Conservation values of the King Leopold, Oscar and Napier Range areas of the Kimberley region of Western Australia

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A report to
the Environmental Protection Authority

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Summary

In support of the Environmental Protection Authority's System 7 (Kimberley) recommendation 7.16 relating to the King Leopold Ranges, the Authority commissioned a report on the conservation significance of the area. The report reviews the biological data and land use practices of the area, and the results of a biological study in 1988.

Biological data are presented which identify areas of high conservation value in the King Leopold Ranges, in the central-west Kimberley. This area is identified as significant for the conservation of representative habitats in the Dampier and Fitzgerald Botanical Districts which will encompass a high percentage of the biological diversity of the region. Current proposed extensions in the Oscar and Napier Ranges conservation areas will ensure the protection of representative habitat types in the Devonian Reef limestone formations in the region.

Pastoral activity is the major land use in the central-west Kimberley. Preferential grazing of moderate and high potential pasture types particularly around the Oscar and Napier Ranges has caused degradation of these pastures in all but the inaccessible areas. The reduction in the abundance and structure of the vegetation has significantly reduced the fauna composition.

In comparison, less accessible areas with lower pastoral potential in the King Leopold Ranges have suffered a lower level of impacts (changed fire regimes and limited grazing) which has not led to major changes in the native habitat. These areas show a relatively undisturbed species-rich fauna composition.

Significant biological and geological areas in the King Leopold Ranges are represented by five major habitat types: minor riverine systems, rocky hillslopes and summits, undisturbed grasslands, wetland habitats, both high in the ranges and at the base of the ranges, and the gorges.

The area contains new plant species, ferns, palms (*Livistona* sp.) and lichens as well as other species formerly not recorded for the area.

The highest diversity of native mammals (11 species), including five species not found elsewhere in the study area, were found on the plains at the base of and surrounding the King Leopold Ranges and the minor creek systems. Of particular significance were the four medium-sized mammal species which are lacking in the major river systems of the Oscar and Napier Ranges. Three new important species records for the area are the Striped-faced Dunnart (*Sminthopsis macroura*), Northern Brown Bandicoot (*Isoodon macrouris*), and the rare Rock Ringtail Possum (*Pseudocheirus dahli*).

1. Introduction

1.1 Background

In 1988 the Royal Geographical Society, England, and the Linnean Society, London, held a scientific expedition to the central-west Kimberley. This area included the King Leopold, Oscar and Napier Ranges. Scientists from a variety of disciplines collected information on the geomorphology, botany, ecology and hydrology of the area. Information from some of the work undertaken during this expedition is included in this report. The main reference to the expedition is the work undertaken by Sawle (1988) who surveyed the native mammals and discussed the associated habitat. The 12 week study, funded by the Western Australian Heritage Committee and Australian Geographic, was carried out as part of an Honorary Research Associate position with Murdoch University.

1.2 Aims

This report focuses on the native flora and fauna and past and present land use patterns in the King Leopold, Napier and Oscar Ranges, central-west Kimberley. Some areas within these regions have been proposed for National Parks and conservation reserves following the recommendation of the Environmental Protection Authority (EPA) System 7 Red Book and the

submission of the Department of Conservation and Land Management (CALM, 1987) to the Kimberley Regional Planning Study. Information on the flora and fauna of these areas is limited and little is known of what changes there have been, if any, since the arrival of Europeans and the development of the pastoral industry which is one of the most widespread land uses in the Kimberley.

This report aims to add to the existing knowledge of the flora and fauna and to provide a basis to determine appropriate and adequate conservation reserves in the area. Recent records of the flora and fauna have been compared with historical records to determine whether there has been any change in biological composition of the area. To assess possible impacts on the native flora and fauna, this information is related to the land use practices which have been operating in the area since the arrival of Europeans. Areas recognised as representing significant flora and fauna habitats in this report are compared with the reserves recommended in the Department of Conservation and Land Management submission (CALM, 1987) to the Kimberley Regional Planning Study.

1.3 Location

The area reviewed in this report is indicated in Figure 1 showing the location of the King Leopold, Napier and Oscar Ranges, the major river systems and gazetted national parks. The area between the coast and Napier Range includes undulating grassy plains with a sparse overstorey and the major riverine systems of the Fitzroy and Lennard Rivers. The Napier and Oscar Ranges provide an abrupt change to the plains with high cliffs of Devonian limestone. Within the ranges, the Lennard and Fitzroy Rivers have carved spectacular gorges through the limestone, creating picturesque and popular tourist sites at Windjana and Geikie Gorges. A lesser known and smaller gorge, Brooking Gorge, is an attractive waterhole in the Oscar Range.

Approaching the King Leopold Ranges the vegetation becomes more dense and the terrain more rugged and less accessible than the Napier Range. Within the steep sided ridges there are deep gorges and springs leading to pools. A spectacular example includes Bell Gorge (Photograph 1).

1.4 Climate

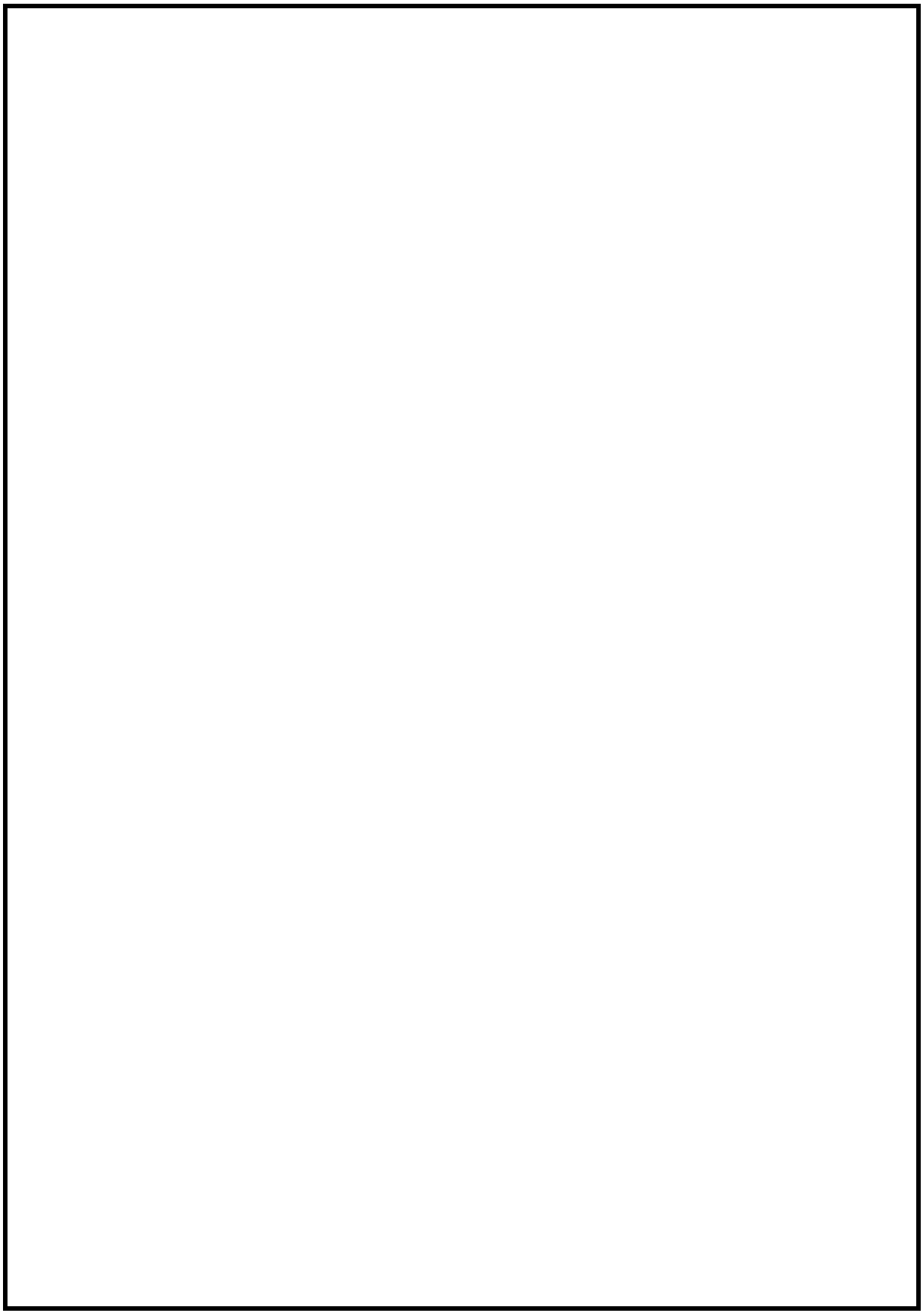
The central-west Kimberley lies in the monsoonal zone of Western Australia where almost all of the rainfall occurs between November and April. During the remainder of the year falls are light and sporadic; and several consecutive rainless months at this time are not uncommon. Temperatures during the day are high throughout the year, but particularly prior to the wet season, when maxima over 40°C are frequent. Marked seasonal contrasts in humidity, cloud and radiation are also characteristic.

The variation in the weather patterns within the central-west Kimberley is shown in Figure 2; the rainfall, 500 mm per annum in the south, increases in a north-north-west direction to 1000 mm per annum. The higher rainfalls closer to the north-west coast are associated with the westerly winds prevailing in the wet season and its proximity to the paths of cyclones. The flora within the central-west Kimberley varies in accordance with these rainfall patterns, as one of the most important factors affecting species composition and distribution is available moisture.

Using rainfall data from stations situated at different locations within the central-west Kimberley it is possible to compare the variations in the periods of time available for plant growth. Longer and heavier periods of rainfall indicate a longer growing season as there is more available moisture for plant growth. Figure 2 shows the variation in the rainfall between Mount Hart station in the King Leopold Ranges and Brooking Springs and Napier Downs stations in the Napier Range. The rainfall at Mount Hart station is greater and falls over a longer period than the other stations indicating a more favourable area for plant growth. This difference in the available moisture affects the composition of plant species in the area.

Although these rainfalls vary from year to year, the figures are averages over five years and

present the general pattern.



Photograph 1. Spectacular Bell Gorge, King Leopold Ranges

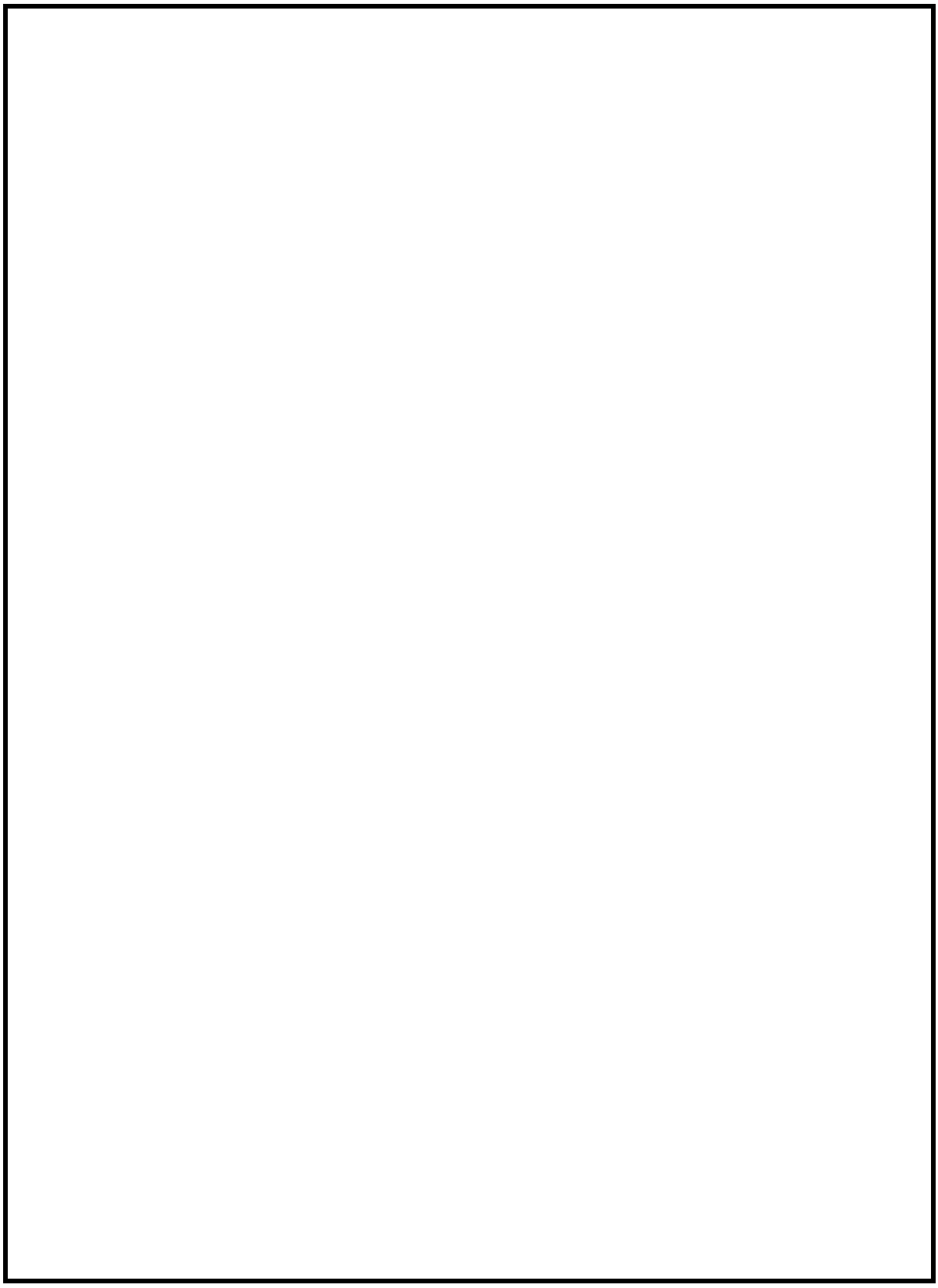


Figure 1. Map of central-west Kimberley, Western Australia

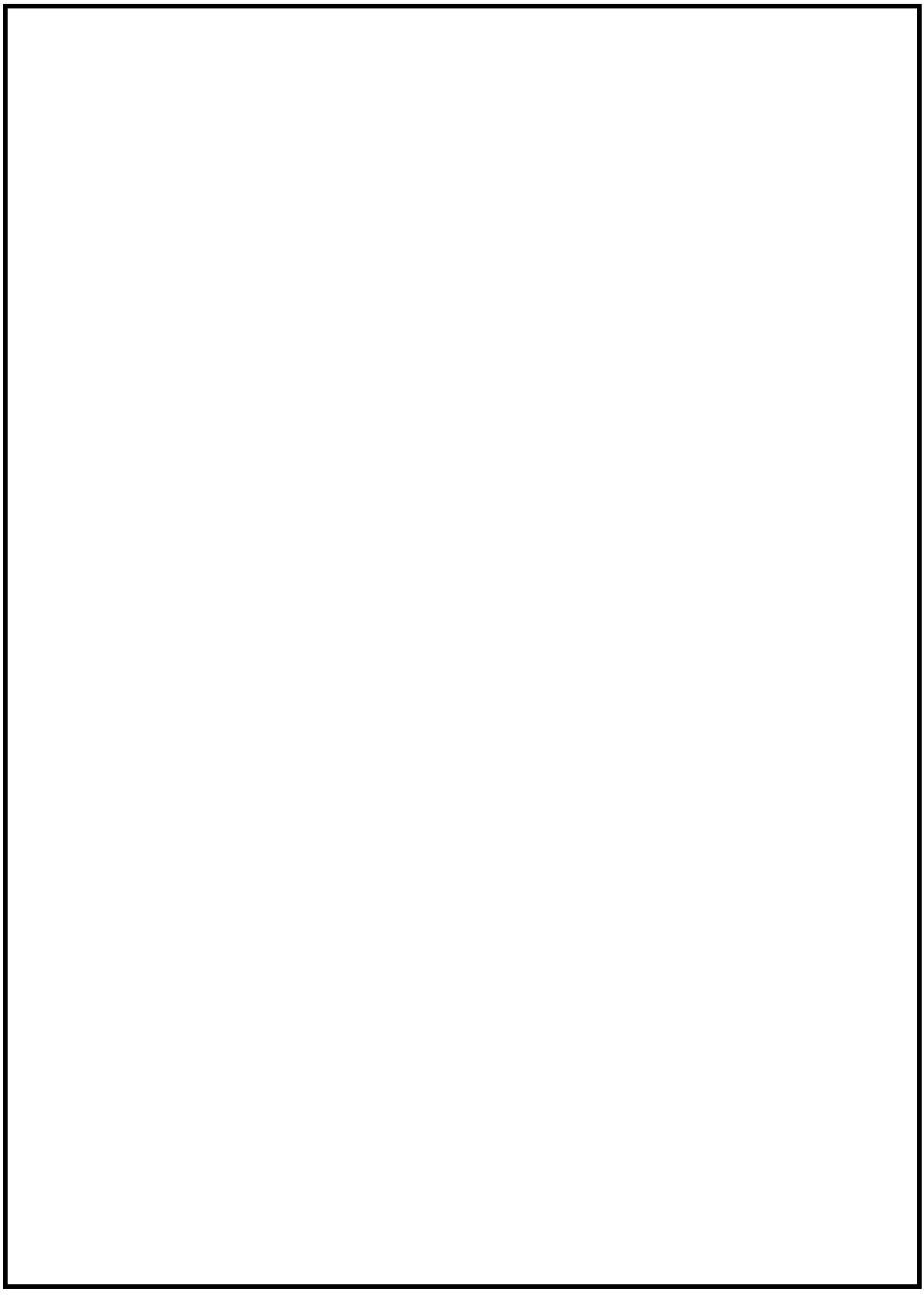


Figure 2. Mean annual rainfall isohyets for the Kimberley and average monthly temperatures and rainfall for some stations in the central-west Kimberley

1.5 Landforms and vegetation

The area of the central-west Kimberley referred to in this report includes two of the botanical districts described by Beard (1979): the Dampier and Fitzgerald districts (Figure 1).

The Dampier District includes the area south of the King Leopold Ranges to the Great Sandy Desert. The components of this district were described by Beard:

Geology: Quaternary sandplains and alluvia with local outcrops of Phanerozoic sandstone and reef limestone.

Topography: Mainly plains, local rugged sections represented by the Devonian limestone of the Napier and Oscar Ranges.

Vegetation: Characteristic pindan on sandplains more or less densely wooded according to rainfall; tall grass savanna with or without scattered trees on clay plains; spinifex steppe on sandstone and limestone outcrops.

The Fitzgerald Botanical District includes the King Leopold Ranges and is described as:

Geology: Mainly siliceous rocks; Proterozoic sandstones, granite, shale and acid volcanics.

Topography: Rugged ranges and hills of the Kimberley Foreland, portion of the Kimberley plateau.

Vegetation: Mainly communities with a curly spinifex ground layer on siliceous rocks. Some tall grass savanna woodland on basic volcanics, short grass savanna on dry calcareous plains, tree steppe on shale.

1.6 Pasture lands

The central-west Kimberley has been described as containing the most extensive areas of high potential pasture land in the Kimberley (Table 1), where 20% of the area is regarded as high or medium pasture land compared to 17% for the north Kimberley and 16% for the east Kimberley (Hacker, 1982). The reason for this is the composition of the grasslands and the presence of the major riverine systems. Suitability of pasture lands is determined mainly by the topography and the nature of the soils and associated vegetation. Lands regarded as unsuitable for pastoral purposes are generally rugged, poorly accessible, with hard spinifex and annual sorghum species. This applies to the rugged ranges and rocky hillslopes of the King Leopold, Napier and Oscar systems. At the other extreme are lands of high pastoral potential which comprise the extensive clay plains of unrestricted access associated with the major drainage systems. The extensive plains surrounding the Napier and Oscar Ranges support the productive black soil plains pasture type, consisting largely of Mitchell grasses and the more complex, but highly productive, frontage grass pasture type.

Table 1: Pasture lands of the west Kimberley region (Hacker, 1982)

Pastoral value	Area km^2	Percentage of survey area	Pasture types*
high	13,700	11.00	Mitchell grass, Mitchell grass - ribbon grass Mitchell grass - spinifex
medium	11,700	9.4	Ribbon grass, white grass - annual sorghum
low	61,600	49.2	Littoral, pindan, pindan - ribbon grass, soft spinifex, curIy spinifex
very low	38,000	30.4	Hard spinifex, inaccessible areas

*See Appendix A for scientific names of the grasses

Pastures vary within the central-west Kimberley from the unpalatable hard spinifex to palatable but poorly productive curly spinifex, to the more productive curly spinifex-ribbon grass, ribbon grass-white grass, bundle bundle and short grass pastures, some of which include small areas of highly productive black soil plain pastures. The carrying capacities of these various pasture lands is dependent on the condition of the pastures which is related to past land use as well as rainfall which varies greatly from year to year.

2. Vegetation

2.1 Flora

There have been extensive vegetation surveys in the Kimberley that have included the central-west area. Beard (1979) described the vegetation of the Kimberley, providing reasonably detailed information on the floristics and structure of the vegetation. A more detailed description, focusing on the west Kimberley, was undertaken by CSlRO (Speck *et al.*, 1964) which assessed the rangeland conditions. This work provided specific information on the vegetation communities and the distribution of these in relation to landforms. These works represent the most comprehensive studies covering the whole of the west Kimberley, however, there have been more recent biological studies on specific sites in the central-west Kimberley, particularly the King Leopold, Napier and Oscar Ranges (Kimberley Research Project, 1988 unpublished results). The results of the 1988 studies provided additional information on the status of some plant species and details on species previously unrecorded in the area.

Survey work during 1988 found that, although the geology of the Napier and King Leopold Ranges differed markedly, their savannah type vegetation was generally similar. The King Leopold Ranges appeared to have a greater species richness than the other areas, possibly because of the physiography of the ranges. The King Leopold Ranges is composed of dissected sandstone with shallow sands and intruded with Hart Dolerite, which forms red dense loamy acid soils in the valleys. Deep shady areas and semi or permanent pools of water, as well as waterfalls, occur in the ranges. The Napier Range consists mainly of large exposed blocks of Devonian limestone with shallow, alkaline soils. There is the occasional small valley created by active water erosion. Permanent water areas are absent except in the deep river gorges of the south-eastern part of the range (Cranfield, 1989).

The effect of insolation on the differing rock surfaces of the two ranges appears to vary greatly. The limestone rocks of the Napier Range apparently heat more rapidly and stay warmer longer than the more reflective rocks of the Leopolds. Thus the Napier Range with its alkaline soils is a harsh environment, differing from the surrounding country. However, although endemism would be expected to be high, this was not the case as was found in the 1988 survey. The survey did reveal there were some species that appeared to be restricted to the Napier Ranges. One plant likely to be a new endemic species belonged to the genus *Acalypha* (Euphorbiaceae), but this has yet to be fully determined (Cranfield, 1989a).

During two weeks of the project a botanical collection of grasses by Simon (1989) within four of the 32 physiographic units described by Beard (1979) found 30% of the grasses. In addition, the survey found new records of grass species within the botanical districts described by Beard, including 31 new records for the Dampier District and 28 for the Fitzgerald District. Specimens of particular note included a new species, *Triodia pascoeana*, found in the Napier Range near Yamera Gap, east of Windjana Gorge. *Brachiaria praetervisa*, collected near the Lennard River, south of the Napier Range, was the first recorded collection of this specimen for Western Australia. *Bothriochloa pertusa* from Fern Creek, King Leopold Ranges, is the first recorded collection of this naturalised Indian species from Western Australia. It is fairly widespread in Queensland and a common weed in Darwin. New records for the Kimberley of particular interest included *Aristida polyclados, Brachiaria windersii, Mnesithea granularis, Plectrachne pungens var. callosum* and *Setaria dielsii* (Simon, 1989).

A gorge above Bell Creek in the King Leopold Ranges contained possibly a new species of fern, belonging to the genus *Isoetes* (Jacobs, pers. comm.).

Several interesting botanical specimens were collected from the King Leopold Ranges in the gullies above Bell Creek and the Lennard River, representing extension of geographic ranges and possibly new species. These records have yet to be determined. The gullies in the ranges provided records of palm species, *Livistona* (species undetermined) (Blackwell, pers. comm.). During the Kimberley 1988 survey, Blackwell (pers. comm.) recorded palm species (*Livistona* spp.) in the gullies running northwards on the Mount Herbert to Mount Broome ridge of the King Leopold Ranges. Approximately 20 km to the east between The Rocks and Mount Gladys, van Leeuwen (1984) recorded a spectacular, large leaved, large trunked species of *Livistona* in dense stands along a permanent creek gorge. A fine leaved, much more slender palm, *Livistona loriphylla*, occurs at Fern Creek on the Gibb River Road and elsewhere in the King Leopold Ranges. He noted that hybrids of the two species occur in the locations surveyed by Blackwell (above).

Van Leeuwen (1984) reports that *Cycas furfuracea*, a cycad belonging to an ancient group of plants, grows on the summit of Mount Ord. It is believed that this species is confined to the King Leopold Ranges.

A recent botanical survey has discovered new species and extended ranges of known plants, and has been sufficient to identify the King Leopold and Napier Ranges as botanically significant and in need of a systematic survey. In comparison, only limited new records were found on the plains which have had the habitat disturbed by pastoral activity.

2.2 Wetlands

The wetlands and associated aquatic flora identified during the recent 1988 (Jacobs, pers. comm.) survey updated information on the distribution and status of aquatic habitats in the area. In addition, information was collected on previously unrecorded plant species for the area. The wetland habitats of the King Leopold, Napier and Oscar Ranges were represented by (Jacobs, pers. comm.):

i Black soil or floodplain billabongs - these systems occur on fertile alluvial self-mulching soils found after rivers break through the ranges, spread out and slow down. These areas are often not deep and vary in permanence.

The significant features of this habitat type in the central-west Kimberley include:

- Brooking Springs billabong (near Brooking Gorge) which contained a new and endemic taxon, possibly a species of *Nymphacea.*
- Lennard River on the plains south of the Napier Range - a new sub-species of *Ottelia* related to *O. ovalifolia.* The distribution of this sub-species is concentrated in the Kimberley but may occur in isolated locations in the Pilbara and Northern Territory where suitable habitats occur.

ii Rocky gorges and creeks high in the ranges - these include sites at Silent Grove (off Bell Creek), Bell Gorge and small creeks within the King Leopold Ranges. This is the best represented and least disturbed habitat of the area, in good condition and characteristic of such habitats throughout the KimberIey.

iii High altitude swamps - above the creeks of (ii) and draining into them. These systems vary in seasonality, and are wet for a shorter period of time than creeks below. This uncommon wetland type for the area occurs on the northern side of the King Leopold Ranges on Mount Hart station.

iv Waterholes in gorges - deep waterholes fringed by *Eucalyptus camaldulensis* and *Melaleuca* spp. This system occurs in Windjana, Geikie, Bell and Brooking Gorges, the last differing physically from the other gorges. This probably explains the botanical significance of Brooking Gorge as it contained aquatic plants not represented elsewhere in the limestone range. It is a much smaller watercourse and flooding does not appear to be as severe as in the other gorges. The depth is more constant and aquatic species are able to grow.

v Rivers - longer lasting pools often spectacularly covered with *Nymphacea violacea.* No species of water plant is particularly common because of the limited amount of water in the central-west Kimberley. The water plants and their relative status which are known to occur in the King Leopold and Napier Ranges are listed in Table 2.

Table 2: Aquatic plants occurring in the King Leopold, Oscar and Napier Ranges (Jacobs pers. comm.)

Common	Less common/ more restricted species	Species with reducing distribution
Najas tenuifolia *Nymphoides indica* *Nymphaea violacea*	*Vallisneria gigantea* *Eriocaulon setaceum* *Eriocaulon* spp. *Cyperus* spp. *Fimbristylis* spp. *Eleocharis* spp. *Ultricularis* spp. *Ludwigia* spp.	*Potamogeton tricarinatus* *Caldesia oligococcaca* *Blyxa* spp. *Aponogeton elongatus* *Nymphoides* spp. *Echinochloa kimberleyensis* *E. macrandra*

2.3 Lichens

Galloway (1989) updated information on lichens of the Napier, Oscar and King Leopold Ranges. He found that the richest sites seemed to be on acidic rocks with south and south-west aspects. Discoveries of interest included species of the non-lichenised fungus Lichenothlia in the arid rock habitats. A cryptoendolithic growth of Cyanobacteria was found to occur on rock samples in the King Leopold Ranges.

Additional work by Elix (unpub) reported species of *Dirinaria* and a *Pyxine* to comprise the most common foliose species while the most common and ubiquitous crustose genera included *Aspicilia, Buellia, Lecidea, Pertusaria* and *Chrysothrix.* About six species of the squamulose genera *Peltula* were found but corticulous lichens were rare and scattered.

Sammy (unpub) found possibly two new species, both from Mount Percy in the Oscar Range, one of the genus *Physica* and another of *Parmelia.*

3. Fauna

3.1 Native mammals

Information on the fauna of the Kimberley has been collected in recent years by Department of Conservation and Land Management. These studies have concentrated on areas that are likely to become nature reserves or national parks (McKenzie *et al.*, 1975; 1977; 1983; Youngson *et al.*, 1981). In the central-west Kimberley there has been limited attention to the King Leopold and Napier Ranges as these areas are largely within pastoral leases.

Surveys similar to those undertaken by Department of Conservation and Land Management in other areas of the Kimberley had not been done in the King Leopold and Napier Ranges until the work of Sawle (1988). There has been information collected on particular groups of the native fauna (land snails, Solem (1988)) and incidental collections of mammals and reptiles which are found in the records of the Western Australian Museum. There have been no published systematic surveys and there is very little information on the habitats and population status of the native mammals of the area.

The recent fauna survey by Sawle (1988), which included the Napier, Oscar and King Leopold Ranges and surrounding plains, provided information on the present distribution of the native animals. This survey concentrated on trapping small and medium-sized mammals, however, data was collected on all reptiles trapped and any other animals observed. The survey included

the variation in the habitat types by trapping in the major topographic units represented by:

- plains;
- riverine systems (major and minor);
- rocky hillslopes.

The survey trapped these units in six areas providing duplication of sites between and within the Napier and King Leopold Ranges. The distribution of the survey locations is shown in Figures 5 and 6. Sites surveyed in the Napier Range included Wagon Pass to Barker Gorge, Windjana and Brooking Gorges and surrounds. The King Leopold Ranges was surveyed from Bell Gorge to lnglis Gap and around the Lennard River on Mount Hart station. As the area from Bell Gorge to lnglis Gap did not include any major riverine areas only minor creek systems were surveyed.

In order to differentiate between the sites on a more detailed level than topography, the sites were assessed floristically. Each site surveyed was described on the basis of the dominant plant species occurring within the area. As would be expected the various topographical types were represented by different groups of dominant plant species. However, similar topographical types were further divided on the basis of different dominant plant species. The plant groups identified are summarised in Table 3.

The plains surrounding the King Leopold Ranges (Groups I and IA) differed in species composition and diversity to those surrounding the Napier Range (Group Il) - the latter having a less diverse dominant plant group. The plains surrounding the King Leopold Ranges were further divided to represent the area immediately below the slopes (Group IA) and those further away (Group 1).

The major riverine systems (Lennard and Barker) all represented the same dominant plant groups (Group IV), however, the minor creek systems, which only occurred in the King Leopold Ranges, represented a different group of dominant plants. The dominant plant species on the rocky hillslopes of the King Leopold Ranges (Group V) differed from those on the Napier Range (Group VI).

Table 4 indicates the distribution within the vegetation groups of the mammals found during the trapping survey.

As indicated in Table 4, certain plant groups supported a more diverse and abundant native fauna than others. The plains at the base and surrounding the King Leopold Ranges (Groups IA and I) included the highest diversity of native mammals. They included species not found elsewhere:

- Delicate Mouse (*Pseudomys delicatulus*)
- Western Chestnut Mouse (*P. nanus*)
- Forrest's Mouse (*Leggadina forresti*)
- Long-tailed Planigale (*Planigale ingrami*)
- Striped-faced Dunnart (*Sminthopsis macroura*)

The plains surrounding the Napier Range contained very few mammals and those that were found were individual animals:

- Striped-faced Dunnart (*Sminthopsis macroura*)
- Western Chestnut Mouse (*Pseudomys nanus*)

The minor riverine systems (Group Ill) in the King Leopold Ranges appeared to be the only suitable habitats for species requiring moist areas with a dense understorey:

- Pale Field Rat (*Rattus tunneyi*)
- Northern Brown Bandicoot (*lsoodon macrourus*)
- Northern Brushtail Possum (*Trichosurus arnhemensis*)
- Sugar Glider (*Petaurus breviceps*)

The major riverine systems (Group IV) supported no species of native mammal apart from a single Sugar Glider seen in the Lennard River in Windjana Gorge.

Table 3: Vegetation groups

Dominant plant group	Vegetation group						
	I	**IA**	**II**	**III**	**IV**	**V**	**VI**
Grass species	X	X	X	X	X		
Eucalyptus tectifica	X	X					
Heteropogon contortus	X	X					
Eucalyptus foelscheana	X	X	X				
Lysiphyllum cunninghamii			X				
Cochlospermun fraseri		X					
Hakea arborescens		X					
Corchorus sp.		X					
Themeda triandra		X					
Astrebla sp.		X					
Tristania grandiflora				X			
Eucalyptus camaldulensis				X			
Melaleuca argentea				X			
Terminalia platyphylla				X			
Eucalyptus papuana					X		
Albizia procerus					X		
Acacia suberosa					X		
Melaleuca leucodendron					X		
Adansonia gregorii							X
Triodia wiseana							X
Ficus playtpoda							X
Owenia sp.						X	
Triodia pungens						X	
Acacia sp.						X	
Heterodendron sp.						X	
Ficus leptochila						X	

Vegetation groups (topographic units)

Group I = King Leopold Ranges - plains
Group IA = King Leopold Ranges - plains (base of rocky slopes)
Group II = Napier Range - plains
Group III = King Leopold Ranges - riverine systems (minor)
Group IV = King Leopold and Napier Ranges - riverine systems (major)
Group V = King Leopold Ranges - rocky hillslopes
Group VI = Napier and Oscar Ranges - rocky hillslopes

Data from Sawle (1988)

Table 4: Occurrence of mammals within the vegetation groups

Mammals	Vegetation group						
	I	**IA**	**II**	**III**	**IV**	**V**	**VI**
Tachyglossus aculeatus (Spiny Anteater)						uc	uc
Dasyurus hallucatus (Northern Quoll)				uc		c	
Sminthopsis macroura (Striped-faced Dunnart)	uc		r				
Planigale ingrami (Long-tailed Planigale)	uc	uc					
Isoodon macrourus (Northern Brown Bandicoot)				uc			
Pseudocheirus dahli (Rock Ringtail Possum)						uc	
Petaurus breviceps (Sugar Glider)		uc		c	r		
Trichosurus arnhemensis (Northern Brushtail Possum)		uc					
Zyzomys argurus (Common Rock Rat)						c	c
Pseudomys nanus (Western Chestnut Mouse)	uc	uc	r				
Pseudomys delicatulus (Delicate Mouse)	c						
Leggadina forresti (Forrest's Mouse)	c	uc					
Rattus tunneyi (Pale Field Rat)				uc			
Onychogalea unguifera (Nailtail Wallaby)	uc	uc	r				
Petrogale brachyotis (Short-eared Rock Wallaby)						c	
Macropus agilis (Agile Rock Wallaby)	c	c	c				
Macropus robustus (Common Wallaroo)	uc	uc	uc			c	c
Macropus antilopinus (Antilopine Wallaroo)	uc					uc	
Macropus rufus (Red Kangaroo)	uc	uc	uc				
Canis familiaris (Dingo)			uc				
**Felis catus* (Feral Cat)			uc				
**Equus caballus* (Horse)			uc				
**Equus asinus* (Donkey)	uc		c				
**Sus scrofa* (Pig)				r			
**Bos taurus* (Cattle)	uc	uc	c	uc	c	uc	uc

c = common (> 10 individuals collected) * introduced species
uc = uncommon (3-9 individuals collected)
r = rare (< 3 individuals collected)

The rocky hillslopes of the King Leopold Ranges (Group V) included the following species:

- Common Rock Rat (*Zyzomys argurus*) (Photograph 2)
- Northern Quoll (*Dasyurus hallucatus*)
- Rock Ringtail Possum (*Pseudocheirus dahli*)
- Short-eared Rock Wallaby (*Petrogale brachyotis*)

whereas the Napier Range (Group VI) supported populations only of the Common Rock Rat.

Although not indicated in the table, there were differences in the distributions of the mammals within the same vegetation group. This suggested that, although the habitat appeared suitable, it did not necessarily mean that it would support species found in similar habitats. The vegetation groups I and IA and V, the plains and rocky hillslopes of the King Leopold Ranges, contained a diverse fauna around the Bell Creek to lnglis Gap area, but not in other areas. The sites around the Lennard River were depauperate of species; only one species was found - the Long-tailed Planigale (*Planigale ingrami*).

The numbers of native mammals in the Oscar and Napier Ranges were so low (apart from bats) that it is difficult to comment on any differences between and within vegetation groups. However the rocky habitats of Windjana Gorge and Brooking Gorge supported high numbers of the Common Rock Rat (*Zyzomys argurus*) compared to very few or none found in other areas (Wagon Pass to Barker Gorge).

Photograph 2. Common Rock Rat (*Zyzomys argurus*)

The abundance status of the native mammals varied; apparently some species have more specific habitat requirements or were simply lower in numbers than others. The most frequently occurring species was the Common Rock Rat (*Zyzomys argurus*) which was found in all the rocky slope habitats in varying numbers apart from the slopes surrounding the Lennard River in the King Leopold Ranges. Other common species included Forrest's Mouse (*Leggadina forresti*) and the Delicate Mouse (*Pseudomys delicatulus*) which only occurred on the plains around Bell Creek and Mount Bell surrounding the King Leopold Ranges. Common in the minor riverine systems were the Northern Brown Bandicoot (*Isoodon macrourus*) and Sugar Glider (*Petaurus breviceps*).

Less common species included the Northern Quoll (*Dasyurus hallucatus*) which was found on the rocky slopes of the King Leopold Ranges around Bell Creek although similar habitat was present, it was not found near the Lennard River. Similarly, the Pale Field Rat (*Rattus tunneyi*) had a restricted distribution as it was only found around the Mount Bell to lnglis Gap area in minor creek systems. Species that were uncommon but found in and around the King Leopold and Napier Ranges included the Western Chestnut Mouse (*Pseudomys nanus*), Striped-faced Dunnart (*Sminthopsis macroura*) and the Long-tailed Planigale (*Planigale ingrami*). However, as these species were found in such low numbers, it is difficult to determine their actual status. Other species which were low in numbers included the Rock Ringtail Possum (*Pseudocheirus*

dahli) and the Northern Brushtail Possum (*Trichosurus arnhemensis*). The locations of the possums, Northern Brown Bandicoot (*Isoodon macrourus*) and the Striped-faced Dunnart (*Sminthopsis macroura*), all represented interesting records as there are very few records of these animals in the area.

The results indicate that the species diversity and status varied according to the location and vegetation type. Areas around the Napier, Oscar and King Leopold Ranges surrounding the Lennard River supported a depauperate fauna compared with the other sections of the King Leopold Ranges.

Photograph 3. Northern Brown Bandicoot (*Isoodon macrourus*)

The most diverse and abundant group of the native mammals was found in the area of Bell Gorge, Bell Creek tributaries and Mount Bell to lnglis Gap. These areas included the following species:

- Delicate Mouse (*Pseudomys delicatulus*)
- Forrest's Mouse (*Leggadina forresti*)
- Striped-faced Dunnart (*Sminthopsis macroura*)
- Long-tailed Planigale (*Planigale ingrami*)
- Pale Field Rat (*Rattus tunneyi*)
- Northern Brown Bandicoot (*Isoodon macrourus*) (Photograph 3)
- Northern Brushtail Possum (*Trichosurus arnhemensis*) (Photograph 4)
- Rock Ringtail Possum (*Pseudocheirus dahi)*
- Northern Quoll (*Dasyurus hallucatus*)
- Sugar Glider (*Petaurus breviceps*)
- Short-eared Rock Wallaby (*Petrogale brachyotis*)

These records include all the animals expected to occur in the area and represent the highest diversity of native mammals in the area.

The difference in the distribution of the native mammal fauna can be further assessed by comparing the range of different sized animals occurring between the areas (Table 5). The native mammals are grouped into three classes:

- small-sized mammals - small marsupials and rodents
- medium-sized mammals - quolls, possums, sugar gliders, bandicoots and rock wallabies
- large-sized mammals - large macropods

Photograph 4. Northern Brushtail Possum (*Trichosurus arnhemensis*)

As indicated in Table 5, there are few small mammals and no medium-sized mammals around the Napier Range sites, nor site 5, in the King Leopold Ranges which surrounds the Lennard River. The highest diversity of animal size classes occurred in sites 1 and 6, between Bell Gorge to Inglis Gap. Site 5 in the King Leopold Ranges supported fewer mammals in the small and large size classes and none in the medium-sized class. A similar pattern applies to the Napier and Oscar Ranges.

The low number of small and medium-sized mammals along the major riverine systems is a significant result of the survey as these areas would be expected to support populations of the Sugar Glider, (*Petaurus breviceps*), Northern Brushtail Possum (*Trichosurus arnhemensis*), Bandicoot (Golden and Northern Brown) (*Isoodon auratus and I. macrourus*) and Pale Field Rat (*Rattus tunneyi*). All these species apart from the Golden Bandicoot were found in the minor creek systems that led off Bell Creek or at the base of the King Leopold Ranges.

Table 5: Distribution and frequency of three size classes of mammals

	King Leopold Ranges			Napier Range		
Trap-site (Figures 5&6)	1	6	5	2	3	4
Small-sized mammals	4	2	2	2	1	-
Medium-sized mammals	4	4	-	-	-	-
Large-sized mammals	4	2	2	2	2	2

Although the 1988 survey found relatively few mammals around the Napier and Oscar Ranges, previous surveys, particularly between 1960 and 1976, have found a greater diversity of mammals in the area. This is indicated in Table 9 for the Napier Range along with records of the Western Australian Museum for other parts of the ranges. It is possible that there is a higher diversity of mammals than suggested by the survey but as so few were found compared to the King Leopold Ranges it is possible that numbers have been declining, resulting in the extremely low numbers found during 1988.

The composition of the native mammal fauna of the King Leopold Ranges and Napier Ranges can be compared with other areas of the Kimberley, based on the results of surveys undertaken by Department of Conservation and Land Management. The King Leopold Ranges has a similar fauna composition to that of the Prince Regent River in the north Kimberley. However, the Prince Regent has a more diverse and abundant fauna, possibly due to the greater range of habitat types and less disturbed environment.

The survey also assessed the occurrence of introduced mammals which included cattle, feral cat, donkey and horse. The occurrence of cattle will be discussed in more detail later in this report. Feral cats were frequently observed around rocky outcrops and riverine systems of the Napier Range. Similarly, donkeys were also common on the plains surrounding Napier Range and around the Lennard River on Mount Hart Station.

Bats

Survey work in 1988 (Coles, pers. comm.) on the bat fauna of the King Leopold, Oscar and Napier Ranges, provided additional information, including records of populations of rare/uncommon species. All these species were found in caves within the Napier and Oscar Ranges, the numerous caves and rock shelters in these ranges providing ideal habitats. These species included:

- Dusky Horseshoe-bat (*Hipposideros ater*);
- Orange Horseshoe-bat (*Rhinonicteris aurantius*);
- Ghost Bat (*Macroderma gigas*).

In the Napier Range, a large colony (100+) of the carnivorous Ghost Bat (*Macroderma gigas*) was found in the Tunnel Creek cave. Individuals were frequently found roosting in isolated caves extending along the Range, including areas west of Barker Gorge and eastwards to the cliffs at Maroon Cliffs, the western edge of the Oscar Plateau. It seems likely that the Tunnel Creek site is a major maternity roost, despite flooding in the wet season, as suitable roost sites and prey are severely limited.

Other cave dwelling bat species found were:

Common Sheathtail-bat	*Taphozous georgianus*
Yellow-bellied Sheathtail-bat	*Taphozous flaviventris*
Little Broad-nosed Bat	*Scotorepens greyii,*
Western Broad-nosed Bat	*Scotorepens balstoni,*
Little Cave Eptesicus	*Eptesicus pumiIus,*

Yellow-lipped Eptesicus	*Eptesicus douglasi,*
Dusky Horseshoe-bat	*Hipposideros ater*
Orange Horseshoe-bat	*Rhinonicteris aurantius.*
Northern Mastiff-bat	*Chaesophon jobensis*
Gould's Wattled Bat	*Chalinolobus gouldii*

Additional species trapped over water surfaces included:

Little Broad-nosed Bat	*Scotorepens greyii*
Western Broad-nosed Bat	*Scotorepens balstoni*

Several colonies of the rare Orange Horseshoe-bat *(Rhinonicteris aurantius)* and the Dusky Horseshoe-bat *(Hipposideros ater)* were studied in the Napier and Oscar Ranges, including a colony near Geikie Gorge and east of the Oscar Range. The Orange Horseshoe-bat (*Rhinonicteris aurantius*) is of considerable interest due to its restricted range and because it belongs to a monotypic genus, endemic to Australia. The Dusky and Orange Horseshoe-bats (*Hipposideros ater* and *Rhinonicteris aurantius*) were often found to roost in the same caves since they both prefer a similar microclimate (temperature 29-36°C; relative humidity >90%). Only two colonies of the Orange Horseshoe-bat *(Rhinonicteris aurantius)* are known to occur in the region, which reflects their strict habitat requirements (Coles and Guppy, 1989).

The Black Flying Fox *(Pteropus alecto)* and the Little Red Flying Fox *(P. scapulatus)* were common along the Lennard River and minor creek systems within the King Leopold Ranges where they were observed feeding on flowering *Eucalyptus miniata* and *Sesbania* spp.

3.2 Herpetofauna

Data on the herpetofauna of the central-west Kimberley is limited and even more so for the King Leopold and Napier Ranges. Information is limited to incidental collections and expectations of occurrences based on the available habitat information. Data collected during the 1988 mammal survey provided the most detailed information on the herpetofauna of the area to date. The results of this survey are listed in Table 6 indicating the distribution within the vegetation group distinguished during the fauna survey (Section 3.1). The highest diversity of reptiles occurred around the King Leopold Ranges, particularly between Bell Creek to lnglis Gap. The reptile fauna around the Napier Range was not as depauperate as the native mammal fauna.

There was a marked variation in the composition of the herpetofauna within the various vegetation groups. That is, there was not a great overlap in the occurrence within different habitat types. The difference in the species diversity and abundance was not as great as that for the mammals, apart from the area around Brooking Springs where very few reptiles were collected.

Species of interest that were collected included the uncommon species of blind snakes *Ramphotyphlops ligatus* and *R. uniguirostris*. Both were found on the plains surrounding the Lennard River near the King Leopold Ranges.

3.3 Terrestrial snails

During the 1988 survey, Cameron followed the earlier taxonomic work of Solem (1988) who found the terrestrial snail fauna of the Napier and Oscar Ranges endemic and unusually restricted in their distribution. Cameron also found:

- many large Camaenid species, mostly endemic to the hills, with very small (a few square kilometres) ranges, which varied dramatically in species composition and replaced one another sequentially along the ranges (Table 7);
- a number of smaller species of wider distribution, most of which were found throughout the Oscar and Napier Ranges;

- the preferred habitat of the terrestrial snail fauna appeared to be moist, unburnt "vine-thicket" patches, usually near rock faces.

Table 6: Occurrence of herpetofauna within vegetation groups

Species	Vegetation group						
	I	IA	II	III	IV	V	VI
Uperoleia sp.				uc	uc		
Litoria wotjulumensis		uc					
Limnodynastes ornatus				uc	uc		
Crocodylus johnstoni					c		
Diplodactylus ciliaris					uc		
Diplodactylus stenodactylus		c			c		
Rhynchoedura ornata	uc						
Gehyra nana	c						
Gehyra variegata					c		
Heteronotia binoei	c		c		c		
Delma borea				uc			
Lialis burtoni			uc				
Chlamydosaurus kingii	uc						
Diporiphora lalliae	uc						
Varanus scalaris		uc					
Tympanocryptis lineata macra			uc				
Carlia foliorum	c		c				
Cryptoblepharus plagiocephalus		uc					
Ctenotus pantherinus	c		c				
Ctenotus sp.	uc						
Ctenotus robustus	c		c	c	c	c	c
Ctenotus piankai	uc						
Notoscincus wotjulum	uc						
Sphenomorphus isolepis isolepis				r			
Ramphotyphlops ligatus			r				
Ramphotyphlops unguirostris	r						
Liasis childreni						uc	
Boiga irregularis					uc		c
Demansia atra						c	
Pseudechis australis	uc				c		uc
Vermicella approximans							uc

c = common (> 10 individuals collected)

uc = uncommon (2-9 individuals collected)

r = rare (< 2 individuals collected)

Table 7: Distribution of endemic terrestrial snails of the Napier and Oscar Ranges (Cameron, pers. comm.)

Species	Location (see below)					
	1	**2**	**3**	**4**	**5**	**6**
Amplirhagada napurana	X	X				
Amplirhagada percita	X	X				
Amplirhagada burnerensis b			X	X		
Amplirhagada burnerensis u			X			
Quistrachia monogramma					X	
Westaltrachia woodwardi	X					
Westaltrachia commoda		X				
Westaltrachia turbinata		X				
Westaltrachia inopinata			X			
Westaltrachia froggatti c			X			
Westaltrachia froggatti f			X			
Westaltrachia derbyi				X		
Westaltrachia altarna					X	
Westaltrachia cunicula					X	X
Westaltrachia oscarensis					X	X
Westaltrachia tropida						X
Westaltrachia rotunda						X
Westaltrachia limbana						X
Torresitrachia limbana				X		
Kendrickia igniresnatus	X					
Kimboraga micromphala				X		
Mouldingia occidentalis					X	

Locations (see Figures 5 & 6)

1 - Barker Gorge

2 - Yamera Gap

3 - Windjana Gorge

4 - Carpenter and McSherry Gap

5 - Fairfield Valley

6 - Brooking Gorge

All the Camaenids, except *Rhagada* species and *Torresitrachia monticola,* are found only in the Oscar and Napier Ranges. Table 7 lists these endemic species and their distribution in the ranges. As indicated in the table, the species do have very restricted distribution with different species occurring in the north-west to those in the south-east of the ranges. Other Camaenid species found by Cameron in the Oscar and Napier Ranges included *Rhagada gatta, R. mimika, R. basedowana, R. satra* and *T. monticola.* Cameron also found other groups of species including *Gastrocopta recondita, G. simplex, G. macrodon, G. larapinta, Gyliotrachela napierana, Pupoides pacificus, Eremopeas interioris, Stenopylis coarctata, Discocharopa aperta, Westracystis lissus* and *Wilhelminaia mathildae.*

Cameron (pers. comm.) suggested that as the distribution of the endemic species varied so dramatically, all of the Napier and Oscar Ranges were significant sites as they contained different species of endemic snails. He suggested two areas that were particularly important:

1. Brooking Gorge - This area supported a very rich snail fauna and suitable habitat. There were areas of unburnt spinifex - the preferred habitat of certain species. It is one of the few places in the ranges to maintain deep standing water through the dry season.
2. The whole northern end of the Napier Range from Wagon Pass to Barker Gorge - This area is currently not included in any conservation reserves but added to the proposed reserves (Section 8) it would provide adequate representation of the endemic land snails.

The King Leopold Ranges support terrestrial snails, but different species and very little is known about the composition of the populations. It is possible that areas such as Silent Grove and Bell Gorge have endemic species, and for that reason represent significant sites for future research (Cameron, pers. comm.).

4. Historical records

4.1 Flora

Botanical collections and description by early explorers, sometimes accompanied by botanists in the central-west Kimberley, were generally plant lists of the area. Forrest collected botanical specimens for Mueller (1880), and later Brockman, accompanied by the naturalist and botanist Dr F M House (1902), collected specimens prior to the impact of the pastoral industry. These collections provided little information on the distribution and status of plants and represented very broad descriptions of the area. It wasn't until 1921 during an expedition led by E R Easton, accompanied by the botanist C A Gardner, that the first complete botanical description of the area, including structure, composition and taxonomy, was undertaken. Although Gardner (1923) provided more detailed studies than previous surveys, his work still represented very broad scale descriptions.

Therefore, it is difficult to decide whether there have been any changes to the vegetation. Comparing the past and present broad scale descriptions it appears the plant species composition in the south-west Kimberley has not changed significantly. However, it is possible to look at changes to the vegetation at a smaller scale by comparing specific site descriptions by early naturalists to the condition today.

Beard in his vegetation survey of the Kimberley (1979) commented that:

"Although, therefore, there has been little or no land cleared in the Kimberley for urban or agricultural purposes, the plant cover has been modified locally by grazing."

In a study of the Dampier Peninsula, McKenzie *et al.* (1983) referred to the difference in the description of the coastal sand-hill country. Dahl (1897) described the country with thickets of *Acacia* species over tussocks of *Spinifex longifolius*, whereas the 1983 study showed that the sandy surface was completely churned up; much of the *Acacia* and spinifex was trampled. The Dampier Peninsula since 1890 has been subject to pastoral activity involving intensive grazing, very frequent burning and some localised clearing practices not conducive to regeneration of tree species and the persistence of the shrub layer and leaf litter.

"Trampling damage was especially apparent in the species rich communities along watercourses; along ephemeral swamplands and the sub-coastal semi-deciduous vine forests; sites where cattle congregate." (McKenzie *et al.*, 1983).

Similar findings regarding the riverine systems were also identified by Kitchener (1978):

"These woodlands appear to have suffered considerably from regular burning and direct and indirect grazing pressures of stock."

Hacker (1982) also commented on the impact on the riverine systems in the central-west Kimberley:

"These systems have suffered the greatest impact as they have received the effect from early days. Furthermore, during periods of drought these areas are even more heavily grazed and trampled. In addition, there has been a gradual introduction of troublesome weed species, particularly Parkinsonia and Rubber Bush (*Calotropis procera*). Parkinsonia is particularly evident along the degraded frontages of the Fitzroy."

4.2 Fauna

McKenzie (1981) collected available historical records from surveys undertaken by early naturalists including Knut Dahl in 1896, J T Tunney in 1898 and E Lonnberg in 1911, plus several studies by naturalists who accompanied early explorers. These surveys provide sufficient information to make some comparison between the past and present composition of the native fauna. Most of this information is confined to the Napier Range with limited references to the King Leopold Ranges. McKenzie (1981) provides a detailed account of the changes in the composition of the mammal fauna in the south-west Kimberley (defined as the Phanerozoic area). The Phanerozoic area included the Napier Range, south to the Edgar Range and east to the edge of the Great Sandy Desert. McKenzie found within the region that of the ten medium-sized marsupials known to occur in the area, three were now extinct. These are:

- Boodie *(Bettongia lesueur)*;
- Golden Bandicoot (*lsoodon auratus*);
- Spectacled Hare-Wallaby (*Lagorchestes conspicillatus*).

The Boodie *(Bettongia lesueur)* was last recorded in 1895 by Dahl and he described it as exceedingly common in the sand dunes around Roebuck Bay. The Golden Bandicoot (*Isoodon auratus*) was last collected in 1898 and the Spectacled Hare-Wallaby (*Lagorchestes conspicillatus*) has only been recorded once since Lonnberg first collected it in 1911. Three others, the Bilby (*Macrotis lagotis*), Northern Brushtail Possum (*Trichosurus arnhemensis*) and the Sugar Glider (*Petaurus breviceps*), have probably declined in numbers. Dahl recorded these species as common around Roebuck Bay, however, these along with other species have declined dramatically in numbers. The decline of the native fauna around the Dampier Peninsula is described in McKenzie *et al.* (1983) and the changes are listed in Table 8.

McKenzie (1981) refers to the central-west Kimberley as a whole and it is difficult to ascertain specific changes. However, using information available on sites within the Napier Range (McKenzie, 1981) it is possible to compare the past with the present composition of the fauna (Table 8).

The records for 1960-1976 in Table 9 represent incidental collections over a long period of time and indicate what could be expected in the area. The table also includes data collected during the 1988 survey. Data collected during the survey was over a much shorter period, yet work in the King Leopold Ranges during the same time found most of the species expected to occur in the area. It would be expected that the work in the Napier Range would be similarly successful. However, there were very few species found in the Napier Range during the 1988 survey compared with past records. In particular, a notable absentee group from the Napier Range in 1988 compared with earlier records are the medium-sized class of mammals.

The historical records for the King Leopold Ranges are more limited. The naturalist Dr House (1902) who accompanied Brockman on his early expedition into the King Leopold Ranges, described the Dingo (*Canis familiaris*), Nailtail Wallaby (*Onychogalea unguifera*), Bandicoot (*lsoodon* species), Quoll (*Dasyurus hallucatus*) and two species of rock wallabies (possibly including the Short-eared Rock Wallaby (*Petrogale brachyotis*) as common in the range. Comparing this information and records of the Western Australian Museum with the results of the 1988 survey indicated that all native mammals expected to occur there were found. This contrasts with the data from the Napier Range which found few native mammals which were expected to occur there. There appears to have been a dramatic reduction in the species diversity and abundance of the native mammals and to a lesser extent the reptiles around the Napier

Range.

Table 8: Native mammals known from the Dampier Peninsula (from McKenzie, 1983)

Species	Most recent record	Records from proposed/existing reserves	
		CPR	PA
Megaleia rufa	1978	X	X
Macropus robustus	1981		
Macropus agilis	1981	X	X
Onychogalea unquifera	1981	X	
Bettongia lesueur	1895		
Wyulda squamicaudata	?		
Trichosurus arnhemensis	1980		
Petaurus breviceps	1895 (?1970)		
Macrotis lagotis	1978	X	
Isoodon auratus	1895 (?1971)		
Phascogale tapoatofa	1895		
Planigale maculata	1981		X
Hydromys chrysogaster	?1978		
Mesembriomys macrurus	1895		
Pseudomys nanus	1978	X	
Pseudomys delicatulus	1981	X	X

CPR = Coulomb Point Nature Reserve

PA = Pender Area (proposed Borda and Cygnet Bay Nature Reserves)

? = not a positive record

Table 9: Past and present records of the native fauna around the Napier Range (based on McKenzie (1981) and Sawle (1988))

	Pre 1960	1960 - 1976	1988
Large-sized mammals		*Megaleia rufa* *Macropus robustus* *Macropus antilopinus* *Macropus agilis* *Onychogalea unquifera* *Canis familiaris*	*M. rufa* *M. robustus* *M. agilis* *C. familiaris*
Medium-sized mammals	*Lagorchestes conspicillatus*	*Isoodon macrourus* *Petrogale brachyotis* *Trichosurus arnhemensis* *Pseudocheirus dahli* *Macrotis lagotis*	
Small-sized mammals	*Rattus tunneyi*	*Planigale ingrami* *Sminthopsis macroura* *Zyzomys argurus* *Leggadina forresti* *Pseudomys delicatulus* *Pseudomys nanus* *Pseudomys hermannsburgensis*	*S. macroura* *Z. argurus* *P. nanus*

5. Land use and management practices

5.1 Pastoral development

Prior to 1920, unsuccessful attempts at settlement by graziers at Roebuck Bay in 1863-1865 were followed by Alexander Forrest's expedition which included the country between the coast and the Napier Range but not the King Leopold Ranges. Forrest described the country between the May and Meda Rivers:

"as some of the finest pastoral country in the district."

Describing the country around the Napier Range he said:

"We crossed the Lennard River about six miles below the junction of the Barker River and struck the Barker about one mile below the junction of Wombarella Creek; at the southern entrance to Barker Gorge through the Napier Range. The country traversed this far consisted of extensive alluvial river flats and small black soil plains. The whole of the area being splendidly grassed with Mitchell, Flinders, Bundle Bundle and other fine grasses - in lightly timbered country."

He did, however, suggest that the country between the Lennard and Fitzroy Rivers, although there was a good deal of grazing land, was deficient in water, which he associated with a particularly dry season in the inland area. It was essentially the comments of Forrest that led to millions of acres being taken up for leases and the rapid expansion of the pastoral industry in the central-west Kimberley. It is interesting to compare the comments made by Fitzgerald (1907), travelling several years later, who didn't describe the country in such glowing terms. He did explore further north-west to the King Leopold Ranges, around Mount Broome where he commented that:

"... to the base of Mount Broome in the south and Mount Hart in the north - there are comparatively small patches of fair to good grazing ground".

Fitzgerald travelled during one of the driest seasons in ten years and said:

"... was evident along parts of the Lennard River where there were only small pools and dry grass."

Following the recommendations of Forrest, the area around the Napier Range, predominantly the country around the Fitzroy River, was settled by sheep graziers from the south of the State. Cattle ranches established in the Kimberley were run on the open range system without paddocking or the provision of artificial water supplies. The stock concentrated along the pools in the rivers and creeks; therefore, except for brief periods immediately after rain, the stock grazed along river frontages which were the most favourable pastures.

After the initial development of the pastoral industry in the central-west Kimberley, the deleterious impact on the land of overstocking, ignoring periods of drought and little knowledge of appropriate management, gradually became evident. The degrading effect of concentrated grazing on pastures became apparent to the point of disaster (Beard, 1979). In 1917 the cattle population reached a peak of over 400,000 head, and then progressively declined to its lower point of about 153,000 in 1954 (Figure 3). This decline was attributed to the progressive deterioration in the base pasture resource due to the past excessively high stocking rates (Hacker, 1982).

Since the 1950s there has been a gradual rise of cattle numbers in the west Kimberley, reflecting the development of previously unused areas and a reduction in sheep numbers. A subsidised scheme to install bores opened up areas of previously waterless country away from main rivers. This development was particularly marked in the south-west Kimberley where extensive areas of low quality "Pindan" country were opened up for grazing. The steep rise in numbers in the latter part of the 1970s reflects the depressed state of the export beef market and the correspondingly reduced turnoff from the Kimberley herd. In 1978 cattle numbers

(840,000) peaked (Figure 3) in the Kimberley, however, since then numbers have fallen and in the late 1980s the cattle numbers are as low (608,000) as they have been since the early 1970s (Doyle, 1988).

Until the 1920s the degrading effect of the continuous grazing and trampling of thousands of cattle on the pastures was masked by the recuperative power of the country, until a run of bad seasons revealed what had been happening. The impact on the country during this time was graphically described by Bolton (1953):

"Hardly a beast could be seen about the frontage, which was bare and almost nothing left but a lot of scalded ground. The effect was so disastrous that all the pastures on the river frontage had completely disappeared for the time being."

Discussing the progressive decline in the cattle numbers from the mid 1920s Hacker (1982) also attributed this to the progressive deterioration in the base pasture resources:

"To this extent the pattern of stock numbers in the west Kimberley is similar to the documented patterns in other pastoral regions of Australia, eg the pastoral zone of Western Australia south of the Kimberley and the western division of NSW where over-exploitation in the early years of settlement ultimately resulted in catastrophic stock losses and a new low base level of productivity. While in the Kimberley with its relatively reliable rainfall, the decline has been more gradual, the underlying mechanism of progressive pasture degradation is unquestionable."

The impact of concentrating cattle in the attractive pasture areas can be seen in Table 10, which shows the marked degradation in the better quality land in the west Kimberley. The Kimberley pastoral industry is based on relatively small areas of high quality land and large areas of poor and medium quality land. That severe range degradation is restricted to this small "core" of high quality country reflects the history of impact on the system.

Table 10: Lands of the west Kimberley survey area classified by pastoral value and range condition (All entries are in percentages)

Pastoral potential	Area km²	Range condition				
		Good	Good-Fair	Fair	Fair-Bad	Bad
High	11,268	0	0	28.0	20.2	51.7
Moderate	7,421	0	25.8	7.1	22.8	44.3
Low to moderate	24,862	2.3	15.2	40.8	23.5	18.0
Very low to useless	21,665	78.6	0	13.9	0	7.6*

Extracted from Payne *et al.* (1979)

* Poorly accessible land systems whose useful and accessible areas are badly degraded

Hacker (1982) assessed the current stock numbers for the four Kimberley shires, together with estimates of safe carrying capacities for present range conditions and for good range conditions (Table 11). The stocking rates suggest that with the possible exceptions of the Shire of Wyndham-East Kimberley and Halls Creek, pastures were overstocked on a regional basis at the commencement of the 1982 cattle season; particularly so in the west Kimberley, despite years of high turnoff from 1979 onwards. Furthermore, Hacker suggested that since large numbers of feral donkeys exist throughout the region the total grazing pressure is undoubtedly higher than the figures in the table.

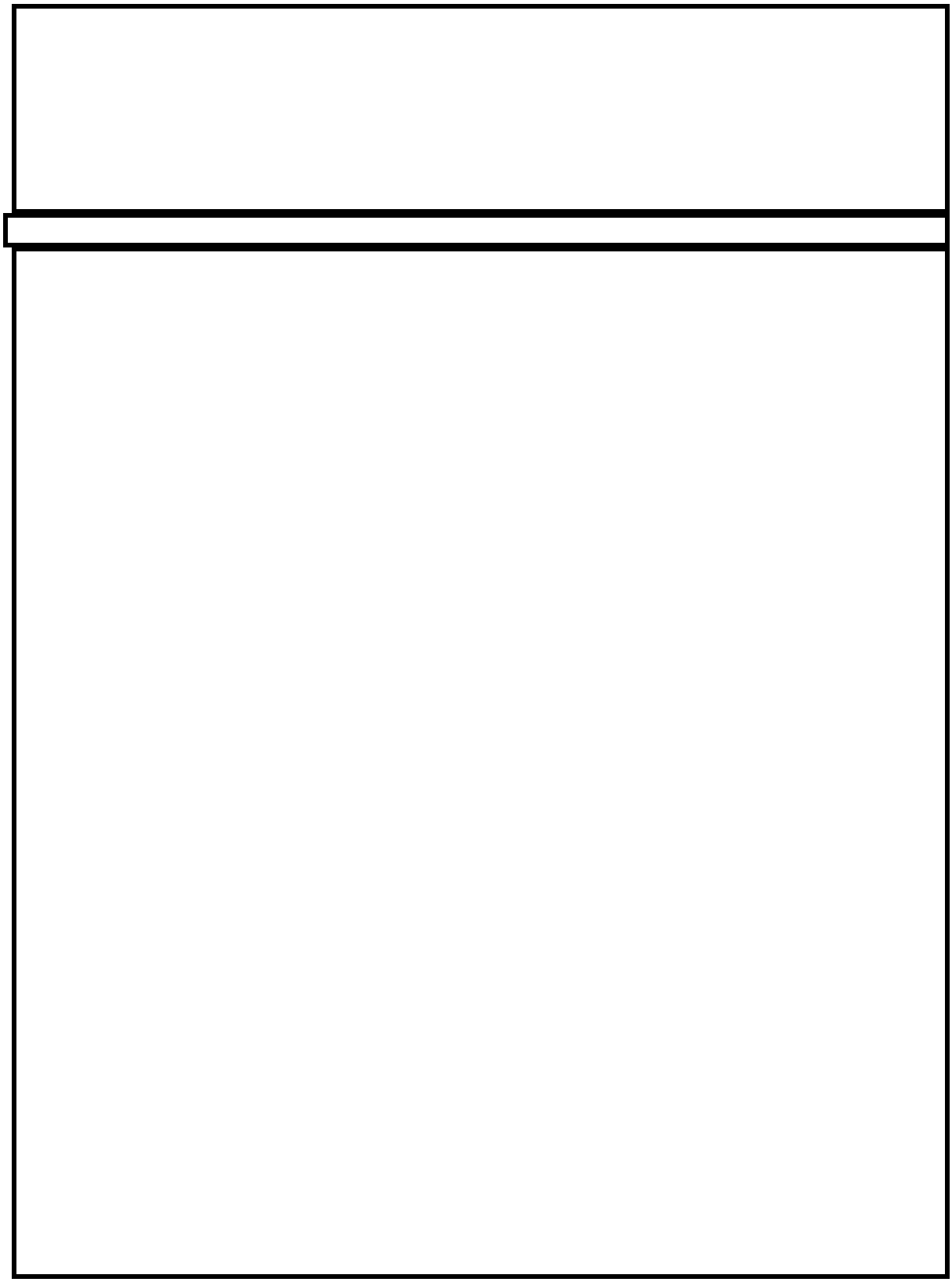


Figure 3. Trend in Kimberley cattle population 1910-1983

Table 11: 1982 stock numbers and estimated safe carrying capacities (CC) for Kimberley shires

Shire	Total stock March 1982	*LSU March 1982 (a)	Estimated safe CC (LSU) present conditions (b)	Stock status (a-b) x 100 b	Estimated safe CC (LSU) good
Wyndham	135,300	115,000	139,645	-17.6	217,225
Halls Creek	233,600	198,560	198,641	-0.1	308,997
West Kimberley	308,400	262,140	223,497	+17.3	347,662
Broome	70,200	59,670	54,440	+9.7	84,684
Kimberley Total	747,500	635,375	616,223	+3.3	958,568

*LSU = Large Stock Units, Cow-Calf Unit or dry stock over two years of age

Large Stock Units = total cattle x 0.5

The pasture deterioration and the subsequent effect on the pastoral industry led the Western Australian Government in 1953 to request surveys to be undertaken to assess the rangeland conditions. The report detailing the status of the rangelands of central-west Kimberley are included in the publication by Speck *et al.* (1964).

The significance of Speck's work, later followed by Payne *et al.* (1979) was to identify the various pasture/soil associations and assess the impact on these systems. The survey work by Payne *et al.* (1979) of the west Kimberley found that 30% of the country in the west Kimberley (including most of the catchments of the Fitzroy and Lennard) was in bad range condition (Table 12). Pasture land in these areas was severely degraded and moderate or severe erosion was widespread. Only 23% of the area traversed was considered to be in good range condition. Significantly good range conditions were encountered only in areas which were virtually or totally inaccessible; which had not been developed for stock; which carried unpalatable spinifex or which had soils inherently resistant to erosion.

Table 12: Summary of erosion and range condition assessments from traverse data for the west Kimberley (All entries are percentages)

Wind erosion		Water erosion		Total erosion		Pasture condition		Range condition	
Nil	71.5	Nil	54.7	Nil	47.1	Excellent	4.1	Good	19.5
Minor	17.5	Minor	23.5	Minor	26.5	Good	15.8	Fair	50.7
Moderate	7.9	Moderate	16.6	Moderate	6.5	Fair	37.1	Bad	29.8
Severe	3.1	Severe	5.2	Severe	9.9	Poor	28.9		
						V Poor	14.1		

Extracted from Payne *et al.* (1979)

5.2 Fire regime

Burning patterns by Aboriginal people

Fire has been a part of the central-west Kimberley long before European arrival, both "natural fires" and burning by Aboriginal people. Natural fires caused by seasonal thunderstorms were, and still are, a result of the climate. With climatic conditions gradually favouring fire, it is likely that a pyrophilous vegetation evolved resulting in the development of grass dominated communities. The frequent firing appears to have had the effect of selecting fire-resistant species among the woody plants and rendering the tree and shrub layers more open.

However, it is likely that the Aboriginal communities inhabiting the area at the time were also responsible for burning. Forrest (J S Battye Library, 1981) referred to the burning by Aboriginal people south of the King Leopold Ranges:

"Nearly the whole of this great plain has been burnt by the natives for quite 100 miles. No doubt with the object of removing the obstructions to travelling; and also for the purpose of getting the pigeon eggs that are afterwards collected in large numbers."

Travelling further south-east to the Napier Range he noticed more areas recently burnt by the Aboriginal people:

"... camped on the river; abundance of feed and water; while the whole country had been burnt."

Similarly, he found the country surrounding Mount Percy in the Oscar Range:

"... Pindan country; whole country had been burnt."

In 1883, during an expedition including the south-west Kimberley, Stokes commented:

"... indeed during the dry season - it not infrequently happens that an immense tract of land is desolated by fire; communicated either by design, that is by the natives to the dry herbage or the surface ..." (Stokes (1846) in McKenzie (1983).

The use of fire by Aboriginal people prior to European settlement was as a tool to maximise the production of particular food items. It was skilfully used - some areas being annually burnt and others completely protected; some burnt early in the dry season and some later. Reasons for the use of fire by Aboriginal people in the arid areas of Australia included:

a. hunting;
b. regeneration of food plants;
c. signalling;
d. warmth; and
e. clearing ground and extension of man's habitat.

These practices, in association with the natural variations in topography, maintained a complex mosaic of habitats at different stages of recovery from fire. As well as providing habitats for plants and animals which required different stages of regeneration, it also eliminated the risk of extensive wildfires. Fires which were started, either by Aboriginal people or by lightning, soon ran into areas of low fuel which acted as a fire break (Burbidge, 1985). The arrival of the Europeans and the movement of Aboriginal people to settlements resulted in changes in the reasons for burning and the burning patterns. The burning patterns have changed from the complex patchwork arrangement developed by the Aboriginal people to more extensive and regular burning patterns.

Pastoral burning patterns

Fires have been used by the pastoralists since settlement for management of the grasslands. The reasons and patterns of burning since the development of the pastoral industry differ markedly from those of the Aboriginal people. The reasons for burning of the pasture lands are summarised by Lenegan (1988) and include:

- Protective burning - 26%
- Spinifex regeneration - 18%

- Fodder/pasture management - 18%
- Tick control - 10%
- Wattle control - 9%

It is difficult to determine the frequency and distribution of these fires as there are no records or studies relating to these forms of burning.

Wildfires

Wildfires, besides those started by lightning, are an increasing contribution to the fire pattern in the south-west Kimberley. Causes of wildfires described by Lenegan include:

- Unknown - 25%
- Aboriginal people - 23%
- Lightning - 22%
- Escape from burnoffs - 11%
- Travellers/tourists/campers - 7%
- Deliberate - 5%
- Bullcatchers - 5%
- Vehicles - 2%

Firing by Aboriginal people today does not follow the original patterns, but consists of randomly lit fires generally in accessible areas.

It is estimated that an average of 600,000 hectares of land in the Kimberley are burnt annually by wildfires. In 1988 this figure was surpassed when in a five month period from June to October 2,000,000 hectares were burnt. There is an increasing number of fires caused by humans compared with natural causes. This increase has resulted from increased access and more people in the area. This has also resulted in the areas that are easily accessible being burnt most frequently, including the plains surrounding the Napier Range (particularly along the Gibb River Road). There is no doubt that the wildfire component of the Kimberley fire pattern has become far more significant over the years and the Bush Fires Board has responded to this problem by initiating control burns in the Kimberley to decrease the spread of wildfires (Lenegan, 1988).

6. Land use impacts

6.1 Impact of pastoral land use on pasture types

Impacts associated with land use can be assessed by examining the status of the land today using reports and studies by CSIRO and the Western Australian Department of Agriculture, which provide information on the pastoral condition of the country. Although these are agricultural based studies designed to provide information and recommendations for the pastoral industry, the data can be applied to assessing the present status of the vegetation.

The land systems described by Speck *et al.* (1964) and adapted by Payne *et al.* (1979) generally follow soil boundaries and the geomorphic units described by Wright (in Speck *et al.*, 1964).

Speck and Payne mapped the land systems according to pastoral affinities and determined the impacts on the vegetation and soil. A modification of the map appears in Figure 4, which includes the King Leopold, Napier and Oscar Ranges.

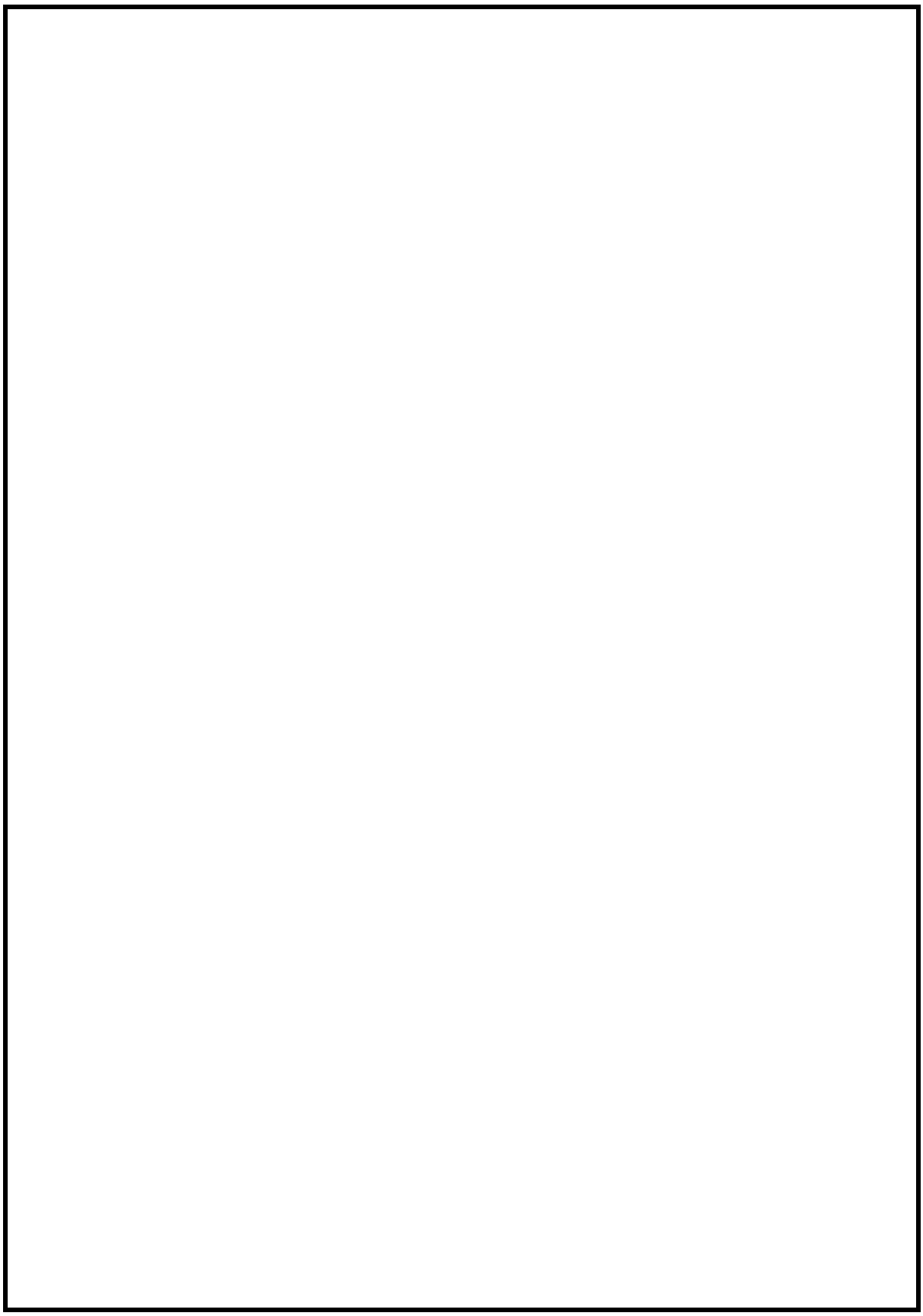


Figure 4. Pasture lands surrounding the King Leopold, Oscar and Napier Ranges.

The land systems described by Speck and Payne for the south-west Kimberley are listed below. The distribution and the condition of these areas around the King Leopold and Napier Ranges are described from information collected during the 1988 fauna survey:

a. Curly Spinifex pasture land (CS) (Photograph 5)

Within the south-west Kimberley this land system occurs on the rocky slopes and plains of laterised granite around the King Leopold Ranges and extensive dunefields south of the Napier Range.

The carrying capacity of this pasture land is restricted - some areas are virtually inaccessible (particularly in the King Leopold Ranges). There is little obvious degradation (overgrazing, erosion) except in restricted areas subject to overuse. This pasture type is not attractive to cattle and therefore few cattle are found in these areas.

There was little or no evidence of degradation of this land system around the King Leopold Ranges, particularly west of the Gibb River Road. However, in the areas around the Lennard River on Mount Hart station there appeared to be some areas of reduced cover compared with similar areas in other parts of this land system. This is possibly due to more cattle in this area because of the nearby Lennard River and more palatable grasses compared to other areas of the station. There was also a greater number of feral donkeys in this area than elsewhere (P. Murray, pers. comm.).

b. Black Soil Plains (BSP)

This system occurs widely in the dark, cracking, clay floodplains which are associated with the major rivers. It is dominant around the base of the Napier and Oscar Ranges and the Fitzroy and Lennard Rivers.

This pasture system is regarded as one of the most valuable in the central-west Kimberley. It is adjacent to water systems and has been one of the most intensively used systems since settlement. Moderate pasture degeneration is common where small patches of this pasture occur adjacent to poor, rugged country, however, overuse has frequently resulted in severe degradation. The most destructive force on the land system has been the removal of the perennial plants which are replaced by annuals. The impact varies with the amount and duration of grazing, particularly in areas close to riverine systems.

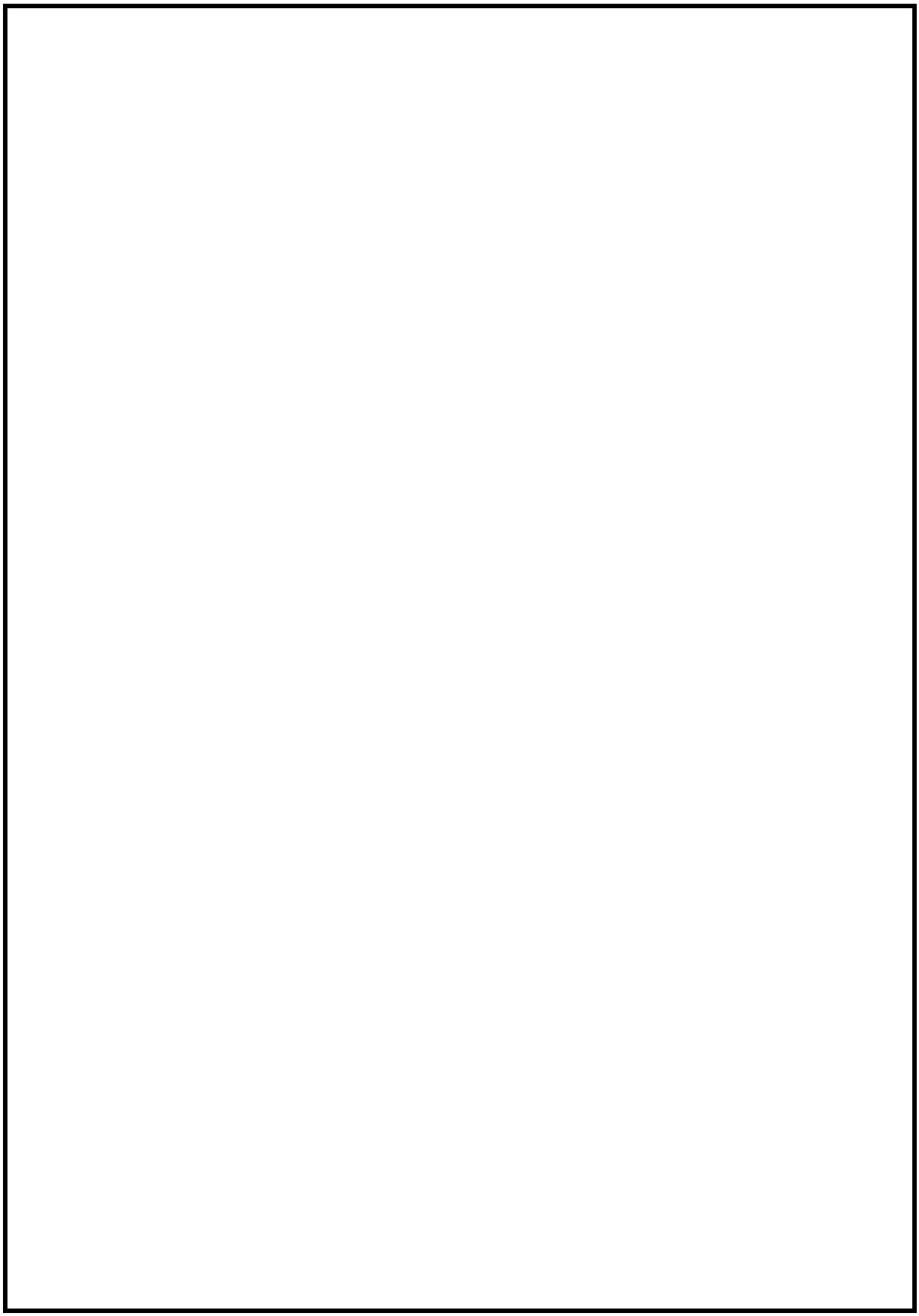
In the central-west Kimberley this is evident around the Barker and Lennard Rivers and Brooking Gorge where overgrazing has in certain areas resulted in large bare patches. This is especially evident around Brooking Gorge where extensive areas of bare ground occur (Photograph 6).

c. Frontage Grassland Pasture (FGP)

This pasture type characterises the levees and levee bank slopes of major rivers and watercourses, following the Fitzroy, Lennard and Barker Rivers.

When in good condition these river frontage pastures are of high value as many of their components are palatable and nutritious. For these reasons they have been subject to heavy grazing pressures from early days of settlement and in many areas are now severely degraded.

When in poor condition these lands are 100% bare ground, perennials are absent and vegetation is restricted and there are scattered remnants of annual grasses and succulents. Moderate to severe wind and water erosion is widespread. Water erosion is usually evident in the form of extensive sheeting, although there are occurrences of moderate and severe gullying. Payne *et al.* (1979) found that severe degradation of frontage pastures was widespread throughout the south-west Kimberley. This was evident in areas around the Lennard River on Napier Downs and Mount Hart stations.



Photograph 5. Rolling hills and rocky hillslopes of the King Leopold Ranges

Photograph 6. Severe degradation of Black Soil Plains near the Brooking Gorge, Oscar Range

d. White Grass Annual Sorghum (WGAS)

This system is characteristic of hilly country based on basic igneous rocks generally around the King Leopold Ranges.

The system is of low value to stock due to poor accessibility and low palatability of its dominant species. If there are unsuitable pastures surrounding this system and there is an adequate supply of sorghum grass it may be stocked. This occurs on Mount Hart station (south of the Gibb River Road) where the surrounding country is CS, therefore stock have to rely on sorghum which also occurs with WGBB land system (see below). WGAS pasture type tends to be burnt regularly to encourage the regrowth of sorghum.

e. White Grass Bundle Bundle (WGBB)

Characteristic of the basalt-derived, deep, red earth soils of the lower slopes of drainage lines into the Lennard River on Mount Hart station.

This is regarded as of moderate value to stock, however, as this system is often surrounded by inaccessible country, it results in carrying excessive concentrations of stock. Moderate to severe degradation is evident on this pasture type, as it is often surrounded by CS on rugged country. This leaves the stock to feed on the WGBB and the WGAS which can lead to highly selective grazing due to the unpalatability of most of the grasses in these systems. This situation occurred along the Lennard River on Mount Hart station and it appeared that stock concentration resulted in the reduction of cover in some areas.

f. Limestone Spinifex (LS) (Photograph 7)

This is confined mainly to the limestone outcrops of the Oscar and Napier Ranges. The pasture of this system is of low palatability and nutritive value. The rugged landscape is difficult to access. Most of these systems are in good to excellent condition due to their unattractiveness to stock, the inherent resistance to erosion of the shallow, rocky soils and the inaccessible topography.

g. Ribbon Grass (RG)

This pasture land is of moderate to high value and in the past has been fairly extensively developed. Most of these pastures are in poor to fair condition and erosion can be severe in some areas.

Comparison of management practices on pasture types

The distribution of the pasture lands illustrated in Figure 4 indicates that the most attractive pasture lands (BSP and FGP) surround the base of the Napier and Oscar Ranges and the major river systems (Barker, Lennard and Fitzroy). The less attractive pastures cover the rocky hillslopes of the King Leopold and Napier Ranges and plains surrounding the King Leopold Ranges. Stations with the preferred pasture lands for grazing carry a higher stock rate as indicated in Table 13. The recommended stocking rates in the table give some indication of how extensively the station is being utilised.

Table 13: Present and recommended stocking rates for some stations in the central-west Kimberley

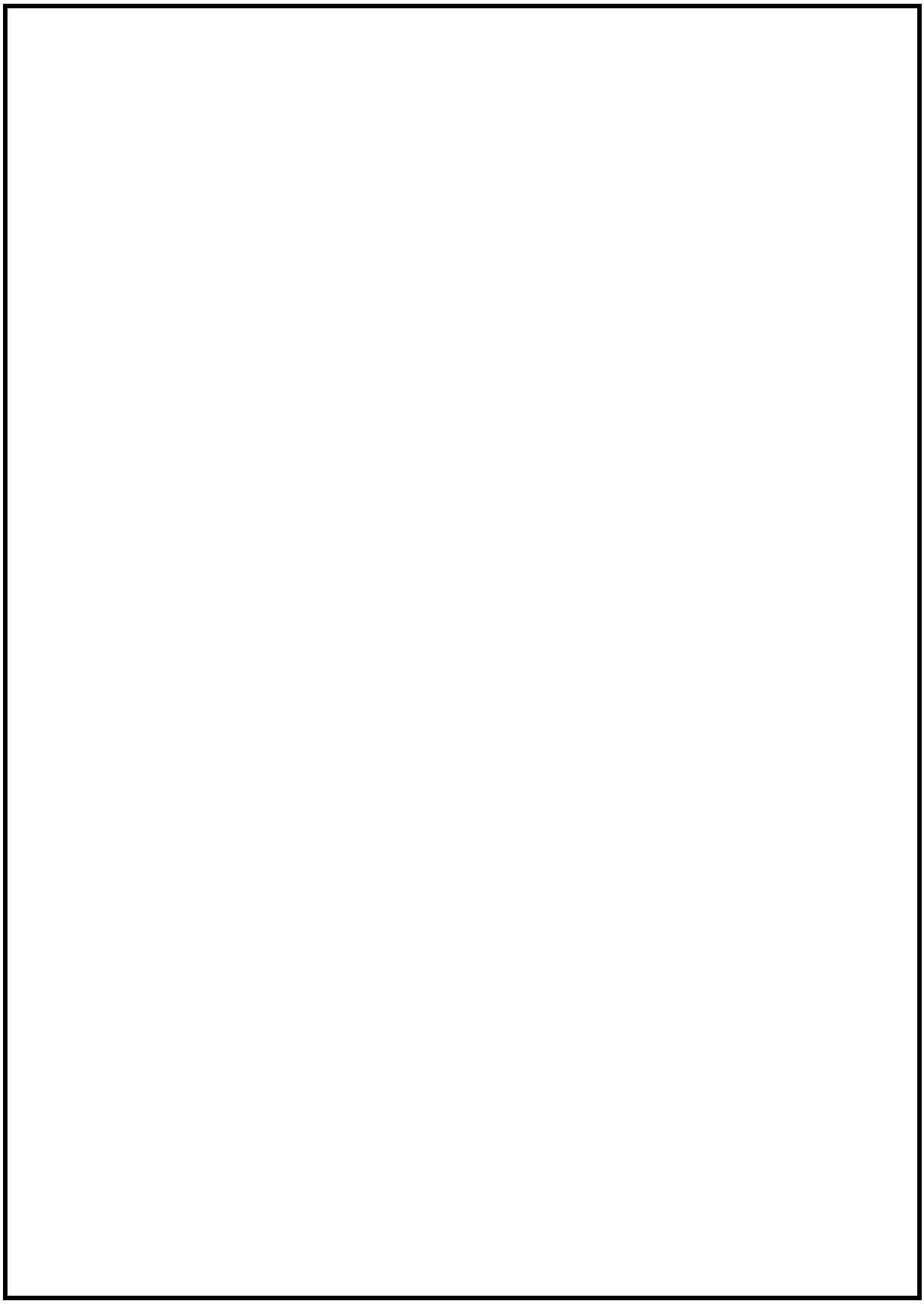
Station	Size (hectares)*	Recommended stock rate*	Stock rate (1988)#
Napier Downs	280,630	21,500	-
Brooking Springs	253,673	18,210	17,500
Mount Hart	368,797	9220	5000

* Pastoral Board, Western Australia

Elders

Napier Downs and Brooking Springs stations, although of smaller size, have much higher recommended stocking rates than Mount Hart station. The higher carrying capacities of Brooking Springs and Napier Downs stations are because of the greater amount and availability of suitable pasture lands. Brooking Springs was also carrying close to its recommended carrying capacity whereas Mount Hart's rate was considerably lower than recommended. In addition, Brooking Springs station has developed more water sources than Mount Hart station, including 36 dams and 31 bores, compared to six dams and one bore on Mount Hart station.

There is a significant historical difference in the development and management of these stations which has most likely affected the impact on the pasture lands. Napier Downs and Brooking Springs stations were developed well before Mount Hart station, which began in the 1920s. Furthermore, Mount Hart station has never been actively stocked, receiving most of its stock from surrounding stations. As a consequence, the stocking rate for Mount Hart station has never been very high and has varied little from the figures given above. It has always carried well below the recommended carrying capacity compared with that of the other stations which have maintained high stocking levels and associated higher grazing and trampling impacts. However, feral donkeys have always been present in relatively high numbers on Mount Hart station (P. Murray, pers. comm.).



Photograph 7. Exposed rugged limestone outcrops, Napier Range

Impact of pastoral land use on wetlands

There has also been some impact on the wetland areas although this has depended on the location. Areas that are not readily accessible to cattle such as the wetlands high in the King Leopold Ranges have suffered no impact. However, wetlands on the BSP, at the base of the Oscar and Napier Ranges are subject to trampling and grazing by cattle. As a result of this, some of the endemic species of water plants are now difficult to find, including *Echinochloa kimberleyenis* and *E. macranda* (Jacobs pers. comm.).

Some of the wetlands at the base of the King Leopold Ranges have been heavily trampled, but the impact on these has yet to be assessed.

6.2 Impact of pastoral land use on fauna

While it is difficult to determine the impact of pastoral land use on the fauna as there are no controlled studies, assessment of past records compared to data collected during the 1988 survey provides some information on changes.

As discussed in Section 3, there appears to have been a decline in native mammal species abundance and diversity around the Napier and Oscar Ranges. The decline is less marked around the King Leopold Ranges.

The decline in the native fauna, particularly around the Napier and Oscar Ranges, can be associated with the wide range and intensive land use practices that have operated in the area since European settlement. The extent to which this has affected the native fauna can be associated with the different land systems and level of impact. The areas that appear to have suffered the highest impact are the plains and riverine areas. These systems have the longest history of impact as they are the most favoured pasture land. Comparing the pasture lands described by Payne *et al.* (1979), discussed in the previous section, it is evident that the occurrence of the fauna varies according to the pasture land. The vegetation types identified for the fauna survey and the pasture land type they correspond with are summarised below.

Vegetation type I and IA	=	Curly Spinifex (around Bell Creek)
		White Grass Annual Sorghum and White Grass Bundle Bundle (around Lennard River, Mount Hart Station
Vegetation type II	=	Black Soil Plains
Vegetation type III	=	Curly Spinifex
Vegetation type IV	=	Frontage Grassland and Black Soil Plains
Vegetation type V	=	Limestone Spinifex
Vegetation type VI	=	Curly Spinifex

As summarised in Table 14, the occurrence of small/medium-sized mammals varies according to the pasture land type. The CS habitat, which covers most of the King Leopold Ranges, supports the highest diversity of native mammals. The CS includes vegetation types I, IA, III and VI, which include the plains, minor riverine systems and rocky hillslopes of the King Leopold Ranges. Most of the native mammal species within the CS pasture type occurred between Bell Gorge to Inglis Gap. The same pasture land type and vegetation types around the Lennard River, however, did not support a similar diversity.

Another significant factor about the area between Bell Creek to Inglis Gap is that it contained a variety of habitats, including the minor riverine systems that supported species not found in other areas. It is possible that these habitats are quite important, particularly as the major riverine systems supported so few native mammals, a trend that had been observed in other studies in the Kimberley (Kitchener, 1978; McKenzie, 1983).

Table 14: Occurrence of small and medium-sized mammals within pasture land types

Pasture land type	Mammals
Curly Spinifex	Common Rock Rat (*Zyzomys argurus*); Western Chestnut Mouse (*Pseudomys nanus*); Delicate Mouse (*P. delicatulus*); Forrest's Mouse (*Leggadina forresti*); Pale Field Rat (*Rattus tunneyi*); Northern Quoll (*Dasyurus hallucatus*); Striped-faced Dunnart (*Sminthopsis macroura*); Long-tailed Planigale (*Planigale ingrami*); Northern Brown Bandicoot (*Isoodon macrourus*); Rock Ringtail Possum (*Pseudocheirus dahli*); Sugar Glider (*Petaurus breviceps*); Northern Brushtail Possum (*Trichosurus arnhemensis*); Short-eared Rock Wallaby (*Petrogale brachyotis*)
Black Soil Plains	Western Chestnut Mouse (*Pseudomys nanus*); Striped-faced Dunnart (*Sminthopsis macroura*);
White Grass Annual Sorghum and White Grass Bundle Bundle	Long-tailed Planigale (*Planigale ingrami*)
Frontage Grassland and Black Soil Plains	Sugar Glider (*Petaurus breviceps*)
Limestone Spinifex	Common Rock Rat (*Zyzomys argurus*)

The rocky hillslopes of the King Leopold Ranges between Bell Gorge to Inglis Gap supported a higher diversity of fauna (excluding bats) than the rocky hillslopes of the Napier Range. However, the rocky hillslopes above the Lennard River in the King Leopold Ranges supported few native mammals.

The Napier and Oscar plains (BSP) and the major riverine systems (FGP) supported the lowest number and diversity of mammals. In most areas there were no native mammals found, also one area notably low in reptiles was Brooking Springs station. As these areas were expected to support a much higher abundance of fauna than found during the 1988 survey, the difference is indicative of the disturbance to the habitat. The plains (mainly BSP) and the riverine systems (FGP) both have a long history of grazing, trampling and fires associated with pastoral management.

In particular, there has been a decline in the medium-sized animals, a pattern that has been observed and discussed in other papers (Kitchener, 1973; McKenzie *et al.*, 1973 and Burbidge and McKenzie 1989). Although these papers suggest that the small-sized mammals and reptiles were not as affected by disturbances as the medium-sized mammals, this study found that some areas around the Napier and Oscar Ranges appeared to have few, if any, small-sized mammals or reptiles, suggesting that not only were medium-sized mammals affected but also small-sized mammals and reptiles.

6.3 Impact of fire regime

Flora

The impact of fires on the native flora is difficult to assess as the effects vary depending on so many factors, including the species composition, time of burn and the subsequent rainfall. The results of various burning patterns have been discussed by several researchers, including Speck *et al.* (1964).

"During and after the wet season fires are comparatively cool. They do not kill old spinifex tussocks, which regenerate rapidly, but do kill many useful grasses and grass seeds. Wet season fires also favour the establishment of scrubby wattle (*Acacia* spp.). The spinifex and

pindan pastures are best burnt in the late dry season. This kills the spinifex tussocks, but by this time many grass seeds are burnt and are not harmed. Regeneration of spinifex from seed is slow and more palatable species are able to compete for several years."

Detailed studies of the impact of fire regimes on the vegetation have been undertaken in the Northern Territory by Hoare *et al.* (1980). The study assessed the impact of fire regimes on the tall open forest and woodland associations. Five years of fire exclusion produced significant changes in community structure, but not species composition. A shrub layer developed and the thick annual grasses common in regularly burnt sites become greatly reduced and replaced by perennial grasses and a litter layer. "Fire shadow" communities were also identified, in which fire rarely takes hold because of a lack of fuel or unfavourable edaphic and topographic conditions.

Coulomb Point Nature Reserve on the Dampier Peninsula was originally created to reserve the mature stands of *Acacia*-dominated Pindan vegetation. Studies (McKenzie *et al.*, 1983) of early descriptions by Dahl have shown that a rapid reduction has occurred in amount of cover of this vegetation community associated with the frequent use of fire.

Although it is impossible to fully assess the impact of the burning patterns of the pastoral industry, past experience has shown that too frequent and inappropriate patterns of burning have created unfavourable conditions for stock, exacerbating overgrazing and erosion leading to habitat degradation (Lenegan, pers. comm.).

Fauna

Again it is difficult to attribute a particular effect to one form of land management , however, it is evident that fire is one of the factors contributing to the decline in populations of some mammal species in the south-west Kimberley.

This is evident in the habitats around the Dampier Peninsula, Napier Range and, to a lesser extent, the King Leopold Ranges. Fires in the Dampier Peninsula have led to a reduction in cover and it is likely that this is one of the factors contributing to the disappearance of the Boodie *(Bettongia lesueur)*, which Dahl had described as common during his early collections. Pasture lands around the Napier Range have been subjected to an increasing number of fires caused by increased numbers of tourists and changed burning practices by Aboriginal people, associated with increased mobility and easier access. The King Leopold Ranges have escaped these forms of fire as they are less accessible and much of the area is unattractive to stock, resulting in fewer pastoral management fires.

Although there have been no studies on the impacts of fire on the native fauna in the Kimberley, research in the Northern Territory has investigated some of the impacts associated with fire. Studies by Begg *et al.* (1981) (in Kerle and Burgman, 1984) indicated that the reproductive rate of the Common Rock Rat (*Zyzomys argurus*) was reduced after fire. In a study by Kerle and Burgman at Jabiru, the trapping success for the Common Rock Rat (*Zyzomys argurus*) was lower after a fire than before the fire. They found that the numbers of the Northern Quoll (*Dasyurus hallucatus*) were the same as pre-fire levels immediately after the fire, however, this declines after a period of a year. They attributed the low numbers of the Common Rock Rat (*Zyzomys argurus*) after the fire to a change in the vegetation composition, litter accumulation and an increase in predation as a result of the reduction in cover. Their results also showed that the Northern Brown Bandicoot (*Isoodon macrourus*) and the Northern Brushtail Possum (*Trichosurus arnhemensis*) had a very patchy distribution and were quite likely adversely affected by severe disturbances such as regular firing.

Calaby (1973) (in Kerle and Burgman) found the Northern Brown Bandicoot (*Isoodon macrourus*) in grassland, woodland and open woodland at Jabiluka. There were larger populations in areas of dense grass cover and therefore they may be adversely affected by fire. Similarly, the Northern Brushtail Possum (*Trichosurus arnhemensis*) occurred in sites rarely burnt and the preferred habitat appeared to be a stable community with sufficient food through the year to enable them to breed continuously. This is attributed to a more diverse and abundant leaf, fruit and flower diet which is enhanced by limited burning.

The observed patchy distribution of the mammal species in the Jabiluka area was related to the mosaic of vegetation communities. Some are very stable with little change between years and seasons but would be severely degraded by regular hot fires. Others are more variable, responding to variation in rainfall and capable of rapid regeneration after fire. Species which were identified as responding readily to habitat change by greater dispersion to more suitable habitats included:

- Western Chestnut Mouse (*Pseudomys nanus*);
- Delicate Mouse (*P. delicatulus*);
- Common Rock Rat (*Zyzomys argurus*).

Species restricted to the more stable habitats and which may be severely affected by major disturbances of habitat:

- Northern Brown Bandicoot (*Isoodon macrourus*) ;
- Sugar Glider (*Petaurus breviceps*);
- Rock Ringtail Possum (*Pseudocheirus dahli*);
- Northern Brushtail Possum (*Trichosurus arnhemensis*).

All these animals were found only around the minor creek systems of the King Leopold Ranges in areas relatively undisturbed and with limited burning. The Sugar Glider (*Petaurus breviceps*) was usually always found in association with flowering *Eucalyptus miniata* and *Sesbania* species. Based on the very limited distribution of these species it is possible that they have, as suggested by the studies in the Northern Territory, strong habitat preferences for undisturbed and unburnt areas.

Cameron (pers. comm.) identified fire as affecting the habitat of the land snails in the Oscar and Napier Ranges. As the species have such small ranges, the impact of fire can have an extremely damaging and possibly permanent effect on the populations.

There have been limited studies on the impact of fire on the native fauna of the Kimberley. However, as suggested by other studies, fire is likely to have had some effect on the native fauna in terms of modifying the habitat.

One aspect of fires in the Kimberley found from aerial photo interpretation is that some fires leave a persistent "scar". This indicates that possibly there is reduced cover and a different vegetation structure resulting from various types of burns. Therefore, habitat type, the time of the burn, and pattern of burn are likely to have different effects on the habitat, some more persistent than others.

6.4 Summary of impacts

The combination of heavy grazing, extensive fires (wildfires and management fires) have varied according to the pasture land type and accessibility. Areas that have been most affected by disturbance include:

a major riverine systems (Barker and Lennard);

b black soil plains (base of the Oscar and Napier Ranges);

c sorghum grasslands (surrounding the Lennard River in the King Leopold Ranges);

d certain rocky habitats (King Leopold Ranges - south of the Lennard River; Napier Range - Barker Gorge to Wagon Pass).

The disturbance created by these impacts has changed the natural habitat and consequently has reduced the composition and distribution of the native fauna.

While it is possible that there is a more diverse and abundant fauna than suggested by the results obtained in 1988, there is, however, sufficient data from previous records, the 1988 survey and the condition of the pasture lands to suggest that the numbers have declined and are continuing to decline. This is associated with the disturbances to the habitats caused by grazing, trampling and fires. A similar pattern has been observed in other areas of the Kimberley,

including the Ord River (Kitchener, 1978), the Dampier Peninsula (McKenzie, 1983) and the Phanerozoic region of the Kimberley (McKenzie, 1981).

Areas that have had limited disturbances such as the less accessible and unpalatable grasslands have maintained a diverse fauna group. Rocky habitats can also be regarded as relatively undisturbed throughout northern Australia (Burbidge and McKenzie, 1989).

Although the Napier and Oscar Ranges supported species of flora and fauna with restricted ranges, most of these species were confined to the rocky hillslopes. Other areas surrounding the ranges have been disturbed most likely causing a decline in the populations of native plants and animals. The survival of some of the species of interest, such as the land snails, certain plant species and lichens, is likely to be attributed to the remaining suitable and protected refuges within the rocky ranges. However, the hillslopes of these areas are not entirely protected as fire is one of the factors known to limit the occurrence of the land snails and it is likely that this has also resulted in the low abundance of mammals in certain areas. The King Leopold Ranges, between Bell Gorge and Inglis Gap, supports a variety of relatively undisturbed habitat types and associated fauna. Unlike the plains of the Oscar and Napier Ranges, the plains of the King Leopold Ranges still support native species and although the major riverine systems have been disturbed resulting in low fauna abundance, the minor riverine systems provide suitable habitat.

7. Significant areas for conservation

The results from the Kimberley 1988 survey, descriptions of the pasture land types and previous records indicate the following areas to be of significance for conservation of habitat types:

King Leopold Ranges

Of the areas studied, the areas between Bell Gorge to Inglis Gap, specifically, contain five representative habitat types (described below) and support the highest diversity of flora and fauna (ie ecosystems) for the region. Species not previously recorded for the area included Striped-faced Dunnart *(Sminthopsis macroura),* Northern Brown Bandicoot *(Isoodon macrourus)* and the rare Rock Ringtail Possum *(Pseudocheirus dahli).*

However, not only is the Bell Gorge to Inglis Gap area of biological significance, but also of importance are those habitat types within other areas of the King Leopold Ranges (Figure 5).

The significant habitat types are:

i minor riverine systems - these areas support native plant and mammal species not found elsewhere;

ii rocky hillslopes and summits - these areas support plant and mammal species not found elsewhere;

iii undisturbed grasslands within and adjacent to the ranges;

iv wetland habitats - both high in the ranges and at the base of the ranges - these are the least disturbed of the wetland habitats, although certain areas at the base of the range were disturbed by grazing;

v gorge systems - for endemic species of land snails - these areas provide some of the most attractive scenery of the south-west Kimberley, similar to the scenes to be found in the north Kimberley such as the Prince Regent River. The King Leopold Ranges supports many waterfalls and deep pools hidden within the ranges.

All these habitat types represent biologically and geologically significant features of the central-west Kimberley worthy of conservation.

Although the King Leopold Ranges does not support some of the flora and fauna found in the Oscar and Napier Ranges, it represents the least disturbed area in the central-west Kimberley.

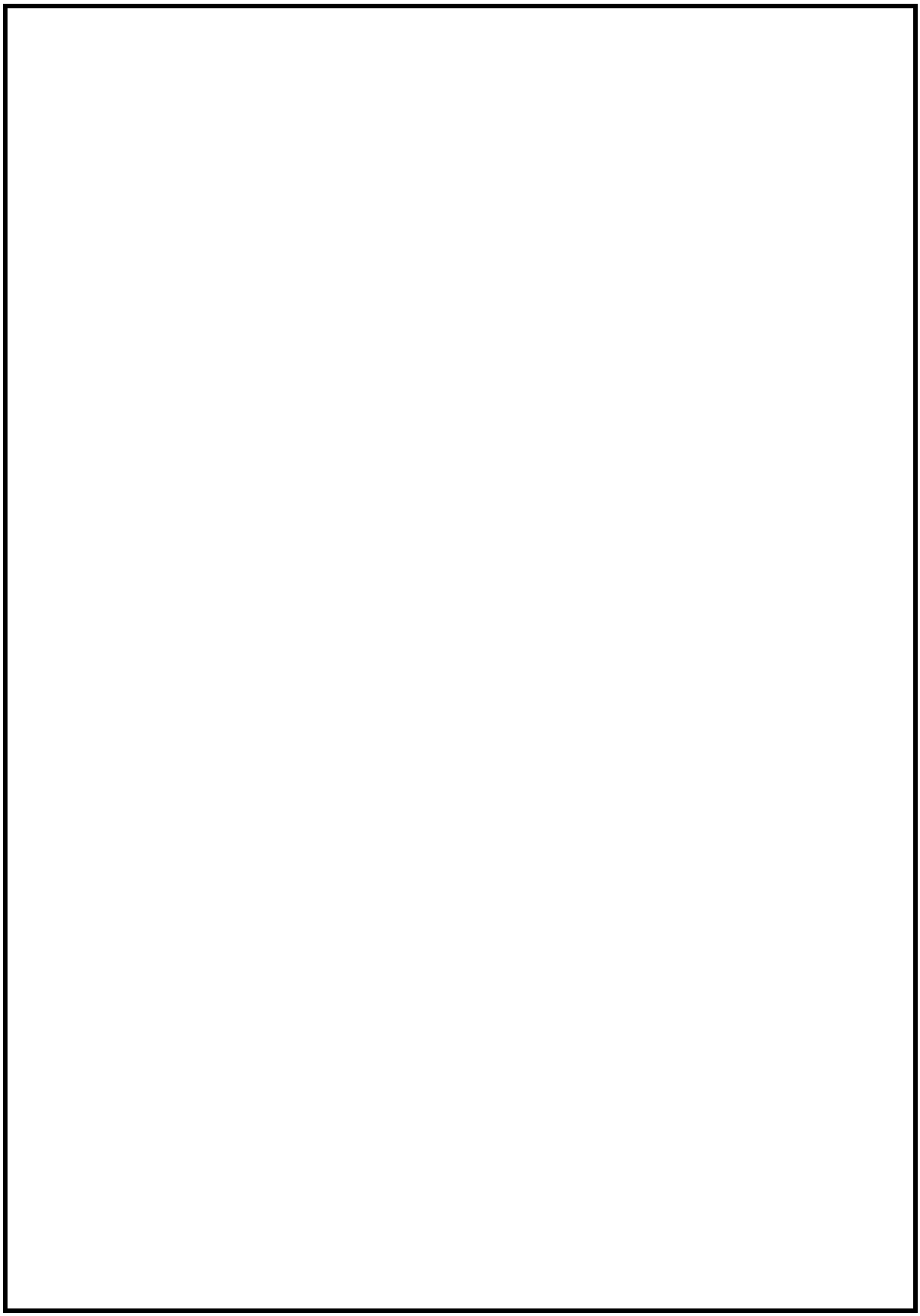


Figure 5. Significant flora and fauna areas within EPA recommendation 7.16 King Leopold Ranges

The area includes a variety of vegetation groups, rare/uncommon mammals, wetlands and attractive scenery. While there are areas such as these within the north Kimberley that represent similar fauna compositions (Prince Regent River), the King Leopold Ranges can still be regarded as an important area for conservation in the central-west Kimberley and as part of the network of conservation reserves throughout the Kimberley. It requires appropriate management to ensure that the habitats and the nature of the area are not adversely affected.

Napier Range

The Napier Range supports endemic species of land snails, rare species of bats and possibly some rare species of mammal. It also represents a unique and scenically attractive feature of the Kimberley landscape; a 300 million year Devonian reef is of interest to many scientists worldwide. The scenic areas include the well known Geikie, Windjana and Tunnel Gorges, however, there are other less known sites, including Barker Gorge, Chedda Cliffs and many hidden valleys and well protected flora sites in inaccessible pockets of the range.

The unique geology of the range possibly contributes to some of the unusual flora and fauna. Particularly, the abundance of caves, including those suitable for the rare Orange Horseshoe-bat (*Rhinonicteris aurantius*). In addition, the caves provide suitable habitat for many species of bats, including other less common species - the Dusky Horseshoe-bat (*Hipposideros ater*) and the Ghost Bat. There have been records (WA Museum) of the Rock Ringtail Possum (*Pseudocheirus dahli*) occurring in the Range, near Barker Gorge.

The Napier Range contains endemic land snails with limited distributions not found in other parts of the rocky environments. These species are of particular interest in continuing research on evolutionary and ecological issues.

The Kimberley 1988 survey found new distribution records for species of grasses, ferns, aquatic plants, lichens and flowering plants.

Oscar Range

The Oscar Range, like the Napier Range, supports populations of rare bats, including the Orange Horseshoe-bat (*Rhinonicteris aurantius*). Similarly, endemic land snails occur in the range, although they are represented by different species compared with the Napier Range. The Kimberley 1988 survey found two possibly new species of lichens near Mount Percy. Also, new distribution records for grasses and flowering plants were collected for the area.

Brooking Gorge represents a wetland unique to that part of the range and contains significant habitats for species of aquatic plants. The gorge also represents important habitats for species of land snails and is a particularly attractive scenic area.

8. Discussion

Changes in the composition of the native fauna in northern Australia since European settlement have been documented in several studies (McKenzie, 1981, 1983; Kitchener, 1983). Morton (unpub) provides a comprehensive bibliography of studies assessing the impact of European land use. There have been few studies in the central-west Kimberley which have assessed changes in the native fauna, and none specifically of the changes in the King Leopold, Oscar and Napier Ranges, where reserves are currently being proposed.

This report has identified the significant reduction in the fauna composition around the Oscar and Napier Ranges compared with the relatively undisturbed species-rich King Leopold Ranges. Land use patterns were assessed and their impacts identified in order to determine the reasons for this difference.

The impact on the native flora was more difficult to assess because of the limited information from earlier studies. However, comparing the general species composition of the vegetation to earlier descriptions, it does not appear to have changed significantly. The abundance and structure have been reduced in some areas which are accessible and of high pastoral potential.

By assessing present day land use practices it is possible to compare the relative effects of grazing, fires and increased access between different land systems. Studies by Payne *et al.* (1979) and Speck *et al.* (1964) have indicated changes caused by land use practices and assessed the impacts on different land systems.

Certain land systems in the central-west Kimberley have been subjected to more intense levels of impact resulting in greater changes to these often more fragile land systems, including the sandplains, black soil plains and riverine systems. These systems generally represent the more attractive pasture lands, higher incidence of fires, a longer history of impact, increased pressure during drought, and are easily accessible.

The change within these fragile systems has also varied depending on the level of impact and this is evident around Brooking Gorge where there has been a high level of grazing resulting in reduced cover and the native fauna on the plains is apparently non-existent. Some areas within the King Leopold Ranges show a similar pattern where the impacts on the plains have been high. However, the diversity of the native fauna within the King Leopold Ranges indicates the isolation of many areas of pasture land from intensive impacts, resulting in "island refuges" which protect the fauna from a high level of interference. Although these areas have suffered certain impacts (changed fire regimes, limited grazing) it has not led to major impacts on the native habitat; however, it is difficult to assess any quantitative changes which may have occurred. The inclusion of these plains areas in conservation reserves is essential because they are relatively undisturbed remnants of a once extensive habitat which has been highly modified by pastoral land use.

The area including Bell Gorge, Bell Creek, Mount Bell and Inglis Gap in the King Leopold Ranges contains a diversity of habitats and associated fauna with little impact caused by past land use. During the study it was within this area that the expected range of fauna was found due to the wide range of habitats that were available and which had been relatively undisturbed. Similar habitat types in the range above the Lennard River are important as they contain new species of flora as well as extending the known geographical ranges of other flora species. From the empirical data, it can be extrapolated that similar habitat types throughout the King Leopold Ranges will also be significant for conservation. This location, together with similar habitat types throughout the King Leopold Ranges, contains the most appropriate areas for the conservation of the representative flora and fauna of the area.

As discussed in McKenzie *et al*. (1989): "When selecting a system of native reserves, the primary objective is to encompass the biological diversity of a region. Particular areas might be set aside for rare species, but the function of a reserve network is to conserve biological diversity. To ensure that as many ecological processes as possible are sustained and that evolutionary opportunities are sustained, the network should encompass:

1. most if not all of the species native to the region as they are the building blocks of the region's communities;
2. not only the individual native species, but various alternative combinations of species that form the naturally occurring assemblage thereby sustaining as much biological complexity as possible."

The habitat types identified in Section 7 within the King Leopold Ranges satisfy these requirements.

Although the Napier Range represents a less diverse range of habitats, there are still significant features of the ranges. These include suitable habitats for rare species of bats, endemic land snails, certain species of plants and unique geological formations. All these habitats are associated with the rocky hillslopes of the Napier and Oscar Ranges and it is likely that they are protected to a certain extent by the rugged nature of the terrain.

9. Proposed conservation areas in the King Leopold, Oscar and Napier Ranges

The Environmental Protection Authority's Red Book Recommendation 7.16 for the King Leopold Ranges is in two parts, as follows:

1. "The vacant Crown land formerly leased as Bell Creek station be declared a Class B Reserve for the purpose of National Park and vested in the National Parks Authority of Western Australia."

2. "Should suitable opportunities occur, the Department of Lands and Surveys negotiate to acquire those parts of Mount Hart station that lie adjacent to the south and west-north-west of this reserve and which include Bold Bluff, Mount Bell, Mount Vincent and Inglis Gap."

The Department of Conservation and Land Management also recognised the biological significance of the King Leopold Ranges and in its submission to the Kimberley Region Planning Study recommended :

> "We endorse the EPA recommendation, except that the National Park should be a Class A reserve. This small area, on its own, does not represent the major landforms and biota of the King Leopold Ranges, nor is it large enough for national park status. We recommend that the Kimberley Region Planning Study identify areas of Mt Hart station that are not needed for pastoral pursuits and that they be referred to the Department of Conservation and Land Management for evaluation for addition to the national park."

This recommendation has been incorporated into the Kimberley Region Plan Study Report (Dept of Regional Development and the North West and Dept of Planning and Urban Development 1990) which designates the King Leopold Ranges as a Category C Parks and Recreation Area, namely an area of environmental significance requiring further investigation.

This current report has achieved the aim of that series of recommendations by the Environmental Protection Authority, the Department of Conservation and Land Management and the Kimberley Region planning Study, by identifying the areas of high conservation significance in the King Leopold Ranges centred on the former Bell Creek station (Figure 5).

In addition the Department of Conservation and Land Management's recommendations cover reserves in the Napier and Oscar Ranges. These recommendations are as follows:

"Our recommendations are based on the view that the existing small reserves in the Napier and Oscar Ranges are inadequate. They are not representative of the ranges, merely including small scenic localities, which are under considerable and increasing recreational pressure. To create a system of conservation reserves representing the structures, surfaces and major tourist attractions associated with the ranges and adjacent alluvial plains to the north and south we recommend that:

1. Brooking Gorge and environs (Figure 6) be declared a Class A Reserve for Conservation Park and it be vested in the National Parks and Nature Conservation Authority.

2. the reserve recommended by the Western Australian Sub-Committee of the Australian Academy of Sciences Committee on National Parks (1962, page 92) be declared a Class A National Park vested in the National Parks and Nature Conservation Authority. The park should be named the Devonian Reef National Park.

3. the Kimberley Region Planning Study, in consultation with the Department of Conservation and Land Management, consider extending Windjana Gorge and Geikie Gorge National Parks to make them more representative of their districts and of the ranges as a whole. In particular, consideration should be given to connecting Windjana Gorge National Park with the proposed Devonian Reef National Park and to connecting the proposed Brooking Gorge Conservation Park with Geikie Gorge National Park."

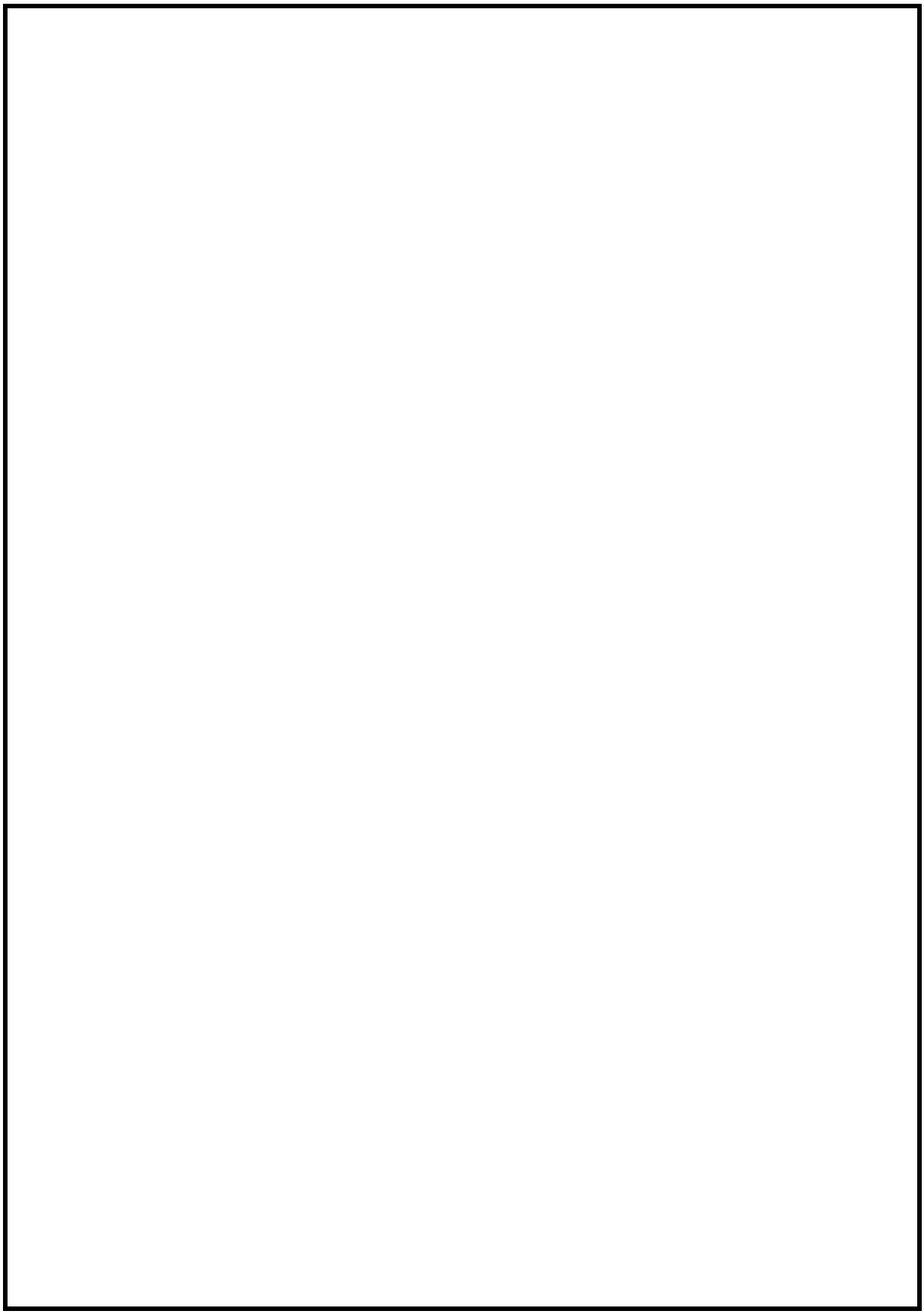


Figure 6. Proposed Devonian Reef National Park

These recommendations concentrate on the significance of the geomorphology, scenic grandeur and Aboriginal cave paintings of Windjana, Geikie and Brooking Gorges. It also refers to some of the significant biological features of these systems, including the aquatic fauna and rare species of mammals.

"There have been no detailed examinations of the fauna of the Oscar or Napier Ranges as a whole. However, the rare Rock Ringtail Possum (*Pseudocheirus dahli*) is known to occur in the Napier Range. Some measure of the biological importance of the ranges can be gauged from the fact that they support a large number of endemic land snails and cave-dwelling invertebrates."

10. Conclusions

This current report has achieved the aim of the series of recommendations by the Environmental Protection Authority, the Department of Conservation and Land Management and the Kimberley Region Planning Study, by identifying the areas of high conservation significance in the King Leopold Ranges centred on the former Bell Creek station (Figure 5). An area significant for flora and fauna in the **King Leopold Ranges** has been identified (see Figure 5) to provide for the reservation of the least disturbed habitats and also representative biota of the area.

Proposed King Leopold Ranges National Park

This report supports the original recommendation of the Environmental Protection Authority that, along with the Mount Bell station area, should suitable opportunities occur those parts of Mount Hart station that lie adjacent to the south and west-north-west of this reserve should be acquired.

This study has indicated that five habitat types in the King Leopold Ranges have been relatively protected from pastoral activity. Consequently, they support a high diversity of flora and fauna. From the data on the limited areas studied in the Bell Gorge to Inglis Gap area, it can be extrapolated that not only will the habitat types in these areas be important but also more extensive areas throughout the King Leopold Ranges.

It is suggested in this report that an area as outlined in Figure 5 be considered the minimum area significant for the protection of flora and fauna. Boundaries of conservation reserves should also be topographically manageable and provide for connection with other reserves in the area.

Areas in the **Oscar and Napier Ranges** (described in Section 7 and summarised below) should also be considered for possible reservation (Figure 6).

Brooking Gorge

Reservation of Brooking Gorge would ensure protection of the wetland habitat and associated aquatic plants and also provide protected habitats for the endemic land snails.

Proposed Devonian Reef National Park

The proposed Devonian Reef National Park should be reserved to include rare species of bats, endemic land snails, flora and the unique nature of the reef.

Windjana Gorge

Windjana Gorge should be added to the proposed Devonian Reef National Park to provide a more representative area of the Napier and Oscar Ranges.

Tourism

Tourism should be managed to protect the conservation values of the above areas. These areas already receive tourists, however, it is likely that this will accelerate quickly as the areas become better known. It is essential that appropriate plans are made to ensure that there is limited disturbance but at the same time enabling people to enjoy the area.

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Appendix 1

Scientific names of pasture land grasses

Scientific names of pasture land grasses

Annual Sorghum	*Sorghum stipoideum*
Curly Spinifex	*Plectrachne pungens*
Bundle Bundle	*Dicanthium fecundum*
Flinders Grass	*Iselema vaginiflorum*
Mitchell Grass	*Astrebla pectinata*
Perennial Sorghum	*Sorghum plumosum*
Ribbon Grass	*Chrysopogon fallax*
Short Grass	*Enneapogon polyphyllus*
Soft Spinifex	*Triodia pungens*
Limestone Spinifex	*T. wiseana*
White Grass	*Sehima nervosum*