasonably evenly sampled, with the minimum sampling percentage being 64% of plots in lowland rainforest. All sandstone heath plots have now been sampled for fauna.

Table 3.3. Number of fire plots sampled for fauna, by vegetation type

District	No. of plots sampled to date	% plots sampled to date
floodplain	8	66.7%
lowland open forest	29	85.3%
lowland rainforest	7	63.6%
lowland woodland	18	78.3%
sandstone heath	31	100%
sandstone woodland	21	91.3%

Sampling has occurred mainly in the mid-late wet season (February), mostly in order to tie in with the scheduled floristic surveys occurring then. Many plots have also been sampled in June. No plots have been sampled in the late Dry season to early Wet season months (November-January), because conditions then place exceptional stress on captured animals, and because site access then may also be compromised.

Table 3.4. Number of fire plots sampled for fauna, by month of baseline sampling

month	No. of plots sampled
January	0
February	49
March	4
April	4
May	2
June	37
July	1
August	1
September	8
October	8
November	0
December	0

A summary table of all fauna records in all sampled fire plots is attached in the accompanying CD.

A total of 250 vertebrate species (comprising 26 frogs, 59 reptiles, 119 birds and 46 mammals) have now been recorded from the fire plots. The species found in the most plots are: mistletoebird (66 plots); *Carlia amax* (62); weebill (59); brown honeyeater (58); white-throated honeyeater (56); white-bellied cuckoo-shrike (51); bar-shouldered dove (50); peaceful dove (48); striated pardalote (42); rufous whistler (38); silver-crowned friarbird, northern quoll, blue-winged kookaburra (36); rainbow lorikeet (32); *Ctenotus inornatus* (31); northern fantail (30); rainbow bee-eater (29); northern brown bandicoot (28); helmeted friarbird, great bowerbird, *Cryptoblepharus plagiocephalus* (27); red-backed fairy-wren, *Heteronotia binoei*, *Carlia munda* (26); spangled drongo, torresian crow, pale field-rat (25); sulphur-crested cockatoo (24); red-winged parrot, common rock-rat (22); forest kingfisher, dusky honeyeater, fawn antechinus (21); and *Limnodynastes ornatus*, *Bufo marinus*, *Diporiphora bilineata*, willie wagtail and pied butcherbird (20) (note that these tallies include the 15 fire plots that were sampled twice, making for a total possible 129 sample sites).

Table 3.5. Summary table of fire plots, and dates at which these have been sampled for vertebrates.

plot no.	habitat1	habitat2	district	baseline sample date	any re-sample date
1	lowland woodland	lowland jungle/riparian woodland	SA		
2	lowland open forest	lowland woodland	SA		
3	lowland woodland	riparian woodland	MR	18-Mar-01	
4	sandstone woodland	sandstone woodland	NO	12-Apr-02	
5	lowland woodland	lowland jungle	MR	01-Feb-96	26-Feb-01
6	lowland woodland	lowland woodland/cycads	MR	27-Feb-04	
7	lowland open forest	sandstone woodland	EA	20-Jun-02	
8	lowland woodland	lowland jungle	MR	27-Sep-03	
9	sandstone woodland	riparian open forest	MR	01-Feb-96	24-Feb-01
10	lowland woodland	paperbark woodland	MR	01-Feb-96	27-Feb-01
11	sandstone woodland	sandstone open forest/callitris	MR	26-Feb-01	
12	lowland woodland	lowland woodland	MR	26-Sep-03	
13	lowland open forest	lowland open forest	NO	06-May-02	
14	sandstone woodland	sandstone open forest	MR	28-Feb-04	
15	sandstone woodland	acacia woodland	MR	01-Feb-96	22-Feb-01
16	lowland woodland	lowland woodland	SA	05-Jun-02	
17	lowland woodland	paperbark woodland	MR		
18	lowland open forest	lowland woodland	JJ	01-Feb-96	22-Mar-01
19	lowland woodland	sandstone woodland	MR	28-Sep-03	
20	sandstone woodland	sandstone open forest/callitris	MR		
21	lowland woodland	riparian woodland	SA	01-Jun-02	
22	lowland open forest	lowland jungle/callitris	SA	07-Oct-03	
23	lowland woodland	riparian open forest	MR	18-Mar-01	
24	lowland rainforest	lowland jungle	SA	13-Feb-02	
25	sandstone heath	sandstone woodland	MR	17-Mar-01	
26	sandstone heath	sandstone woodland	JJ	26-Feb-04	
27	sandstone heath	dry heath	MR	25-Feb-04	
28	lowland open forest	sandstone woodland	EA	28-Jun-02	
29	sandstone heath	dry heath	JJ	18-Feb-04	
30	lowland open forest	lowland woodland	JJ	01-Feb-96	21-Mar-01
31	sandstone heath	dry heath	MR	01-Feb-96	26-Feb-01
32	lowland woodland	lowland woodland	MR	26-Sep-03	
33	lowland open forest	sandstone woodland	MR	01-Feb-96	24-Feb-01
34	lowland woodland	lowland open forest	MR	23-Feb-04	
36	lowland woodland	lowland woodland	MR	01-Feb-96	25-Feb-01
37	lowland woodland	lowland woodland	MR	01-Feb-96	26-Feb-01
38	lowland open forest	lowland open forest	JJ	01-Feb-96	22-Mar-01
39	sandstone woodland	escarpment jungle/sandstone open forest	JJ	20-Feb-04	
40	lowland woodland	riparian woodland	MR	23-Feb-04	
41	sandstone woodland	sandstone woodland/callitris	MR	01-Feb-96	24-Feb-01
42	lowland open forest	lowland open forest	SA	03-Jun-02	
43	lowland open forest	lowland open forest	JJ	01-Feb-96	21-Mar-01
44	lowland open forest	lowland woodland	JJ	01-Feb-96	22-Mar-01
46	sandstone heath	escarpment jungle/callitris	JJ	22-Feb-04	
47	sandstone heath	dry heath	JJ	22-Feb-04	
48	lowland open forest	lowland open forest/callitris	JJ	01-Feb-96	21-Mar-01

plot no.	habitat1	habitat2	district	baseline sample date	any re-sample date
60	sandstone woodland	sandstone woodland	JJ	04-Jul-01	
61	sandstone heath	escarpment jungle/callitris	JJ	16-Feb-04	
62	sandstone woodland	riparian open forest	JJ	20-Feb-04	
63	sandstone heath	sandstone woodland/callitris	JJ	19-Feb-04	
64	sandstone heath	dry heath	JJ	17-Feb-04	
65	sandstone heath	wet heath/callitris	JJ	21-Feb-04	
66	sandstone heath	wet heath	JJ	16-Feb-04	
67	sandstone heath	sandstone woodland/callitris	JJ	22-Feb-04	
68	lowland open forest	lowland woodland/riparian open forest	JJ	22-Feb-04	
69	sandstone woodland	escarpment jungle/callitris	JJ	24-Feb-04	
70	lowland woodland	lowland jungle	MR	17-Sep-03	
71	lowland open forest	lowland open forest	SA	06-Sep-02	
72	lowland open forest	lowland open forest	SA	06-Sep-02	
73	lowland open forest	lowland open forest	SA	10-Jun-02	
74	lowland open forest	lowland open forest	SA	05-Jun-02	
75	lowland open forest	lowland woodland	JJ		
76	sandstone woodland	lowland woodland	JJ		
77	sandstone woodland	sandstone woodland/callitris	JJ	24-Feb-04	
79	lowland open forest	lowland open forest	SA	02-Jun-02	
80	lowland rainforest	lowland jungle	SA	09-Oct-03	
81	lowland woodland	riparian woodland	SA	01-Jun-02	
82	lowland open forest	lowland open forest	SA		
84	lowland open forest	lowland open forest	SA	15-Oct-03	
85	lowland rainforest	lowland jungle	EA	26-Jun-02	
86	lowland open forest	lowland open forest	SA	17-Sep-03	
87	lowland rainforest	lowland jungle	SA	13-Feb-02	
88	lowland rainforest	lowland jungle	EA		
89	floodplain	riparian woodland	EA		
90	lowland rainforest	lowland jungle	EA		
92	lowland open forest	lowland open forest	EA	20-Jun-02	
93	sandstone heath	dry heath	EA	26-Jun-02	
94	lowland open forest	lowland woodland	EA	26-Jun-02	
95	lowland woodland	lowland woodland	SA		
96	lowland open forest	lowland jungle	SA	08-Aug-01	
97	lowland open forest	lowland open forest	EA		
98	lowland open forest	lowland open forest	SA	15-Oct-03	
99	sandstone heath	dry heath	EA	26-Jun-02	
100	lowland open forest	lowland woodland	JJ	22-Mar-01	
110	lowland open forest	lowland woodland	NO		
111	lowland woodland	lowland woodland	EA	17-Jun-02	
112	sandstone heath	dry heath	EA	12-Jun-03	
113	floodplain	open floodplain/paperbark open forest	SA	17-Oct-03	
114	floodplain	open floodplain	SA	13-Feb-02	
115	lowland rainforest	lowland jungle	EA		
116	lowland woodland	riparian woodland	NO		
117	lowland open forest	escarpment jungle	EA	11-Jun-03	
118	lowland rainforest	riparian open forest/lowland jungle	EA	24-Jun-02	
119	floodplain	paperbark open forest	EA	27-Jun-02	
120	sandstone woodland	escarpment jungle	MR	26-Feb-04	
121	sandstone heath	wet heath	NO	18-Feb-04	
122	floodplain	paperbark open forest	EA	17-Jun-02	
123	sandstone heath	sandstone woodland	NO	13-Jun-03	
124	floodplain	riparian woodland	JJ		
125	sandstone heath	escarpment jungle/dry heath	MR	25-Feb-04	
126	sandstone woodland	escarpment jungle/callitris	NO	18-Feb-04	
127	lowland rainforest	lowland jungle	JJ		
128	sandstone heath	escarpment jungle/dry heath	MR	28-Feb-04	

plot no.	habitat1	habitat2	district	baseline sample date	any re-sample date
130	floodplain	open floodplain	SA	14-Oct-03	
131	sandstone woodland	escarpment jungle/callitris	NO	14-Jun-03	
132	sandstone heath	riparian open forest	NO	13-Jun-03	
133	sandstone heath	escarpment jungle/dry heath	MR	27-Feb-04	
134	sandstone woodland	callitris	MR	28-Feb-04	
135	floodplain	paperbark open forest	SA	10-Oct-03	
136	lowland open forest	callitris	NO	29-Feb-04	
137	sandstone heath	wet heath	EA	11-Jun-03	
138	sandstone heath	wet heath	NO	12-Apr-02	
139	sandstone heath	dry heath	NO	14-Jun-03	
140	sandstone heath	escarpment jungle	NO	20-Feb-04	
141	lowland rainforest	open floodplain/lowland jungle	EA	23-Jun-02	
142	sandstone woodland	escarpment jungle/sandstone open forest	EA	11-Jun-03	
143	sandstone woodland	escarpment jungle/callitris	EA	12-Jun-03	
144	sandstone heath	escarpment jungle/callitris/dry heath	NO	12-Jun-03	
145	floodplain	open floodplain/paperbark open forest	JJ		
146	lowland woodland	lowland woodland	SA		
147	sandstone heath	dry heath	NO	12-Apr-02	
148	floodplain	paperbark open forest	SA	17-Oct-03	
149	lowland open forest	lowland open forest	EA	26-Jun-02	
150	sandstone heath	escarpment jungle/dry heath	NO	14-Jun-03	
151	floodplain	riparian woodland	JJ		
152	lowland open forest	lowland woodland	NO	06-May-02	
153	sandstone heath	escarpment jungle/dry heath	NO	16-Feb-04	
154	sandstone woodland	escarpment jungle	NO	15-Jun-03	
155	lowland rainforest	open floodplain/lowland jungle	EA	23-Jun-02	
156	floodplain	riparian woodland	EA	26-Jun-02	
157	sandstone woodland	lowland open forest/callitris	NO	12-Apr-02	
201	sandstone woodland	escarpment jungle	EA	20-Jun-02	
202	sandstone heath	escarpment jungle	EA	17-Jun-02	
203	sandstone woodland	sandstone woodland	EA	19-Jun-02	

4. INVESTIGATION OF CHANGE IN VERTEBRATE (ESPECIALLY MAMMAL) SPECIES COMPOSITION AT SITES SAMPLED IN HISTORIC SURVEYS: a. Jabiluka

Introduction

A detailed study of the mammal fauna of the Jabiluka Mining Lease was carried out by Anne Kerle between July 1979 and September 1981 (Kerle 1983; Kerle and Burgman 1984). Three major landform types are present within the lease area:

- the Djawamba Massif (a large outlier of the Arnhem Land Plateau);
- part of the Magela Creek floodplain; and
- lowland areas consisting of undulating plains and small rocky outcrops (Kerle 1983; Kerle and Burgman 1984).

During the original survey a total of 18 sites (some including a number of sub-sites) were selected to represent the range of vegetation types present in each of the three landforms. All sites were encompassed within an area of about 120 km^2.

In August and September 2003, 15 of the original 18 sites were re-surveyed in an effort to investigate the current status of small mammals on the lease area. The remaining three sites were not re-sampled due to restrictions on access and/or problems with re-location. Sites were relocated using detailed archival information and a map provided by Anne Kerle from the original survey. All sites were re-sampled at the same time of year (plus or minus six weeks) in an attempt to minimise any seasonal influences on trapping results.

Fire events were identified as a potential determinant of mammal populations during the original survey of the Jabiluka lease (Kerle 1983; Kerle and Burgman 1984) and by other mammal studies in the region (Begg *et al.* 1981; Friend and Taylor 1985; Kerle 1985; Woinarski *et al.* 2001; Pardon *et al.* 2003). Consequently, in this study, relationships between a range of fire history parameters and changes in mammal populations were investigated.

Although the cane toad (*Bufo marinus*) had been present in parts of Kakadu National Park, at the time of the re-sampling it was not known to have reached the survey sites on the Jabiluka lease.

Methods

<u>Baseline</u>

Kerle (1983) and Kerle and Burgman (1984) provide a map and description of the 18 survey sites and methods adopted during the original survey. This is summarised briefly below. The mammal fauna of the Jabiluka Mining Lease was surveyed during six visits to the area between July 1979 and September 1981 (15 July – 30 September 1979, 18 February – 16 March 1980, 26 May – 13 June 1980, 25 August – 27 September 1980, 5 November – 12 December 1980 and 26 July – 19 September 1981). Fourteen sites were established in 1979 with a further two sites added in each of September and November 1980. The 18 sites were distributed between the three major landform units present within the mining lease (Fig. 4.1).

At each sub-site between 80 and 100 small Elliott traps were set in four or five rows with approximately 20m between traps. A wire cage trap (either bandicoot or possum sized) was placed adjacent to every fifth Elliott trap. The traps were not placed in set grid patterns, the researchers instead opting to arrange the traps according to the mosaic of habitats present within the vicinity of each trapping site. Trapping was carried out over a 3 night period at each site. Trap success rate (expressed as a percentage) at each trap site (or sub-sites where appropriate) was used as an index of the relative abundance of each species and to examine differences in population size between trapping periods. The number and time of fires was recorded during the study period.

Pitfall trapping was occasionally carried out during the first year of the original study. In these instances, six pits consisting of 50cm x 20cm tins were evenly spaced along a 50m x 30cm drift fence.

2003 Re-sampling.

Fifteen of the original 18 sites were re-sampled during August and September 2003 (Table 4.1 and Figure 4.1). The number and arrangement of traps in 2003 replicated as closely as possible the descriptions provided by the original researchers. However, in 2003 only possum sized cage traps were used, rather than a mix of "possum" and "bandicoot" sized cage traps. Since both of these trap types are used to target the larger mammal species found at these sites (e.g. northern brown bandicoots, northern brushtail possums, black-footed tree-rats and northern quolls) it is unlikely that this slight difference in equipment will affect trap success. Traps were laid out as described in archival information provided by Anne Kerle. As with the original survey, each site was trapped for three consecutive nights using a bait mixture of honey, rolled oats and peanut butter. Pitfall traps were not used during the 2003 re-sample. Large mammals (e.g. macropods, dingoes and feral ungulates) were recorded in both sampling periods by incidental day-time observations.

Analysis.

Changes in the native mammal fauna on the Jabiluka lease were determined by comparing the number of each species and the total number of native mammals caught at each subsite during the original survey and the 2003 re-sample. Wilcoxon Matched-Pairs tests were used to make these comparisons. Wherever possible, the 2003 sampling data were compared to that collected from the final dry season sampling of the original study (i.e. July – September 1981). However, some sub-sites were not surveyed at this time so comparisons were made with earlier data (see Table 4.1 for dates).

Changes in abundance of native mammals at the Jabiluka site were related to habitat type and fire history for each sub-site. All sub-sites were assigned to one of five broad habitat types: riparian woodland, sandstone woodland, mixed eucalypt woodland, closed forest and floodplain fringe (as identified in the original study). For each species, the extent of change between the two sampling periods was compared across the five habitat types using one-way analysis of variance. Fire history parameters for each of the sub-sites were calculated using the library of interpreted satellite imagery for Kakadu National Park. Fire history data is based on fine resolution Landsat-TM imagery (pixel size 0.06ha) for the period 1996-2003, and coarser Landsat-MSS imagery (pixel size 0.5ha) for the period 1982-1995. For each year between 1982 and 2003, each sub-site was scored as burnt or unburnt over the early dry season (May-July) and late dry season (August-November). From these data, summary fire parameters were calculated for each sub-site. These parameters were:

- The total number of fires for the period 1982-2003 (Tfire 82-03)
- The number of late dry season fires between 1982-2003 (Lfire 82-03)
- The interval between the 2003 resample and the last fire. (TSB – total)
- The interval between the 2003 resample and the last late dry season fire (TSB – late)

Given the greatly improved precision of the Landsat-TM imagery, separate parameters were calculated for the 1996-2003 period. These parameters were the total number of fires (Tfire 96-03) and the number of late dry season fires (Lfire 96-03). Generalised linear modelling was used to investigate the relationship between these fire parameters and observed changes in mammal populations.

Figure 4.1. Location of sampling sites at Jabiluka lease.

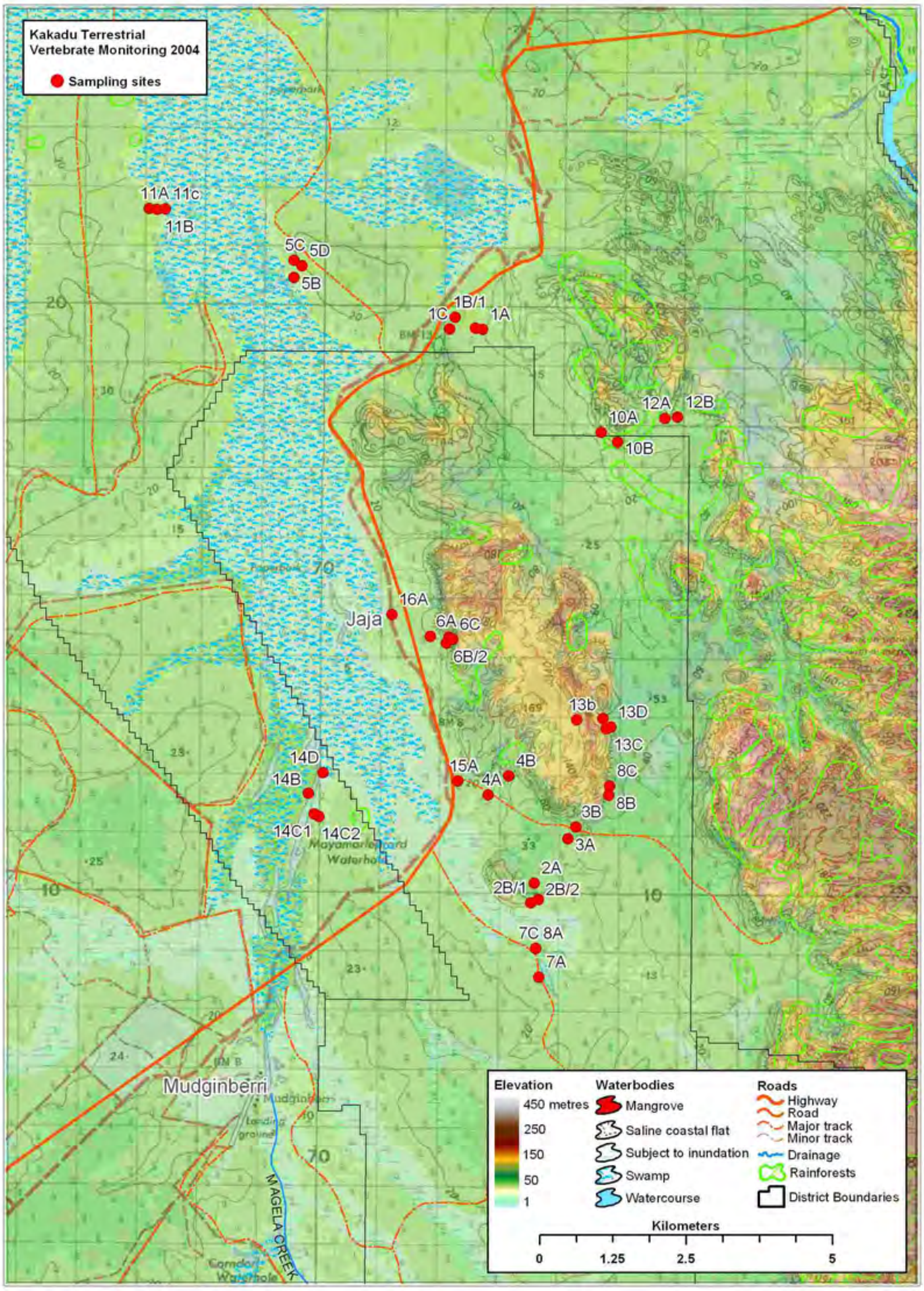


Table 4.1. Location and sampling time of fauna survey sites, Jabiluka Mining Lease

site	*name*	*baseline sampling*		*repeat sampling*	
		Sub-site	*date*	*Sub-site*	*date*
1	Anthill Drive (3 Pools Track)	A, B/1, B/2 & C	27-30 July 1981	A, B/1, B/2 & C	6-9 August 2003
2	Winmurra Hill	A, B/1 & B/2	5-8 August 1981	A, B/1 & B/2	18-21 August 2003
3	South-Eastern Corner of Djawamba Massif	A & B	30 July – 2 August 1981	A & B	9-12 September 2003
4	Burnt Truck Creek	A & B	2-5 August 1981	A	9-12 September 2003
				B	10-13 September 2003
5	Jabiluka Billabong	A, B, C & D	12-14 August 1981	A	Flooded, no re-sample at subsite A
				B, C & D	19-22 September 2003
6	Between Djarr Djarr Camp and Djawamba Massif	A, B/1, B/2 & C	15-17 August & 15-16 September 1981	A, B/1, B/2 & C	19-22 September 2003
7	Hades Flat, 7J Creek and Winmurra Billabong	A B C	21-23 August 1981 29-31 August 1979	A B C	19-21 August 2003 Not trapped 29-31 August 2003
8	Eastern side of Djawamba Massif	A, B & C	2 – 4 September 1979	A, B & C	6-9 September 2003
9	Jabiluka Hill (Mine Valley)				Access restrictions, no re-sample
10	Swift Creek (Rock Gate Area)	A & B	26 – 29 August 1981	A & B	15-18 September 2003
11	Magela Point	A B & C	8-11 September 1981 16-19 September 1979	A, B & C	22-25 September 2003
12	Between Rock Gate and Rock Pools (3 Pools Track)	A & B	16-19 September 1979	A & B	15-18 September 2003
13	Rock "Jump-Up", Eastern side of Djawamba Massif	A, B, C & D	21-24 September 1979	A, B, C & D	5-8 September 2003
14	Island Billabong	B, C1 & D C2	24-26 September 1979 5-8 August 1981	A B, C1, C2 & D	Flooded, no re-sample at subsite A 29 August – 1 September 2003
15	Borrow Pits adjacent to Burnt Truck Creek	A	2-5 August 1981	A	18-21 August 2003
16	Riparian woodland adjacent to Djarr Djarr Camp	A	14-18 August 1981	A	18-21 August 2003
17	Leichhardt Billabong	A		A	Flooded, no re-sample
18	Lonely Rocks (near Anthill Drive)	A		A	Access restrictions, no re-sample

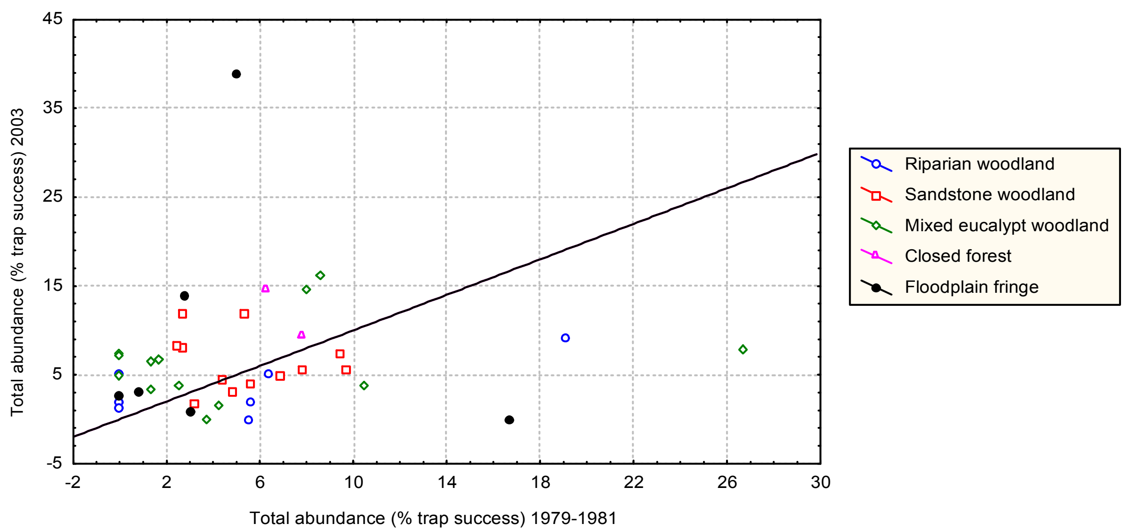
Results

Patterns of change in mammal populations

Between 1979-1981 and 2003, the total abundance and species richness of native mammals at the Jabiluka sites increased by 16.5% and 25.7% respectively. While neither of these increases was statistically significant, that for species richness approached significance (p=0.07).

Overall, the pattern of change in native mammal abundance was variable with some sites showing increases while others decreased (Figure 4.2). The most dramatic increase occurred at Site 16 where large numbers of Northern Brown Bandicoots and Pale Field Rats were recorded in 2003. Conversely, at Site 11 the dramatic decrease in native mammal abundance was a result of only seven Northern Brushtail Possums being recorded in 2003, compared to 63 in 1981. Overall, slightly more sites showed an increase (21) than decrease (17) in total mammal abundance between 1979-1981 and 2003.

Figure 4. 2. Total abundance (% trap success) of native mammals at Jabiluka survey sites sampled in both 1979-1981 and 2003.



Changes for individual mammal species and the native mammal fauna as a whole, are summarised in Table 4.2. Of nine native mammal species recorded in at least five sub-sites from the combined 1979-1981 and 2003 sampling, the abundance of three species (Northern Quoll, Pale Field Rat and Northern Brown Bandicoot) increased significantly and one species (Sandstone Antechinus) declined significantly. Two other species (Arnhem Rock Rat and Northern Brushtail Possum) showed a strong trend for decline, though this was not quite statistically significant.

Four species that were not recorded in the original study were recorded in 2003 (Fawn Antechinus, Black Wallaroo, Black-Footed Tree-rat and Pale Field-rat) although, with the exception of the Pale Field-rat, there were only a small number of records for these species. Conversely, two species (Water Rat and Short-Eared Rock-wallaby) were recorded in the original survey but not in 2003. Again there were only a few records of these species so no conclusion can be drawn from their absence in the 2003 re-sample.

Correlates of change: habitat

Of the six species that were recorded in 10 or more sub-sites, only one showed significant variation across the five habitat types in the pattern of its change in abundance (Table 4.3). The Northern Brown Bandicoot increased in all habitat types, but the extent of this increase was significantly greater in the floodplain fringe habitat ($F=11.7$, $p=0.001$). The total number of mammals decreased in riparian woodland and mixed eucalypt woodland but increased in the remaining three habitats (Table 4.3; Fig. 4.2).

Correlates of change: fire history

The Jabiluka survey sites have had a variable range of fire histories over the 22 years between baseline and subsequent sampling. These fire histories are summarised in Fig. 4.3. The maximum number of times any of the sub-sites was burnt between 1982 and 2003 was 14. No sub-sites remained unburnt for the entire period, although one site had only one fire and a number of others had fewer than five fires. Late dry season fires were relatively uncommon between 1982 and 2003, with no sites having more than six late dry season fires. This extent of late dry season fires is low relative to that typical for the Park as a whole (e.g. Turner *et al.* 2002). The longest time since any of the sub-sites was last burnt was five years, with the majority of sub-sites having an interval of two years between the 2003 resample and the last fire. The time since the last late dry season fire at the majority of sub-sites was five years, however this ranged from 0 to 13 years.

Of the six native species with sufficient records for modelling, four had significant relationships with the calculated fire history parameters. The generalised linear models for these species, the total mammal abundance and number of species are summarised in Table 4.4. There was no significant model for the Common rock-rat, Sandstone antechinus, or number of species. In summary, the significant relationships for the other four species and total mammal abundance were:

- **Northern brown bandicoot** became less abundant at sites with increasing time since the last fire.
- **Grassland melomys** became more abundant at sites with increasing time since fire but also showed a positive relationship with more frequent fires.
- **Arnhem rock-rat** became more abundant at sites with more frequent fires between 1996 and 2003.
- **Northern quoll** became less abundant at sites with a longer time since the last late dry season fire and also less abundant with more fires between 1996 and 2003.
- **Total mammal abundance** increased with more fires between 1996 and 2003 and, somewhat confusingly also showed a positive relationship with increasing time since the last fire.

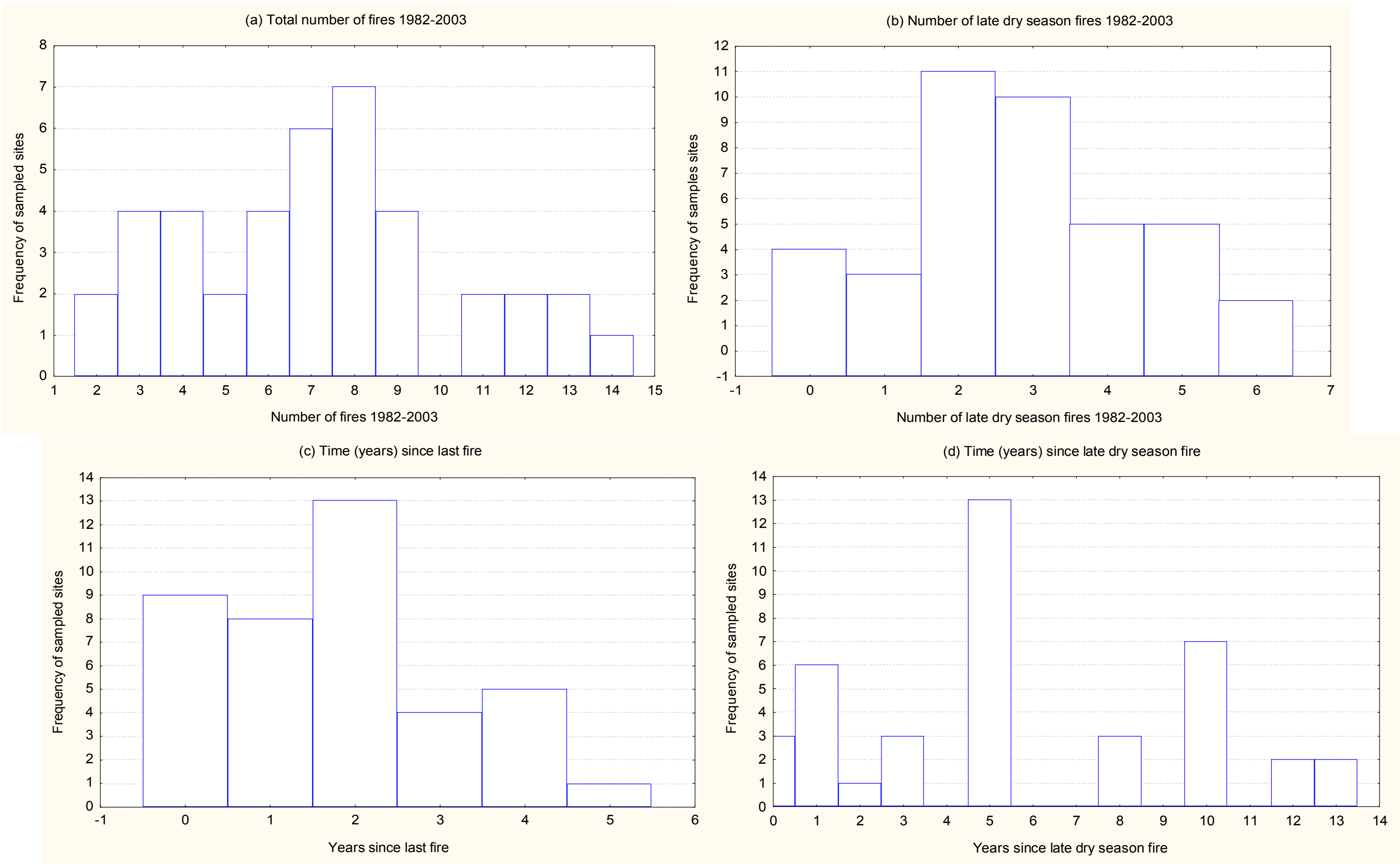
Table 4.2. Change in mammal abundance over the period 1979-2003, across the 40 sub-sites re-sampled on the Jabiluka Mining Lease. Species in red font denote significant change in abundance; species in blue font indicate change in abundance with a p level between 0.1 and 0.05.

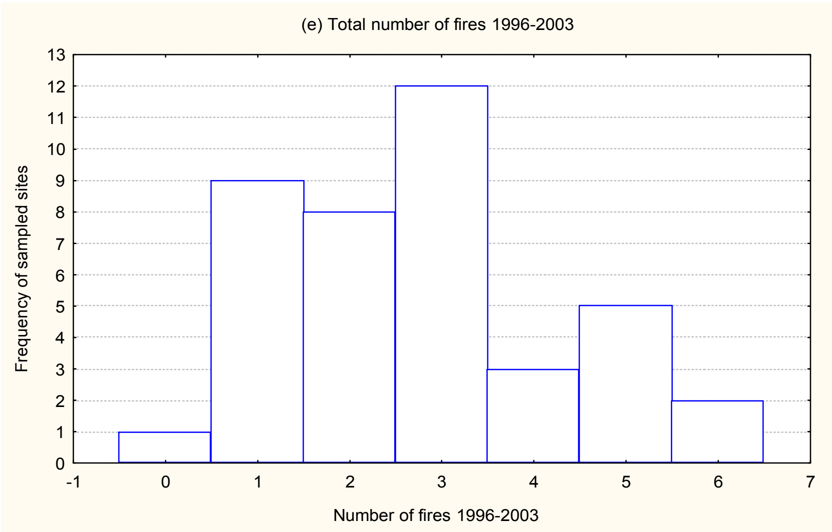
Species	1979-1981 sampling		2003 Resampling		z-score	Prob.	Trend
	No. of sub-sites in which recorded	*Mean abundance across all sub-sites*	*No. of sub-sites in which recorded*	*Mean abundance across all sub-sites*			
Dasyurids							
Northern Quoll *Dasyurus hallucatus*	11	0.6	23	1.6	2.53	0.01	Increase
Fawn Antechinus *Antechinus bellus*	0	0.000	2	0.08	-	-	
Sandstone Antechinus *Pseudantechinus bilarni*	8	0.4	3	0.10	2.20	0.03	Decline
Red-cheeked Dunnart *Sminthopsis virginiae*	2	0.05	1	0.03	-	-	
Macropods							
Black Wallaroo *Macropus bernardus*	0	0.000	2	0.05	-	-	
Short-eared Rock Wallaby *Petrogale brachyotis*	2	0.05	0	0.000	-	-	
Rodents							
Black-footed Tree-rat *Mesembriomys gouldii*	0	0.000	3	0.10	1.60	0.11	
Water Rat *Hydromys chrysogaster*	1	0.03	0	0.000	-	-	
Pale Field-rat *Rattus tunneyi*	0	0.000	7	0.93	2.37	0.02	Increase
Grassland Melomys *M. burtoni*	10	1.68	8	0.55	1.54	0.12	
Common Rock-rat *Zyzomys maini*	12	0.9	14	1.63	1.02	0.31	
Arnhem Rock-rat *Z. maini*	7	0.48	3	0.15	1.75	0.08	
Western Chestnut Mouse *Pseudomys nanus*	3	0.35	1	0.03	1.28	0.20	
Delicate Mouse *P. delicatulus*	4	0.15	3	0.15	0.00	1.00	
Others							
Northern Brown Bandicoot *Isoodon macrourus*	6	0.33	14	2.58	3.12	0.002	Increase
Brushtail Possum *Trichosurus vulpecula*	4	1.98	3	0.15	1.75	0.08	
Total Native Mammals							
Abundance		6.95		8.10	1.00	0.32	
No. of species		1.75		2.2	1.82	0.07	Increase

Table 4.3. Variation among habitats in change of abundance between the sampling periods of 1979-1981 and 2003. Negative values indicate decline. Only species recorded from 10 or more sub-sites during the combined sampling period are listed. Values in brackets are number of sub-sites from which recorded.

species	**habitat**					F	*p*
	Riparian Woodland	*Sandstone Woodland*	*Mixed Eucalypt Woodland*	*Closed Forest*	*Floodplain Fringe*		
Dasyurids							
Northern quoll	2.0 (5)	1.13 (8)	1.0 (9)	3.0 (1)	-1.0 (1)	0.52	0.72
Sandstone antechinus	- (0)	-1.33 (3)	- (0)	-3.0 (2)	- (0)	3.75	0.15
Rodents							
Grassland melomys	-8.75 (4)	1.0 (1)	-1.67 (3)	- (0)	0.4 (5)	1.02	0.43
Common rock-rat	-3.0 (1)	0.00 (11)	1.25 (4)	4.5 (2)	- (0)	1.47	0.26
Arnhem rock-rat	- (0)	-1.17 (6)	- (0)	-3.0 (2)	- (0)	0.98	0.36
Other native mammals							
Northern brown bandicoot	4.0 (2)	1.75 (4)	6.5 (6)	1.0 (1)	36 (1)	11.74	0.001
Total native mammals							
Abundance	-2.86 (7)	1.5 (12)	-1.15 (13)	5.0 (2)	10.83 (6)	1.09	0.38
No. of species	1.0 (7)	0.42 (12)	0.62 (13)	0 (2)	0 (6)	0.55	0.70

Figure 4.3. Summary of fire histories of the re-sampled sub-sites on Jabiluka Lease, over the period 1982-2003. Histograms show the number of sub-sites within each value for each of four fire parameters: (a) the total number of years in which the sub-site was burnt: (b) the number of late dry season fires: (c) the number of years elapsed since the last fire, at the time of re-sampling (2003): (d) the number of years since the last late dry season fire: (e) total number of fires 1996 – 2002: and (f) number of late dry season fires 1996-2002.




(e) Total number of fires 1996-2003
Frequency of sampled sites
Number of fires 1996-2003
13
12
11
10
9
8
7
6
5
4
3
2
1
0
-1
0
1
2
3
4
5
6
7

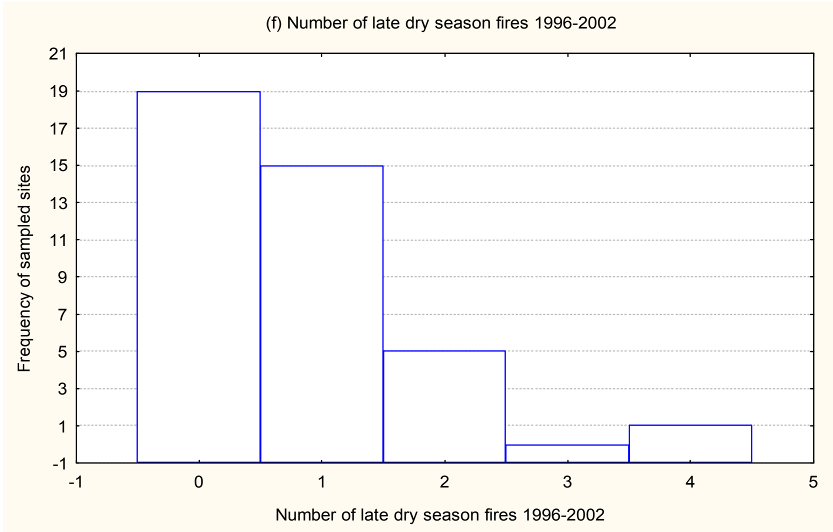

(f) Number of late dry season fires 1996-2002
Frequency of sampled sites
Number of late dry season fires 1996-2002
21
19
17
15
13
11
9
7
5
3
1
-1
-1
0
1
2
3
4
5

Table 4.4. Generalised linear models showing relationship of change in abundance of mammal species over the period 1979-1981 to 2003 with the fire history of sub-sites over the periods 1982 to 2003 and 1996 to 2003. See text above for abbreviations for fire terms.

species	*explained deviance*	*N*	*term*	*Wald statistic*	*estimate*	*s.e.*	*prob.*
northern brown bandicoot	87.7%	13	intercept	366.07	2.45	0.13	<0.00001
			TSB - total	12.55	-0.26	0.07	P<0.001
Sandstone antechinus	No significant model						
common rock-rat	No significant model						
Grassland melomys	61.4%	10	Intercept	69.89	2.21	0.26	<0.00001
			TSB-total	4.57	0.08	0.03	0.03
			Tfire 96-03	18.36	0.19	0.04	<0.00001
			TSB - late	5.21	0.05	0.02	0.02
Arnhem rock-rat	28.8%	6	intercept	0.69	-0.804	0.97	0.40
			Tfire 96-03	5.15	0.78	0.34	0.02
northern quoll	70.9%	21	intercept	176.19	2.41	0.18	<0.00001
			TSB - late	5.96	-0.06	0.02	0.02
			Lfire 96-03	6.34	-0.30	0.12	0.01
abundance of all native mammals	87.5%	36	intercept	1917.63	3.52	0.08	<0.00001
			Lfire 96-03	5.23	6.03	0.01	0.02
			TSB - total	4.42	0.04	0.02	0.04
			Tfire 96-03	11.94	0.06	0.02	<0.0001
species richness of all native mammals	No significant model						

Discussion

The re-sampling of a set of sites on the Jabiluka lease in the north of Kakadu National Park has provided results that contrast with mammal re-sampling carried out elsewhere in the Park, e.g. Kapalga (Braithwaite and Muller 1997; Woinarski *et al.* 2001), Little Nourlangie Rock (Woinarski *et al.* 2002), Stage 3 (Mary River District) (Woinarski *et al.* 2002) and Stage 1 and 2 (2003 report). The results of the Jabiluka re-survey do not show evidence of the major decline of native mammals recorded at Kapalga (Woinarski *et al.* 2001). In fact, three of the species (northern quoll, northern brown bandicoot and pale field-rat) that had decreased at Kapalga have increased at the Jabiluka sites.

Notwithstanding these increases, some other mammal species showed significant or near-significant decline at Jabiluka. These (probable) decreasers included the Northern Brushtail Possum and Arnhem Rock-rat, two species that have been reported to have declined elsewhere in Kakadu National Park and the Top End generally. Indeed, although the Northern Brushtail Possum was recorded at too few sites to permit detailed modelling, at one site alone there was an order of magnitude decline in the number of possums recorded in the two survey periods: a clear indication of at least local changes in that species.

Like the recent re-sampling of Stage 1 and 2 (2003 report) and Stage 3 (Woinarski *et al.* 2002), the results from the Jabiluka re-sample are noisy, with some sites showing dramatic increases in native mammal abundance while others have shown dramatic declines. At a number of sites, these changes have been driven by major local changes in the abundance of one or two species (e.g. increases in Northern Brown Bandicoots and Pale Field-rats at Site 16 and decline of Northern Brushtail Possums at Site 11). The causes of such dramatic changes remain unclear. As discussed below, investigation of fire regimes at the survey sites provides some insights into factors that may be contributing to these localised changes but a substantial proportion of the observed variation remains unexplained.

Investigation into relationships between changes in the mammal fauna at Jabiluka and fire history parameters showed significant relationships for some species. However, some care needs to be taken during the interpretation of these results. There is a high level of imprecision associated with ascribing fire attributes at the site level, particularly when the size of the sample site is equivalent to the pixel size of the satellite imagery being used (as is the case for the Landsat MSS imagery used to generate fire history data prior to 1996) (Russell-Smith *et al.* 1997). This error is magnified over multiple years, such that the description of a 20 year fire history (as is being used here) will undoubtedly lack precision. In addition, there is also some error associated with the identification of burnt sites from satellite imagery, such that some sites may be incorrectly scored as burnt or unburnt (Russell-Smith *et al.* 1997).

Notwithstanding these issues, the results of the analysis showed some quite significant relationships between the change in abundance of some species and fire history parameters. Some of the models that contained multiple fire terms were a little confusing, possibly a result of the correlation between fire variables. The model for the Arnhem Rock-rat, which suggested a positive relationship with recent fire frequency contrasts with results of similar analyses of data collected for this species in other parts of the park (Begg *et al.* 1981; Woinarski *et al.* 2002; Watson and Woinarski 2003) and in the original study of the Jabiluka fauna (Kerle and Burgman 1984). These studies have reported negative relationships between the abundance of this particular species and fire history attributes.

The frequency of recent fires (1996-2003) was an important factor in many of the models, suggesting short-term responses may be important in the observed changes in abundance of some species. Indeed, substantial year-to-year variation in the abundance of some species during the original survey of the Jabiluka mammal fauna was attributed to local fire events (Kerle and Burgman 1984).

In summary, it appears that the broad scale decline of native mammals observed at Kapalga during the 1980s and 1990s has not occurred at Jabiluka. Overall, the results of this re-sampling exercise revealed that more species had increased than decreased. However, of the species that have declined, a number have been found to have suffered similar negative changes elsewhere in the Park, suggesting that some broad-scale factor may be at work. Of the three species that were found to have significantly increased between the two sampling periods, two (northern quoll and northern brown bandicoot) have been identified as definitely and possibly susceptible to cane toad toxin (van Dam *et al.* 2002). At the time of the re-sample cane toads had not reached any of these sites. However, their recent arrival at sites within 20 km had resulted in dramatic declines of northern quolls. As a result, the populations of these species on the Jabiluka lease should not be considered secure.

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Appendix 4.A.
GPS Co-ordinates of all sub-sites sampled on the Jabiluka Lease, August - September 2003.

Site	Easting	Northing
1A	272770	8619754
1B/1	272312	8619959
1B/2	272651	8619775
1C	272220	8619759
2A	273698	8610360
2B/1	273646	8610021
2B/2	273770	8610080
3A	274260	8611115
3B	274386	8611314
4A	272923	8611852
4B	273265	8612171
5B	269613	8620609
5C	269613	8620906
5D	269750	8620810
6A	271937	8614537
6B/1	272246	8614521
6B/2	272202	8614424
6C	272311	8614489
7A	273793	8608761
7C	273735	8609247
8A	273735	8609247
8B	274931	8611859
8C	274949	8612018
10A	274759	8618023
10B	275031	8617859
11A	267189	8621765
11B	267325	8621751
11c	267460	8621760
12A	275818	8618270
12B	276033	8618292
13A	274828	8613159
13b	274390	8613135
13C	274880	8612988
13D	274956	8613015
14B	269923	8611853
14C1	270024	8611506
14C2	270106	8611463
14D	270167	8612204
15	272410	8612085
16	271290	8614900

Appendix 4.B. Abundance of all native mammal species recorded during 2003 survey of the Jabiluka Mining Lease.

Site	Species	Abundance
1A	Northern Quoll *Dasyurus hallucatus* Northern Brown Bandicoot *Isoodon macrourus* Fawn Antechinus *Antechinus bellus* Grassland Melomys *Melomys burtoni*	5 (1 recapture) 7 (1 recapture) 2 (1 recapture) 2
1B/1	Northern Quoll	2 (1 recapture)
1B/2	Grassland Melomys	2
1C	Northern Quoll Northern Brown Bandicoot Common Rock Rat *Zyzomys argurus*	4 1 1
2A	Delicate Mouse *Pseudomys delicatulus*	3
2B/1	Northern Quoll Common Rock Rat	2 2
2B/2	Common Rock Rat Sandstone Antechinus *Pseudantechinus bilarni*	3 1
3A	Delicate Mouse Northern Quoll Northern Brown Bandicoot	1 1 1
3B	Common Rock Rat Northern Quoll	2 1
4A	Grassland Melomys Northern Quoll Northern Brown Bandicoot Pale Field Rat *Rattus tunneyi*	4 (1 recapture) 3 (2 recaptures) 3 (1 recapture) 2
4B	Common Rock Rat Northern Quoll Sandstone Antechinus	8 (1 recapture) 2 (1 recapture) 2
5B	Grassland Melomys	1
5C	Northern Quoll Northern Brown Bandicoot	1 3
5D	Northern Brown Bandicoot Northern Brushtail Possums *Trichosurus vulpecula* Black-footed Tree-rat *Mesembriomys gouldii*	14 2 1
6A	Northern Brown Bandicoot Northern Quoll	4 (1 recapture) 4
6B/1	Common Rock Rat Pale Field Rat Northern Brown Bandicoot	1 2 6
6B/2	Common Rock Rat Northern Quoll Northern Brown Bandicoot	6 (1 recapture) 4 (2 recaptures) 1
6C	Northern Quoll Common Rock Rat Northern Brown Bandicoot	3 11 (3 recaptures) 1

7A	Fawn Antechinus Grassland Melomys Red-Cheeked Dunnart *Sminthopsis virginiae*	1 2 1
7C	Western Chestnut Mouse *Pseudomys nanus* Northern Quoll Grassland Melomys	1 1 1
8A	Northern Quoll Black-footed Tree-rat	4 (1 recapture 1
8B	Common Rock-Rat Black Wallaroo *Macropus bernardus*	7 (2 recaptures) 1 (sighted)
8C	Northern Quoll Common Rock-Rat Sandstone Antechinus	2 (2 recaptures) 2 1
10A	Northern Quoll Common Rock-Rat	5 (2 recaptures) 1
10B	Northern Quoll Arnhem Rock-Rat *Zyzomys maini*	3 3 (1 recapture)
11A	Black-footed Tree-rat Northern Brushtail Possum Northern Brown Bandicoot	2 (1 recapture) 3 14 (5 recaptures)
11B	NIL	
11C	Northern Brushtail Possum	1
12A	Northern Quoll Northern Brown Bandicoot	3 (1 recapture) 2
12B	Northern Quoll Northern Brown Bandicoot	10 (5 recaptures) 2
13A	Grassland Melomys Pale Field Rat Northern Quoll Common Rock-Rat Black Wallaroo	1 1 2 5 1 (sighted)
13B	Pale Field Rat Arnhem Rock-Rat Common Rock-Rat	2 1 11
13C	Common Rock-Rat Arnhem Rock-Rat	5 (1 recapture) 2
13D	Pale Field Rat	2 (1 recapture)
14B	Grassland Melomys Pale Field Rat	9 (2 recaptures) 1
14C/1	Northern Quoll	1
14C/2	Northern Quoll Delicate Mouse Northern Brushtail Possum	1 2 1 (sighted)
14D	NIL	
15	NIL	
16	Northern Brown Bandicoot Pale Field Rat	43 (16 recaptures) 27 (9 recaptures)

4. INVESTIGATION OF CHANGE IN VERTEBRATE (ESPECIALLY MAMMAL) SPECIES COMPOSITION AT SITES SAMPLED IN HISTORIC SURVEYS: b. Kapalga

Introduction

The Kapalga Research Station has been the focus of much ecological research within Kakadu National Park, culminating in the landscape-scale fire experiment conducted by CSIRO from 1990-94. However, prior to the CSIRO Kapalga Fire Experiment (Andersen *et al.* 1998), a number of detailed ecological studies of small mammals were carried out at the Kapalga providing valuable information about the ecology and population dynamics of a number of native mammals (Kerle 1983; Friend 1985; Friend and Taylor 1985; Kerle 1985; Friend 1987). In this report, two study sites used in these studies are re-sampled for small mammals in an attempt to assess the current status of the small mammals of Kakadu National Park.

Methods

Baseline Sampling

<u>Fawn Antechinus and Black-footed Tree Rat</u>

Friend (1985) and Friend (1987) report the results of detailed studies of the Fawn Antechinus *Antechinus bellus* and the Black-footed Tree-rat *Mesembriomys gouldii* at Kapalga between 1980 and 1983. Small mammal trapping was carried out every 2-3 months between June 1980 and January 1983 to sample Fawn Antechinus and Black-footed Tree-rat populations at Kapalga. The trapping methods are described in Friend (1985; 1987) and briefly summarised here. Three trapping grids (A, B and C), each consisting of ten columns and five rows, were established in 1980. Grids A and B had 20m spacing between columns and 40m between rows, while Grid C had 40m spacing between rows and columns. The grids encompassed a total area of approximately 12 ha. A single small Elliott trap was placed at each trap site (the intersection of rows and columns) giving a total of 50 Elliott traps per grid. In September 1980, an additional 25 wire cage traps were set on each grid. Traps were baited with a mixture of peanut butter, rolled oats and sardines and set for three consecutive nights. Details of trapping results for Fawn Antechinus and Black-footed Tree-rat are presented in Friend (1985) and Friend (1987) respectively. (1985).

<u>Northern Brushtail Possum</u>

Northern Brushtail Possum populations were sampled at Kapalga during 1979-81 as part of a study of the ecology and distribution of the species in the Alligator Rivers Region (Kerle 1983; 1985). At Kapalga, two trapping grids were used, however one was abandoned after only one trapping session. The other grid ("Kapalga Billabong") was trapped in September 1979, September 1980, November 1980 and September 1981. On each of these occasions 30 wire cage traps were baited with a mixture of peanut butter and oats and set for three consecutive nights. A population abundance index (% trap success) was calculated during each trapping session.

Re-sampling

In September 2003, two of the trapping grids (A and B) used by Friend (1985;1987) and the Kapalga Billabong grid of Kerle (1983; 1985) were relocated and resampled using the same methods as adopted in the original survey. Grids were relocated using archival information and maps provided by Gordon Friend and Anne Kerle. The number and positioning of traps were as per the descriptions provided in published papers. However, at the Kapalga Billabong grid, 50 small Elliott traps were set in addition to the original 30 wire cages to target some smaller mammal species, such as small rodents, that are not readily caught in cage traps. All sites were trapped from the 25 – 28 September.

Trapping results obtained from Grids A and B in 2003 are compared to results from September 1982 while the results from the Kapalga Billabong are compared to Anne Kerle's results from September 1981. GPS co-ordinates were collected for each of the three grids to facilitate future revisits if required (see Appendix 4C).

Results

Very few mammals were trapped at the three grids in September 2003. Over the three nights trapping, no animals were trapped on Grid A and only one Northern Brushtail Possum was trapped on Grid B, giving trap success rates of 0% and 0.4% respectively. Two Agile Wallabies were also observed on Grid B when traps were being checked. Direct comparison with trap success rates for the original work is difficult because raw data from these studies was not available for comparison and because Friend (1985 and 1987) do not present % trap success rates for each trapping period or grid. However, the number of Fawn Antechinus and Black-footed Tree-rats known to be alive across the study area in September 1982 was two and three respectively. These figures had declined dramatically during the course of Friend's three-year study period, from a peak of 34 Fawn Antechinus in June 1981 and 17 Black-footed Tree-rats in November 1981.

A total of five mammals (one Northern Quoll, one Northern Brown Bandicoot and three Delicate Mice) were trapped at the Kapalga Billabong grid in September 2003. The total trap success for the grid was 2.1% (wire cage trap success rate was 0.8% and Elliott trap success rate was 1.3%). In September 1981, 18 Northern Brushtail Possums, six Northern Quolls and six Northern Brown Bandicoots were trapped on the grid, giving a total (and wire cage) trap success rate of 33.3% (Kerle, unpublished data). At the same site in November 1980, a trap success rate of 18.3% was recorded (Kerle, unpublished data).

Discussion and Conclusions

The re-sample of small mammal survey sites on Kapalga revealed very few mammals in comparison with previous records. Fawn Antechinus and Black-footed Tree-rats were not caught at sites in which they had once been very common (Friend 1985; 1987). Similarly, Northern Brushtail Possums were not captured at the Kapalga Billabong site where they had also been previously recorded at high numbers. Although present at the Kapalga Billabong site, Northern Brown Bandicoots and Northern Quolls were not trapped as often as they were in September 1981 (or the previous survey in November 1980).

The results of the re-sample of Friend and Kerle's survey sites in Kapalga support previous studies that have recorded substantial declines in native mammals on the Kapalga Research Station (Braithwaite and Muller 1997; Woinarski *et al.* 2001). Both of these studies reported rapid and dramatic declines for Fawn Antechinus, Black-footed Tree-rat, Northern Brushtail Possum, Northern Quoll and Northern Brown Bandicoot, all of which seemed to have declined at the sites described in this study.

The decline of at least some of these species appears to have begun prior to the Kapalga Fire Experiment which commenced in 1990 (Andersen *et al.* 1998). Friend (1987) reported a decline in the abundance of Black-footed Tree-rats during his three year study, with only two animals known to be alive in the study area at the completion of trapping. In addition, retrapping of the study site in 1983, 1984 and 1985 failed to record any tree-rats. Friend (1987) hypothesised that this was related to fire events and rainfall patterns. At the time of sampling in 2003, Grids A and B had recently been burnt by what appeared to have been a relatively intense fire (no ground layer vegetation present across most of the grids and some canopy scorch was evident). This may have contributed to the lack of trapping success at these sites.

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Woinarski, J. C. Z., Milne, D. J. and Wanganeen, G. (2001) Changes in mammal populations in relatively intact landscapes of Kakadu National Park, Northern Territory. *Austral Ecology* **26**, 360 - 370.

Appendix 4C. Co-ordinates of central point in trapping grids.

Kapalga Billabong	53 220591	8603451
Grid A	53 214735	8600261
Grid B	53 214740	8600041

5. SURVEY OF THREATENED PLANTS

This activity is reported elsewhere:

Kerrigan, R.A. (2003) "Kakadu Threatened Flora Report. Results of a threatened flora survey 2003". Unpublished Report.

Kerrigan, R.A. (2004) "Kakadu Threatened Flora Report (Vol 2.). Results of a threatened flora survey 2004". Unpublished Report.

6. INVESTIGATION OF CENSUS AND TRAPPING METHODS FOR FERAL CATS AND DINGOES

Introduction

Feral cats (*Felis catus)* have been variously implicated in the decline and/or extinction of numerous mammal and bird species in Australia and elsewhere around the world (Dickman 1996). On many islands, predation by introduced cats has had an obvious and deleterious impact on the native fauna, particularly birds but also mammals (Karl and Best 1982; Bloomer and Bester 1992; Smucker *et al.* 2000). However, the role of cats in the decline or extinction of species on larger land masses is less obvious, primarily because of the co-occurrence of a number of other possible causes (Clapperton *et al.* 1994). For example, the decline of small-medium sized mammals from Central Australia has occurred against a backdrop of altered fire regimes, habitat modification resulting from livestock or other introduced animals or plants and the introduction of feral predators including cats (Morton 1990; Short and Smith 1994). As a result it has been difficult to determine which of these factors have been more or less important in the decline of the mammal fauna in the region since European settlement (Morton 1990).

Recent research, particularly that focussing on mammal reintroduction programs in Central Australia suggests that predation by feral cats may indeed have played a significant role in mammal declines (Short *et al.* 1992; Gibson *et al.* 1994; Southgate and Possingham 1995). As a result of their implication in the demise of some of Australia's native fauna, particularly small mammals, feral cat populations in some parts of Australia (particularly arid and semi-arid regions of Western Australia, New South Wales and the Northern Territory) have become the subject of intensive research and control programs (Jones and Coman 1982; Paltridge *et al.* 1997; Short *et al.* 1997; Risbey *et al.* 1999; Edwards *et al.* 2000; Risbey *et al.* 2000; Edwards *et al.* 2001; Molsher 2001; Paltridge 2002; Short *et al.* 2002). These studies have revealed that in areas where rabbits are present, they form the bulk of the diet of feral cats. However where rabbits are absent or in low numbers (eg. temperate forests of eastern and south-eastern Australia) small mammals are the most important prey species (Dickman 1996; Risbey *et al.* 1999; Read and Bowen 2001). Some of these studies have also revealed relationships between feral cat abundance and the presence and/or abundance of other predators, particularly dingoes (*Canis familiaris)* (Dickman 1996). Cats are consistently eaten at low numbers by dingoes in all regions of Australia (Corbett 1995). Dingoes and cats also compete for food especially when resources are limited (Dickman 1996) and local declines in dingo numbers have been found to facilitate dramatic increases in feral cat numbers (Dickman 1996). However, the relationship between feral cat and dingo numbers is not always negative. In Central Australia, the carcasses of kangaroos killed by dingoes have been observed to sustain feral cat populations during periods of drought (Dickman 1996).

Despite calls for more research into the impacts of feral cats in parts of the Northern Territory not infested with rabbits (Strong and Low 1983; Dickman 1996), basic information such as the distribution and relative abundance of cats is still lacking for much of the Top End of the Northern Territory. Cats were recorded at the Port Essington Settlement in the Top End of the Northern Territory by Ludwig Leichardt during the 1840's (Abbott 2002). Cats were also recorded as frequently seen around Katherine and northwards to the coast in 1912 (Abbott 2002). The earliest records of cats in Kakadu are from Kapalga and Deaf Adder Creek in the 1920's (Ridpath 1990). In contrast, dingoes first arrived in Australia some 3,500 years ago (Corbett 1995) and rapidly colonised the entire continent (except for Tasmania). Dingoes have been studied in some detail at a number of locations in Australia, including the Kapalga Research Station in Kakadu National Park (Corbett 1995).

There has to date been only one (incomplete and not formally published) study focussing on cats in the wet-dry tropics of the Northern Territory (Cameron, 1994) and one other mammal study in which feral cats were given some consideration (Corbett 1995). Both of these pieces of research revealed that feral cats were indeed preying on small mammals in the region, particularly native rodents (eg. the Dusky Rat *Rattus colletti* , Pale Field Rat *Rattus tunneyi,* the Long-Haired Rat *Rattus villosissimus* and the Grassland Melomys *Melomys burtoni*) and the Northern Brown Bandicoot *Isoodon macrourus* (Cameron 1994). Some of these species, as well as other small mammals that fall within the size range of prey taken by feral cats were among the species found to be declining at Kapalga Research Station in Kakadu National Park (Braithwaite and Muller 1997; Woinarski *et al.* 2001). The potential role of feral cats in this decline has yet to be determined, primarily because there is currently insufficient information about the distribution and abundance of feral cats and the nature and extent of their interactions with prey and other predators in this region (Woinarski *et al.* 2001).

Estimating the distribution and abundance of feral cats and dingoes, as with other small mammalian carnivores, is made difficult as a result of their tendency to be shy, cryptic, solitary and generally present at low densities (Dickman 1996; Edwards *et al.* 1997; Risbey *et al.* 1999). Methods that have been used to estimate the relative abundance of feral cats and dingoes include live captures, scat counts, spotlight surveys, passive track counts and active track counts using baits.

Live capture techniques may employ cage traps or leg-hold traps, the latter is considered to be the more successful method but the potential for injury of non-target species can render this technique unsuitable in some areas (Short *et al.* 2002).Spotlight surveys, although frequently used to survey mammalian carnivores, often simply fail to detect species such as feral cats, dingoes or foxes (Mahon *et al.* 1998; Edwards *et al.* 2000). These results arise because of behavioural responses of cats and dingoes (ie. they may simply not look at the spotlight and therefore not be seen) (Jones and Coman 1982) and because spotlight surveys only sample a small part of the time that predators are active and a small portion of the habitat in which they are found (usually near roads) (Mahon *et al.* 1998). As a result, many spotlight surveys reported in the literature may be negatively biased (Mahon *et al.* 1998).

Passive and active track counts are also extensively used to estimate relative abundance of cats and dingoes. Active-track based methods generally employ some type of bait or lure to attract cats to a particular area where the number of tracks will be counted. The results of these surveys can be affected by bait shyness (Thompson and Fleming 1994) or the appropriateness of baits used during the survey (Clapperton *et al.* 1994; Edwards *et al.* 1997; Risbey *et al.* 1997). Passive track counts do not employ baits to attract target species. Instead, tracks are counted at survey sites located randomly throughout a study site, or more commonly along roadsides or vehicle tracks. Scat counts employ a similar methodology, in which the number of scats are counted within a sampling area and this figure is used to calculate an estimate of abundance.

Track and scat counts offer a number of advantages over spotlight surveys: they are generally less time consuming, sample the entire period in which cats and dingoes are active and as a result may provide less variable estimates of relative abundance. They are also useful in that they can be used to simultaneously provide estimates of abundance of other species (Catling and Burt 1994). However, data collected from track based methods may be more reflective of animal activity levels rather than abundance (Edwards *et al.* 2000). Activity levels can be influenced by seasonal shifts in resource availability, breeding behaviour, territorial responses to conspecifics and interactions with other species (Phillips and Catling 1991; Thomson 1992; Allen *et al.* 1996; Fleming *et al.* 1996; Edwards *et al.* 1997). For example, Edwards et al (2000) found that cat visitations were lower at bait stations previously visited by dingoes. Some of these factors can be mitigated through careful study design. For example, carrying out surveys outside of breeding seasons (Edwards *et al.* 2000), at multiple times throughout the year or in multiple habitat types. In addition, careful consideration must be given to the distance between sampling units so as to ensure spatial independence in respect to animal movements (Allen *et al.* 1996; Engeman *et al.* 1998; Edwards *et al.* 2000). To do this, some knowledge of home range size and movement patterns of the target species is required.

A variety of approaches have been taken to track-based methods. Allen *et al* (1996), Catling and Burt (1994) and Mahon *et al* (1998) have utilised passive track-based methods to survey feral cats and dingoes with mixed success. Both Allen *et al* (1996) and Catling and Burt (1994) established soil plots along vehicle tracks while Mahon et al (1998) used a similar road based method as well as randomly locating soil plots throughout their study site. Road based surveys are particularly useful for dingo surveys as they offer highly precise estimates of abundance due to the tendency for dingoes to utilise vehicle tracks. However, the tendency for dingoes to utilise these areas can introduce positive bias into these surveys. In contrast, Mahon *et al* (1998) found that soil plots randomly located throughout their study site provided evidence that feral cats do not show preferences for roads, and estimates of their abundance based on sampling of roads may be biased by this fact.

Many of these methods have been developed and implemented in arid/semi-arid areas of Australia where vegetation (especially the ground layer) is relatively sparse, allowing greater visibility over long distances for spotlight surveys and easier location and identification of tracks and scats. Some of these methods may be less successful in the savanna woodlands of the Top End of the Northern Territory because the tall grass understorey (which may reach heights of 2-3 metres during the dry season) greatly reduces visibility during spotlight surveys and in some areas may be so dense as to prevent the location and identification of tracks and scats. Leg-hold traps (even the soft jawed models currently used successfully elsewhere) are unsuitable in the Top End because of the large numbers of non-target native species present in these habitats.

In this chapter we discuss results from a study that used two methods to estimate distribution and relative abundance of feral cats and dingoes in the savanna woodlands of Kakadu National Park. Both methods employ a combination of spotlighting and track counting to provide a relative abundance of both feral cats and dingoes along survey transects. Research from elsewhere in Australia has shown that dingoes prey on feral cats, and the presence of dingoes in an area may affect the behaviour of feral cats (eg. cats may avoid areas where dingoes have recently been active, a potential source of bias in the survey methods employed during this study). For this reason, relationships between feral cat and dingo/dog abundance are investigated. Simultaneous mammal trapping in the vicinity of cat/dingo survey transects was used to provide information about the abundance and diversity of small mammals in these areas and to allow investigation into the relationships between cat/dingo numbers and small mammal populations. This study represents the first dedicated attempt to quantify feral cat populations in Kakadu National Park and has been prompted by recent concern over the current status of small mammals within the Park and the potential role that feral cats may play in determining native mammal populations.

Methods

Two survey techniques were used to investigate feral cat and dingo distribution and abundance in two regions within Kakadu National Park. The first technique, which utilises baited survey stations has previously been tested as a method to determine relative abundance of feral cats and to test the efficacy of a range of baits at a number of sites in the Top End of the Northern Territory (Cameron 1994) and elsewhere in arid/semi-arid areas of Australia (Clapperton et al. 1994; Edwards et al. 1997; Risbey et al. 1997). As well as providing some indication of feral cat numbers in the study sites, this method was also designed to test the efficacy of a number of types and combinations of baits and lures for possible use in future trapping programs in Kakadu National Park. The second technique has been extensively employed to survey mammals on the east coast of New South Wales and Queensland and to survey cats and dingoes in the Alice Springs region, but has only been used once in the tropical savannas of the Northern Territory (Catling et al. 1999).

Baited survey stations

The baited station survey used in this study is based loosely on previous surveys performed in the Alice Springs region by Edwards et al. (1997) and in the Top End of the Northern Territory (Cameron 1994). During this survey, two transects were established in both the East Alligator and South Alligator Districts of Kakadu National Park (see Appendix A for GPS co-ordinates). Each of the transects was located along an existing vehicle track that passed through *Eucalyptus* dominated woodland. The dominant tree species were *Eucalypts tetrodonta, E. miniata and Corymbia bleeseri* with a mixed midstorey and dense grass understorey dominated by *Sarga sp*.

Baited survey stations were set up at 200m intervals along a 6 km transect centred on an existing vehicle track. Survey stations were located approximately 10 m into the woodland on the left hand side of the track. At each station an area of approximately 1.5m x 1.5m was cleared of ground vegetation and covered with a layer of sand collected locally. One of five bait/lure/trap combinations was set up at the centre of each station. The range of lures and baits used during the study are described in Table 6.1. Wire cage traps (700mm x 300mm x 300mm) were the only trap type used. Treatments were blocked and randomised every 1 km, giving five spatial replicates on each transect. Survey stations were checked each morning for tracks and animal captures. All tracks visible in the sand were recorded at this time. The sand was then raked smooth and the bait replaced each afternoon. Each transect ran for three consecutive nights. The two transects in the East Alligator District were surveyed from the 21-28 April 2003, and the transects in the South Alligator District were surveyed from the 2-9 May 2003.

The effectiveness of each of the stations (including the control) was evaluated with respect to both cats and dingoes. Cat and dingo visitations in each trial were assigned to the appropriate station. Data for all the bait/lure combinations from each of the four sites were pooled. For each lure, the proportion of stations visited by cats and dingoes was calculated and compared using a contingency table analysis equivalent to a chi-square test (Zar 1999).

Table 6.1. List of baits, lures and traps used during bait station surveys in Kakadu National Park.

Lure No.	Description
1	Control (cleared area, no bait, lure or trap)
2	Feline Audio Phonic** device and tinned fish based cat food in pipe
3	Cage trap and tinned fish based cat food
4	Catnip and cage trap
5	Tinned meat-based cat food in pipe
6	Tinned meat-based cat food in cage and suspended bird feathers

** Feline Audio Phonic (FAP) device is a battery operated device that emits an amplified cat call (meow) previously used to successfully attract cats to traps in Western Australia and Christmas Island (D. Algar pers. Comm.)

Spotlighting surveys were also carried out along existing vehicle tracks in the South Alligator (herein referred to as Kapalga) and East Alligator districts (referred to as Magela Point), including the areas used for the bait station surveys. Two spotlighting transects were surveyed in both the Kapalga and Magela Point areas. Each transect was surveyed twice. These transects passed through Eucalyptus woodland with a dense grass understorey (see above for habitat description). The dense grass understorey limited the distance at which cats and dingoes could be observed. To allow calculation of density indices from spotlight data it was assumed that cats could be detected up to 50m from the track and dingoes up to 100m from the track. One of the Magela Point spotlight transects included a 1.5 km section of floodplain fringe where the vegetation was dominated by short grasses and only scattered trees (eg. Pandanus spiralis). In this section of the transect cats could be detected up to 150m from the track and dingoes up to 200m. The date of survey, length of transects and total area surveyed for cats and dingoes during spotlight surveys is described in Table 2. Spotlighting surveys were carried out from a vehicle moving at 10-15 km/hr.

Observations were made by an individual sitting on the roof of the vehicle using a hand-held 100w spotlight. Each transects was surveyed on two consecutive nights following the bait-station survey.

Too few cats and dingoes were observed during the individual spotlight surveys to employ distance methods to calculate an estimate of density. A simple index of density for cats and dingoes was calculated and expressed as the mean number of individuals of each species observed per square kilometre surveyed, averaged over the four surveys in the Kapalga and Magela Point areas. Co-efficients of variation were calculated for each of these estimates.

Soil plots

The second cat and dingo survey was undertaken during June and July 2003. The methods used in this survey follow those used by Catling and Burt (1994) and Catling et al. (1999) to survey medium and large mammals in forest habitats throughout New South Wales and in the Roper River region of the Northern Territory. Survey transects, each 3km long, were established along existing vehicle tracks at six sites in Jim Jim, East Alligator and South Alligator Districts of Kakadu National Park. Soil plots, each 1m wide and spanning the width of the track (approximately four metres), were established at 200m intervals along each transect (giving a total of 15 soil plots per transect). The number of soil plots with tracks of each species was recorded for three consecutive nights. Some tracks, such as those of macropods, were difficult to identify to species but incidental observations during visits to the site were used as a guide to the species present in the area. For the purpose of analysis, all macropod tracks are grouped as a single species. Soil plots were checked for tracks each morning and raked clear of tracks and debris each afternoon.

These methods were not designed to provide comprehensive surveys of the mammals present nor to provide accurate estimates of abundance (Catling and Burt 1994). Instead the methods provide a method to rank the abundance of particular species in a given area and compare this measure to other sites. As a result, areas of higher or lower relative abundance for particular species (in this case feral cats) can be identified. Since very little information relating to cat abundance is available for the Kakadu area data collected in this study is compared to the findings of other studies, particularly Catling and Burt (1994) and Catling et al. (1999).

Correlation of feral cats, dingo/dog and native mammal abundance

Since small-medium sized mammals are difficult to identify from tracks in soil plots (Catling and Burt 1994), additional trapping was carried out to target smaller species. A survey quadrat was established in the woodland alongside the first, fifth, ninth, twelfth and fifteenth soil plot of each transect, for a total of 30 quadrats over the course of this study. These quadrats followed the standard Parks and Wildlife Commission survey procedure outlined in Chapter 2. The small mammals captured were identified and released at point of capture. Each quadrat operated for the same three nights as the cat transect.

The relationship between the presence/absence of feral cats and total mammal abundance at each quadrat was investigated using generalised linear modelling. Cat presence/absence was the dependent variable and total mammal abundance (number of native mammals trapped at each quadrat), dingo presence/absence and transect location were the explanatory variables. Dingo presence/absence was included in the modelling to investigate whether cats were avoiding sites where dingoes were present. Models were fitted using the binomial distribution because the dependent variable was presence/absence data (Crawley 2002). Generalised linear modelling was also used to investigate relationships between dingo presence/absence (dependent variable) and cat presence/absence, native mammal abundance and transect location (explanatory variables).

Results

Baited survey stations

No cats were caught in traps during the survey. Only five separate cat visitations were recorded over the total 360 station-nights (120 stations x 3 nights) (ie. 1.4% of stations visited). Three different bait types were visited by cats: feathers and meat food with cage, fish food in cage and fish food in pipe. The latter had the most cat visitations. However, the same station had a cat visitation on 3 consecutive nights, suggesting that the same cat may have been responsible for all 3 visitations. Statistical analysis showed no significant difference between the number of cat visitations to each of the bait/lure combinations (χ^2=10.33, d.f.=5). In comparison, there were 7 dingo visitations over the 360 station-nights (1.9% of stations visited). Dingoes also visited three different types of bait stations: control, fish bait and pipe and the Feline Audio Phonic (FAP) meat food and pipe combination. Over the duration of the survey no stations were visited by both cats and dingoes. There was no statistical difference between the number of dingo visits to each of the bait/lure combinations (χ^2 =7.739, d.f. = 5). A number of native animals also visited the bait stations or were trapped in cages over the duration of the survey. The number of captures, visitations and bait types visited by each species are listed in Table 6.3.

Very low numbers of cats were recorded during the spotlight surveys (maximum n=1 on any night) (see Table 6.2 for summary). One cat was recorded in the vicinity of the two transects in the East Alligator district and two cats were recorded at Kapalga. Both the sightings in Kapalga were within 1.5km of each other and were of a large ginger animal, suggesting that it may have been the same animal. A total of three dingoes were recorded during spotlight surveys. All dingoes observed during the spotlight surveys were moving along the vehicle tracks. The four cats were also initially spotted while moving along the vehicle tracks but fled into the surrounding vegetation as the vehicle drew nearer. The estimated indices of feral cat density derived from spotlighting surveys for the Kapalga and Magela Point areas were 0.68 cat.km^{-2} and 0.19 cat.km^{-2} respectively. Co-efficients of variation for these estimates were high (111 and 200 respectively). Indices of density for dingoes at Kapalga and Magela Point were 0 dingoes.km^{-2} and 0.17 dingoes.km^{-2} respectively. The coefficient of variation for dingo density at the Magela Point area was also quite high (66.7). The high co-efficients of variation for density indices for both feral cats and dogs possibly indicates a large degree of imprecision in the survey technique or high spatial variability in the distribution and/or abundance of both species.

Table 6.2. Summary of spotlight survey results, including dimensions of survey transects.

Location	Length of transect	Survey number	Total area surveyed for cats	Total area surveyed for dingoes	No. of cats observed	Cat density (cat/km^2)	No. of dingoes observed	Dingo density (dingo/km^2)
Magela Point Transect 1	13km	1	1.6km^2	2.9 km^2	0	0	0	0
		2	1.6 km^2	2.9 km^2	1	0.62	0	0
Magela Point Transect 2	10km	1	1.0 km^2	2.0 km^2	0	0	0	0
		2	1.0 km^2	2.0 km^2	0	0	0	0
Magela Point Total			**5.2 km^2**	**9.8 km^2**	**1**	**0.19**	**0**	**0**
Kapalga Transect 1	10km	1	1.0 km^2	2.0 km^2	1	1.0	1	0.5
		2	1.0 km^2	2.0 km^2	1	1.0	0	0
Kapalga Transect 2	12km	1	1.2 km^2	2.4 km^2	0	0	1	0.42
		2	1.2 km^2	2.4 km^2	1	0.83	1	0.42
Kapalga Total			**4.4 km^2**	**8.8 km^2**	**3**	**0.68**	**3**	**0.34**

Table 6.3. Results of the bait station survey, showing number of visits by cats, dingoes and native fauna species.

Trial	Lure	Cat	Dingo	Pig	*Native animals*						
Location	No.	visits	visits	Visits	Northern Brown Bandicoot	Northern Quoll	Northern Brushtail Possum	Agile Wallaby	Small Unidentified Mammal	Goanna	Frill Necked Lizard
Crater Hole	1				4	3	1				2
	2							1	4		
	3				1						
	4								3		
	5	3			2					1	1
	6				1				1	1	2
Magela Point Track	1		1		1	1	1	1	1		
	2					1	2		2	2	
	3	1			3	2	1	2	1		
	4				4			2	3		
	5				2	1	1	1	6		
	6		1		2				2		
Rookery Point Kapalga Research Station	1		1	1	2	1				1	
	2	1			1				1		
	3					1			2		
	4				1						
	5		1			1					
	6		2		1	1					

Table 6.3. cont.

Trial Location	Lure No.	Cat visits	Dingo visits	Pig Visits	*Native animals*						
					Northern Brown Bandicoot	Northern Quoll	Northern Brushtail Possum	Agile Wallaby	Small Unidentified Mammal	Goanna	Frill Necked Lizard
Western Track	1								1	1	
Kapalga	2				1					2	
Research Station	3				1					4	
	4										
	5		1								
	6									2	

Soil plots

In all a total of 12 species were recorded on the soil plots. This figure consisted of 4 native mammals (northern quoll, northern brown bandicoot, northern brushtail possum and agile wallaby), 3 introduced mammals (cat, dingo and pig), 2 reptiles (sand goanna and an unknown snake) and 3 birds (emu, scrub fowl and torresian crow). The abundance of these species (% of soil-plot-nights with tracks) is presented in Table 6.4.

Cat tracks were recorded on soil plots in four of the six transects, but only in low numbers. The highest number of soil plots with cat tracks was at Mardugal (4 in total or 8.9% of soil plot nights). Cat tracks were recorded on only one soil plot in the other 3 transects. Dingo tracks were recorded more frequently than all other species. They were recorded on soil plots in five of the six transects and observed in the vicinity of the sixth transect during the survey period. At the Mardugal transect, dingo tracks were recorded on 84.4% of soil plots. The lowest number of soil plots with dingo tracks (apart from zero) was the Munmalary transect where only 4.4% soil plots had dingo tracks.

The abundance of native mammals (% of soil plot nights with tracks) was highly variable between transects (Table 6.4). Northern quolls and agile wallabies were the most frequently recorded native species, with tracks from both species found on soil plots in four transects. The two areas with the highest number of dingo and cat recordings also had the highest total native mammal abundance and diversity.

A total of 13 species of small mammals were trapped along the survey transects. The abundance (% trap success) of each species at each transect is shown in Table 6.5. The transects at Area 1 and 2 (Mardugal and Nourlangie Camp) had the highest total mammal abundance. No small mammals were trapped along the transect in Area 3 (Four Mile).

Correlation of feral cats, dingo/dog and native mammal abundance

Fitting a generalised linear model including the factors dingo presence/absence, transect location and mammal abundance to the cat presence/absence data revealed no significant factors in the models. Similarly, fitting a generalised linear model including the factors cat presence/absence, transect location and total mammal abundance to dingo presence/absence data also revealed no significant factors in the model.

Comparison of results with other studies.

There has previously been very little focus on feral cats in Kakadu, however Corbett the population of cats in the 600 km^2 Kapalga Research Station was estimated to be 16 (Ridpath 1990; Corbett 1995). This density estimate of 0.03 cats/km^2 (Ridpath 1990; Corbett 1995) at Kapalga is much lower than the estimates produced from spotlight surveys at Kapalga and in the Magela Point area during this study (0.68 cat.km^{-2} and 0.19 cat.km^{-2} respectively).

The estimates of relative abundance of feral cats derived in this study are also comparable to those produced in other regions in Australia. Using similar spotlighting techniques, Edwards *et al*. (2000) reported cat densities ranging from 0.007 to 0.043 cats/km^2 from semi-arid rangelands in central Australia. In north-western Victoria, the relative abundance of feral cats was estimated to range from a minimum of 0.34 cats/km^2 in winter to a maximum of 3.5 cats/km^2 in summer, based on spotlight surveys (Jones and Coman 1982).

In their study of medium-large ground dwelling mammals in south-eastern New South Wales, Catling and Burt (1994) recorded cat tracks on 1.7 -20.6% of plot-nights in their 13 study sites. Based on historical data and their own knowledge of mammal abundance at their study sites they ranked sites as having scarce, low, medium or high cat and dingo abundance according to the number of soil plots with tracks. Cats were considered scarce at sites where tracks were recorded on <2% of soil plots, at low abundance where tracks were recorded on 2-5% of soil plots, at medium abundance where tracks were recorded at 5-15% of soil plots and at high abundance where tracks were recorded at >15% of soil plots. In the current study, the highest number of cat tracks were recorded on the Mardugal transect (8.9% of soil plots had cat tracks) while a number of sites had cat tracks on 2.2% of soil plots. If these sites were to be ranked based on the figures calculated by Catling and Burt (1994) the sites in Kakadu would be allocated to low or medium cat abundance.

Catling and Burt (1994) recorded dingo tracks were on 0.8% - 15% of plot-nights at their 13 study sites. They considered dingoes to be scarce at sites where tracks were recorded at <5% of soil plots, at low abundance where tracks were recorded at 5-10% of plots, at medium abundance where tracks were recorded at 10-20% of plots and at high abundance where tracks were recorded at >20% of soil plots. The number of soil plots with dingo tracks in the current study ranged from 0% to 84.4%. Using the abundance rating system of Catling and Burt (1994), two of the six sites (Mardugal and Nourlangie Camp) have exceptionally high dingo abundance in comparison with the sites in New South Wales. The Four Mile track site had high dingo abundance, the Binjil Binjil transect had medium dingo abundance and the Munmalary and Narradj sites had low dingo abundance.

Catling et al (1999) used the same soil plot techniques to estimate abundance of cats and dingoes in the Roper River area of the Northern Territory. In their study three sites, each with 25 soil plots were surveyed for three consecutive nights (giving 75 soil plot nights per survey) on four separate occasions. The number of soil plots with cat tracks ranged from 1.3% to 21.3%, while the number of plots with dingo tracks ranged from 1.3% to 62.7%. In comparison with the current study, the Roper River sites had a higher maximum number of soil plots with cat tracks but some of the Kakadu sites had higher dingo abundance.

Table 6.4. Abundance of all species recorded on soil plot transects in Jim Jim, South Alligator and East Alligator districts of Kakadu National Park. Values are the percentage of plot-nights with tracks. ** denotes species observed in area but not recorded on soil plots.

Area	Total Plot Nights	Dingo/ Dog	Cat	Northern quoll	Agile Wallaby	Northern Brown Bandicoot	Northern Brushtail Possum	Sand Goanna	Snake	Emu	Crow	Pig	Scrub Fowl
1	45	84.4	8.9	2.2	17.8	4.4	4.4				4.4	2.2	
2	45	60.0	2.2	**	2.2	4.4	4.4	**					17.8
3	45	26.7			**							4.4	
4	45	**	2.2	37.8		13.3			**		6.7	4.4	
5	45	11.1	8.9	8.9				2.2	2.2			4.4	24.4
6	45	4.4	2.2	24.4	17.8				**	2.2			

Table 6.5. The abundance of small mammals sampled in quadrats along each transect in Jim Jim, South Alligator and East Alligator districts of Kakadu National Park. Values are the trap success rate (%) for each trapped species.

Area	Trap-Nights	Fawn Antechinus	Red Cheeked Dunnart	Northern Quoll	Brush Tailed Phascogale	Northern Brown Bandicoot	Northern Brushtail Possum	Black Footed Tree-Rat	Brush Tailed Rabbit Rat	Grassland Melomys	Pale Field Rat	Common Rock Rat	Delicate Mouse	Kakadu Pebble Mound Mouse	Total Native Mammals
1	360	8.3						0.6	0.3		0.6		0.3		10.0
2	360	7.8			0.3	0.6		1.9		3.3					13.9
3	360														0
4	360			1.1	1.9				0.8		0.3			4.2	
5	360		0.3	0.8										1.1	
6	360			1.1		0.3							0.6	1.9	

Discussion

The aim of this study was to attempt to provide some estimation of relative abundance of feral cats in Kakadu National Park. The indices of cat density calculated from spotlight surveys during this study are higher than previous estimates of cat density from the Kapalga Research station in Kakadu (Corbett, 1995). The estimates produced during this study are comparable to minimum feral cat density estimates of Jones and Coman (1982) but are substantially lower than their maximum density estimates. However, their study was conducted in an area that supports substantial rabbit populations, a factor known to contribute to high feral cat numbers (Dickman 1996). The absence of European rabbits in the Top End of the Northern Territory has been regarded as an important factor in determining perceived low numbers of feral cats in this region. However, a lack of information regarding the distribution, abundance and ecology of feral cats in this region prevents the confirmation of this hypothesis.

A comparison of the estimated dingo density calculated from spotlight surveys in this study and that of Edwards et al (2000) suggest that dingo numbers are high in Kakadu National Park. Comparison of track counts from eastern Australia (Catling and Burt 1994) and the Roper River (Catling et al 1999) also support this result. Many authors have suggested that dingo density can have a regulating effect on feral cat numbers (Morton 1990; Dickman 1996; Smith and Quinn 1996; Edwards *et al.* 2000; Read and Bowen 2001). This effect can arise as a result of dingoes preying on feral cats or through competition for resources (Dickman 1996). Corbett (1995) recorded considerable overlap in prey species (particularly small-medium sized mammals) consumed by feral cats and dingoes at the Kapalga Research Station. Although this study did not show any relationship between cat presence/absence and dingo presence/absence further research in this area may be useful in determining factors affecting cat numbers in this region.

The methods employed to estimate the relative abundance of cats during this study have many recognised limitations. Spotlight surveys, although frequently used to survey mammalian carnivores, often simply fail to detect species such as feral cats, dingoes or foxes (Mahon *et al.* 1998; Edwards *et al.* 2000). These results arise because of the naturally cryptic nature of cats, behavioural responses of cats (ie. they may simply not look at the spotlight and therefore not be seen) (Jones and Coman 1982) and because spotlight surveys only sample a small part of the time that predators are active and a small portion of the habitat in which they are found (usually near roads) (Mahon *et al.* 1998). As a result, many spotlight surveys reported in the literature may be negatively biased (Mahon *et al.* 1998). In addition, the estimates of abundance produced from spotlight surveys are often accompanied by high coefficients of variation (often in excess of 100% and rarely lower than 40%) (Mahon *et al.* 1998; Edwards *et al.* 2000). This may be due to a lack of precision in the survey method, spatial variability in the distribution and abundance of the target species or a result of avoidance behaviour of the target species. Changes in habitat structure (spatially and temporally) can affect the detectability of cats and dingoes during spotlight surveys. In this study, dense annual speargrass (Sorghum sp.) often limited visibility to no more than 100m from the vehicle. In arid Australia, visibility during spotlighting surveys is often greater than 100m (Edwards *et al.* 2000). This obviously increases the area surveyed and increases the detectability of cats and dingoes at these sites.

Both passive and active track-based methods, such as those employed during this study suffer a number of shortcomings. Spatial independence and serial correlation of sampling points are two common problems in track surveys (Mahon *et al.* 1998; Edwards *et al.* 2000). To avoid these issues careful consideration should be given to the distance between sampling points in relation to the home range and movement patterns of the target species (Mahon *et al.* 1998; Edwards *et al.* 2000). Unfortunately as this information is not available for cats in the savannas of Kakadu, the distances between track survey points in this study were determined from other studies and their appropriateness is not known.

The use of baits to attract target species to survey sites can also cause some errors in resulting density or abundance estimates. Scent based lures can lead to the avoidance of an area by less dominant individuals of a species, or alternatively could attract abnormally high numbers of the species to a site (for example, a lure based on female scent may attract a high number of males, leading to an overestimate of local abundance or density) (Clapperton *et al.* 1994; Edwards *et al.* 1997; Risbey *et al.* 1997). Baits may also attract species that deter visitation by the target species. For example Edwards et al. (2000) found that cat visitation rates were lower at bait stations that had been visited by dingoes. In this study, visual lures (bird feathers), olfactory lures (catnip), auditory lures (feline audio phonic devices) and food baits were tested, with none of these baits proving to be more effective than the others. The decision to test these lures was based on their success at other localities. Clapperton et al (1994) found that catnip extracts were more attractive to cats than any food based or visual lure and in Western Australia, feline audio phonic devices have increased trap success of feral cats (D. Algar pers. comm.). Neither of these lures proved to be successful in Kakadu National Park. Further testing of a range of lures and baits may be useful in identifying more effective baiting methods.

Feral cats were recorded (either visually or by tracks) in all bar one site during this study, indicating that they are indeed present in the savanna woodlands at a number of localities within Kakadu National Park. However, due to the relatively small sample size and the limited extent of these surveys (both spatially and temporally) the indices of abundance presented here should be considered superficial and require further investigation. So although anecdotal evidence from long-term residents, Aboriginal traditional owners and employees of Kakadu National Park asserts that feral cats are not common in Kakadu, the results of this study suggest that they are present in a number of locations and in numbers comparable to other areas of Australia in which cats have been implicated in the demise of native species. The small amount of evidence available suggests that feral cats are feeding on mammals in the savannas of the Northern Territory (Cameron 1994). However, the level of predation is difficult to quantify without more reliable estimates of feral cat abundance and further study of dietary selection. As a result it is difficult to imply from this study what effect, if any, feral cats may be having on populations of small native mammals in Kakadu National Park. Much more intensive assessments of feral cat abundance, habitat selection, dietary preferences and prey availability are required to make any meaningful assessment of any such impacts. The presence of large numbers of dingoes in Kakadu National Park could also be an important factor in determining the impact of feral cats on native fauna. As such it would be prudent to give further consideration to dingo/cat interactions in any future research in this area.

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7. TRAINING FOR PARKS AUSTRALIA STAFF IN FAUNA SURVEY THROUGH A FIELD-BASED TRAINING CAMP

A training camp was held for rangers, traditional owners, scientists and other Park personnel over the period 20-26 September 2003, at Gunlom. Six staff from the Department of Infrastructure Planning and Environment attended the camp, and provided training in a broad range of activities related to wildlife survey, including:

- handling of mammals;
- capture of bats;
- use of Anabat detectors;
- bird identification and survey;
- mammal trapping;
- quadrat and grid-based sampling;
- radio-telemetry;
- data analysis;
- spotlighting;
- survey design;
- data basing and use of GIS;
- use of environmental pro-formas; and
- plant identification.

These training activities were augmented by students and staff from other institutions, including the Key Centre for Tropical Wildlife Management and Bushfires Council.

Fauna results from the training camp were compiled and documented in a separate report:

Woinarski, J.C.Z., and Hempel, C.J. (eds). (2003). *Report on mammal studies at Gunlom Ranger Training Camp, September 2003*. (NT Department of Infrastructure Planning and Environment: Darwin.).

Copies of that report have already been delivered to all ranger staff attending, and to the Parks Australia (North) library.

An internal appraisal of the training camp was prepared by Parks Australia North staff.

8. COMPILATION OF DATA BASES AND GIS LAYERS SHOWING EXISTING AND CURRENT FAUNA RECORDS

Plant and terrestrial animals data bases and GIS layers continue to be compiled, and can be distributed to Parks Australia staff whenever required. There are some issues to be resolved in use of these data bases:

custodianship. Currently the Biodiversity Unit, DIPE, maintains an overarching plant and animal data set. This can be downloaded at any time to PA, but the currency of the data set will become confused if the data set is added to independently by both PA staff and DIPE staff. This applies not only to who is adding in new data to which data set, but also to maintaining currency of taxonomic names.

compatability of GIS and data base software and storage.

inputs of additional and new data. Many PA staff make valuable wildlife observations; but relatively few of these observations are recorded or collated to a park-wide data base. It may be appropriate for PA to seek a tailored data base with attractive data entry process.

Appendix A.

Schedule for consultancy RS19 Vertebrate monitoring and re-sampling in Kakadu National Park 2002 Stage 3.

THE SCHEDULE

A. Proposal and quotation

This proposal is a continuation of the work completed in 2002-2003 Vertebrate Monitoring and re-sampling in Kakadu National Park Stage 2, as part of long term ongoing fauna monitoring in Kakadu National Park.

The VERTEBRATE MONITORING AND RE-SAMPLING IN KAKADU NATIONAL PARK – STAGE 3 2003-2004 will provide data towards 4 main objectives:

1. Provide data on species diversity and abundance prior to cane toads.
2. Assess changes in species diversity and abundance at sites recently invaded by cane toads
3. Investigate the apparent decline in species diversity and abundance in the northern regions of the Park in comparison with the southern regions of the Park;
4. continue the ongoing process of establishing fauna survey sites within or adjacent to established Fire Plot Monitoring Sites.

B. Consultancy Services

The consultancy service is for R19 VERTEBRATE MONITORING AND RE-SAMPLING IN KAKADU NATIONAL PARK – STAGE 3 2003-2004. This will involve:

(i) continuation of a monitoring program (for terrestrial vertebrate fauna) which will contribute to the assessment of impacts of cane toads;

(ii) assessment of vertebrate fauna at existing fire monitoring plots (and hence establishment of baseline for ongoing monitoring of the impacts of fire upon fauna at these plots);

(iii) investigation of change in vertebrate (and especially mammal) species composition at sites sampled in historic surveys, notably in the north of the park;

(iv) surveys of rare and threatened plants and assessment of current status;

(v) investigation of censusing and trapping methods for feral cats and dingos;

(vi) training for Parks Australia staff in fauna survey through a field based training camp; and

(vii) compilation of data bases and GIS layers showing existing and current fauna records.