A RESOURCE INVENTORY OF THE BUNGLE BUNGLE AREA, EAST KIMBERLEY REGION, WESTERN AUSTRALIA

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I RECOMMENDATIONS

Certain aspects of the physical and biotic environment, and associated human use patterns require further study to enable a management plan to be compiled for the Study Area. These are:

a) Prehistory of Aboriginal use including the location of sacred sites, sites of significance and areas of ethrographic and mythological importance.

b) The determination of the requirements of contemporary Aboriginal communities. This includes proposals for occupation of area, the design and siting of any structures and the pattern of use which will occur to sustain any occupation.

c) The future plans and works of the Department of Agriculture and Agricultural Protection Board. This should include the study area as well as the land in the Ord Regeneration Area. Land use and resource information may have to be extended to cover the catchment areas of any rivers and streams which flow through the Study Area.

d) The status of water resources, including surfact catchments and groundwater quality and yields.

e) A survey of the biological resources of the Study Area. This should include flora and fauna and be conducted both during the Wet and Dry seasons.

f) A survey of existing recreational use of the study area, and the requirements of the tourism industry. This should include use patterns, intensity seasonality of visitation available, accommodation in adjacent areas, and future requirements for facilities and services.

g) The involvement of Aboriginal groups in the future management of the Study Area and details of joint management arrangements with the State Government.

II INTRODUCTION

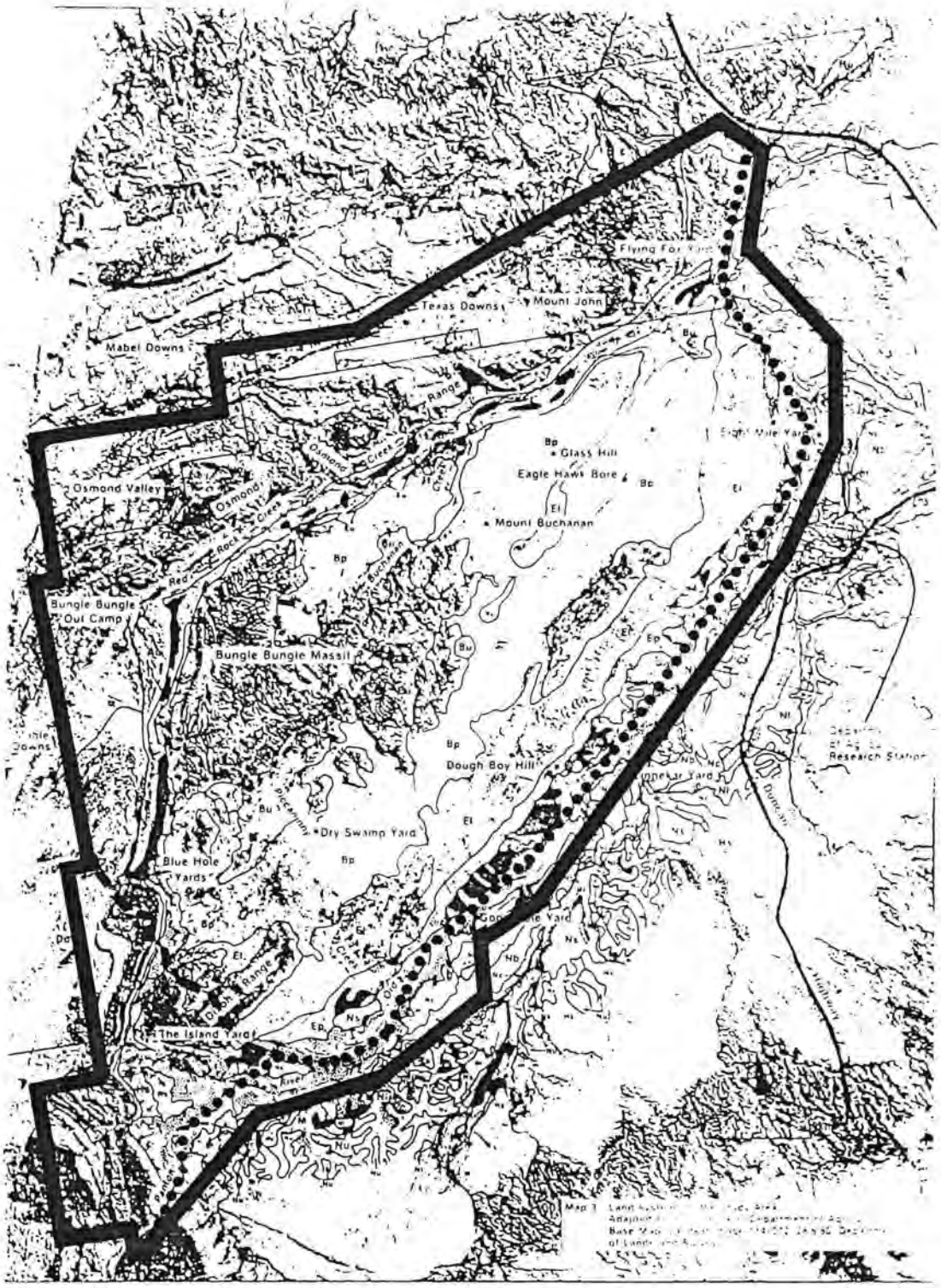
The Study Area, is located in the Kimberley region of Western Australia within the Halls Creek Shire. It is approximately 160 km south of Kununurra, 120 Km north east of Halls Creek and 50 km from the Northern Territory Border and occupies about 3 500 square kilometres (see Fig. 1). The Study Area was proposed by a Working Group formed by the Environmental Protection Authority in 1983.

The Study Area occupies the north western portion of the Ord River Regeneration Reserve - No. 28538. This is currently a Class 'C' reserve, for the purpose of 'Regeneration of Eroded Areas in the Ord River Catchment Area', and is managed and administered by the Department of Agriculture.

In the north, the area extends to cover the Osmond Valley pastoral lease and the southern portions of the Texas Downs pastoral lease. Both do not expire until 2015. To the south and east, the boundaries follow the eastern banks of the Ord and Panton Rivers, along the Department of Agriculture fenceline.

The Working Group, in their draft report submitted to the Environmental Protection Authority, recommended that the Study Area should be proclaimed a National Park, vested with the National Parks and Nature Conservation Authority as a Class 'A' reserve, and that the vesting should be subject to mechanisms providing secure residence and equitable input to management for Aboriginal traditional owners (Working Group, 1984).

The focal point of interest within the Study Area is the Bungle Bungle Range. The origin of the name is unknown, but it is suggested that Bungle Bungle is a mispelling of Bundle Bundle, the name of a common grass in the area. The name Bungle Bungle Range, is immediately derived from Bungle Bungle Outcamp which is located to the west of the massif.



Key

Boundaries proposed by the Working Group, Draft Report, 1984.

Boundaries Recommended, Department of Agriculture.

Interim Boundary Amendments, Working Group, 1985.

Fig. 1. Approximate Boundaries of the Study Area
(Source: Working Group, 1984; Dept of Ag. submission 1984; D.C.E. Files 23/83).

III CONSERVATION VALUES

Recent development in the Kimberley region has allowed greater vehicle access to remote areas and consequently tourism to the region has increased. It has therefore become important to protect significant features for the benefit of local people, visitors and future generations.

The Study Area has several attributes which afford it a high priority for conservation. These are noted below:

A. PAUCITY OF CONSERVATION RESERVES IN THE SOUTH EAST KIMBERLEY

Currently, there are no conservation reserves in the south-east Kimberley. The World Conservation Strategy has indicated the need to conserve areas of tropical grasslands and savannah as these ecosystems are poorly represented in protected areas throughout the world. These ecosystems are represented within the Study Area.

B. UNIQUE AND INTERESTING FLORA

The Bungle Bungle massif supports several unique species of flora. Kenneally (1985), recently carried out a vegetation survey of the Bungle Bungle Range and adjacent areas. He recorded two new plant species for Western Australia, - a Grevillia and a Comesperma. Other records for Western Australia (rare species or those with a restricted distribution) include the first collection of a Livistona palm 'Victoria River', Blumea pungens, Uleobryum peruvianum, Taenitis pinnata, Stephania japonica and Leptospermum longifolium. A biological survey has yet to be carried out during the wet season. Kenneally (1985) comments:

> 'The absence of detailed biological surveys of the area means that with few exceptions it is not possible to consider the conservation significance of species collected or habitats recorded in terms of overall regional representation. Only with further surveys of the east Kimberley will this information become available.' (Kenneally and Forbs, 1985).

C. FAUNA

To date, no fauna surveys in the area have been carried out. However, it is likely that many species are restricted in regional distribution to the study area (May, 1983). P.F. Berry believes the area could support new sp. of herpto-fauna.

D. LANDFORMS OF THE STUDY AREA

The Study Area possesses a range of contrasting geology over relatively short distances. The differences in relief and erosion characteristics and the subsequent differences in vegetation associations provide rich and varied habitats (May, 1983).

Much of the area is based on the easily erodible Buchanan land system, an area which requires protection from the impact of vehicles.

Of regional conservation significance are the alluvial surfaces and river frontage slopes (Draft Report, 1984) adjacent to the Ord River. These areas are otherwise almost entirely contained within pastoral leases (Draft Report, 1984).

(i) The Bungle Bungle Massif

The rarity of the Bungle Bungle formation, together with its visual impact, scientific and landscape value, qualifies the massif for a high level of conservation protection (Working Group, 1984).

It is possible that the area could be added to the World Heritage listing. However, it presently lacks secure management, other than the regeneration programme, and, although the features are unusual they are not totally unique.

The Wildlife Preservation Society are keen to have the Study Area included on the list of National Heritage Parks.

Milton (1985), the Chairman of the Committee for the Environment, referring to the protection of the Bungle Bungle, wrote that the Massif was not just visually spectacular, but was also of national and

international scientific significance. The committee recommended that further investigations into the heritage value of the area was necessary.

(ii) Gorges and Valleys

Gorges and valleys within the Bungle Bungle Range have a high conservation value as they often retain water in the summer months providing sheltered, moist habitats for specialized communities. Vegetation within these habitats contrasts sharply to that of the plateau.

E ANTHROPOLOGICAL VALUE

The Study Area was and still remains an area of considerable significance to members of the Aboriginal communities and to the Aboriginal culture.

It is important that such areas of significance be preserved from incompatible human activity.

IV NATIONAL PARK RECOMMENDATIONS

The proposals for the development of the National Park have been fully discussed in the Draft Report prepared by the Working Group (1984). Therefore only some changes to their initial recommendations have been noted.

FUNDING FOR ABORIGINAL COMMUNITY DEVELOPMENT

Establishment of the Aboriginal Community is not proposed to be the direct responsibility of the Department of Conservation and Land Management. Instead, it will require a commitment from both State and Federal Governments. The Commonwealth Government will require security of tenure, but not Aboriginal ownership, before they will provide any funding.

Resources will be required by the traditional owners to:

- facilitate communication between the State Government and the Aboriginal Community regarding the establishment of the joint management structure.
- help form an incorporated Aboriginal organisation.
- assist Aboriginals to develop an understanding of the concepts involved in National Park management.
- initiate discussions on ranger training and employment.
- allow consultation of Aboriginals regarding a management plan for the park.
- co-ordinate funding bodies that may assist in this programme.

(D.C.E. file 23/83, 1985).

The Working Group have proposed that a consultant be employed on a short term contract basis to undertake this role.

Total funding necessary for the development of an Aboriginal community (which will include travel, accommodation, vehicle purchase and maintenance, salary costs associated with organizing meetings of traditional owners and anthropological research costs) will amount to approximately $100,000 (D.C.E. file 23/83, 1985). Additional resources will be needed to enable the community to effectively participate in joint management.

Agencies which may provide funding or other assistance in some aspects of this process include:

- Department of Aboriginal Affairs
- Aboriginal Development Co-operation
- Australian Institute of Aboriginal Studies
- Aboriginal Sites, W.A. Museum
- Australian National Parks and Wildlife Service
- Department of Conservation and Land Management
- National Employment Scheme for Aboriginals and Commonwealth Employment Scheme
- Other Aboriginal Resource Organisations and Associations (e.g. Balanggari, Gagadju)

FUNDING FOR THE PROPOSED NATIONAL PARK.

The estimated levels of funding presented by the Working Group in their draft report have been revised. They consider funding for management planning and, the development of access and limited visitor facilities are the top priorities in the first year.

Revised estimated costs are as follows:

- $400,000 -	to establish a minimum of two management staff and associated infrastructure (housing, power, water, communication facilities and vehicles).
- $ 60,000 -	for temporary accommodation and office for visiting planning staff, consultants etc.
- $ 65,000 -	for a biological survey of the Bungle Bungle area and proposed additions to the park.
- $100,000 -	to establish and maintain basic access and management tracks and visitor facilities etc.
- $ 50,000/ 100,000 -	contingency for the development of an all weather dirt airstrip.
- $100,000 -	funding for Aboriginal community development.(noted previously)
$775,000/ 825,000	Total

(D.C.E. file 23/83, 1985).

The Working Group recommend this funding be additional to the existing funds allocated for National Park management in Western Australia. Present funding levels will not absorb the costs associated with the establishment of this major National Park.

The Department of Conservation and Land Management should reach some agreement with the Department of Agriculture regarding the allocation of funds and the co-ordination of the regeneration programme within the study area.

Milton (1985), recommended that the Government assist the Warmun Community and the State by providing funding and other resources for the development of the Study Areace to the State can be provided under the State's Assistance Programme. He also recommended that the Minister for Aboriginal Affairs approach his State counterparts, regarding the provision of resources to enable the Aboriginal community to participate effectively in this programme. The Committee for the Environment also recommended the Australian National Parks and Wildlife Service, in consultation with the Warmun Community and relevant Western Australian Government authorities, offer assistance in the development of Aboriginal training programmes for the traditional owners.

AMENDED BOUNDARIES

A submission to the Environmental Protection Authority on behalf of the Department of Agriculture, noted that the area of land to the north of the Department's Research Station and immediately east of the Ord River, will be required by the Department for future research work (Fig 1). It also indicated that the existing fenceline, along the southeast of the Ord River, was not an appropriate boundary for the park. In view of these concerns the Working Group amended their original recommendations:

> "The proposed park should have an interim South-eastern boundary following the eastern bank of the Ord and Panton Rivers, then west along the southern bank of the tributary to within 1km of the western boundary of the Regeneration reserve, and then south to include the two hills of significance for Aboriginals, Jaji and Duru, but that this boundary would in the long term be extended to correspond with the eventual fencelines" (D.C.E. file 23/83, 1985).

The Department of Agriculture do not believe that the MacIntosh Plains - in the south-west sector of the study area, - should be included within the boundaries of the park, as once regenerated the area has a high grazing potential. However, these grasslands also have a high conservation value. Tenure will be therefore considered when the area has fully regenerated.

On the northern sides of the study area the proposed boundaries have been extended to include a portion of Mabel Downs, possibly to Winemma Gorge.

JOINT MANAGEMENT

The concept of joint management is based on the Kakadu National Park and Coburn Wildlife Sanctuary models in the Northern Territory. The idea is centred upon joint control and management between Aboriginal traditional owners and the West Australian Government.

As the concept is new to Western Australia, supportive legislation will need to be introduced by the Government before any policies and management practices can be determined by the traditional owners and the Department of Conservation and Land Management.

The Working Group recommended that Aboriginal hunting and gathering should not be restricted to traditional methods and they should be allowed to hunt using vehicles and firearms etc. It is believed Aboriginals will use discretion for hunting and gathering, which would be at subsistence levels. Hunting rights should be restricted to the traditional owners.

The Working Group believe there is no need to have a technical sub-committee within the joint management administrative structure as its functions could be fulfilled by the Aboriginal incorporated body.

Any future management decisions which will affect Aboriginal people or their sacred sites should be subject to agreement by the Aboriginal incorporated body.

MANAGEMENT ZONING

The study area should consist of 2 basic management zones (D.C.E. file 23/83, 1985). The bulk of the reserve, including the Bungle Bungle massif, will be included in the conservation zone. Other small areas will be designated as Parks Facilities Zones. For further details, refer to the Working Group Draft Report,1984.

These zones consist of the following:

1. Conservation
   - conservation units
   - landscape protection units
   - regeneration units
   - Aboriginal traditional units
2. Park Facilities Zone
   - tourist facilities units park
   - park administration units
   - access routes
   - Aboriginal living units

EMPLOYMENT

The Working Group have recommended that Aboriginal and non Aboriginal people should be employed in the park, and that Aboriginal employment should not be restricted to traditional owners. Further, employment of Aboriginals should not be restricted to normal ranger positions nor to permanent, full time employment. The possibility of contract employment should be considered.

Aboriginal training programmes will be additional to the ranger training programmes. Structure and content of the training programmes should be closely linked to the requirements of employment.

The Department of Conservation and Land Management should not be made responsible for Aboriginal Welfare. However, it should be the Department's responsibility to ensure that adequate funds are available for Aboriginal participation in joint management.

TOURISM

The Working Group emphasised that the basic philosophy of their report is tourism in a National Park context not tourism for tourism's sake.

The type of facilities envisaged by the Working Group that should be provided in the park in the short term would be unlikely to interest any private developers, e.g. camping areas, barbecues, bins etc.

If more sophisticated facilities are needed they should be located outside the proposed park boundaries - at existing recreational centres or townsites. Given the park's size and isolation it would be impractical to house such facilities within the park.

PART A: THE PHYSICAL AND BIOTIC ENVIRONMENT

1.0 CLIMATE

The study area has a typical arid monsoonal climate (Slatyer 1970) characterized by two distinct seasons; hot, wet summers (the wet season), and warm, dry winters (the dry season).

There are no meteorological recording stations in the study area, therefore data from Turkey Creek and Halls Creek Meteorological stations has been taken to be representative of the area. The average monthly temperature, rainfall and humidity readings for each station are given in Figs. 2 and 3.

Precipitation in the area is generally concentrated into a wet season, extending from November to March. For the remainder of the year the area is relatively dry. Of the total rainfall, 85% falls between December and March. Most of the precipitation is localized by thunderstorms although cyclones bring widespread falls. Rainfall in the region is intense, erratic and very unreliable.

Daytime temperatures during the dry season (April-October), are in the upper twenties to lower thirties and are accompanied by easterly winds with little cloud cover. Night temperatures are also relatively high, though frosts may occur during cooler months. After July, the coldest month in the year, temperatures rise accompanied by increases in humidity, cloud cover and the incidence of thunderstorms. Wind direction becomes more variable, with a strong westerly component.

Temperatures commonly exceed 40°C and reach their peak prior to the wet season (November-March). During the wet season, temperatures are slightly lower, but humidity is high (see Figs 2 and 3).

Climate Relation to Plant Growth

Rainfall characteristics place severe limitations on the time favourable for plant growth. Over the study area, falls are too light and sporadic to support a stable agriculture. The length of the growing season is directly related to the duration of the wet season, and is determined by the length of time where stored soil water is greater than 62-65mm (Slatyer, 1970). The

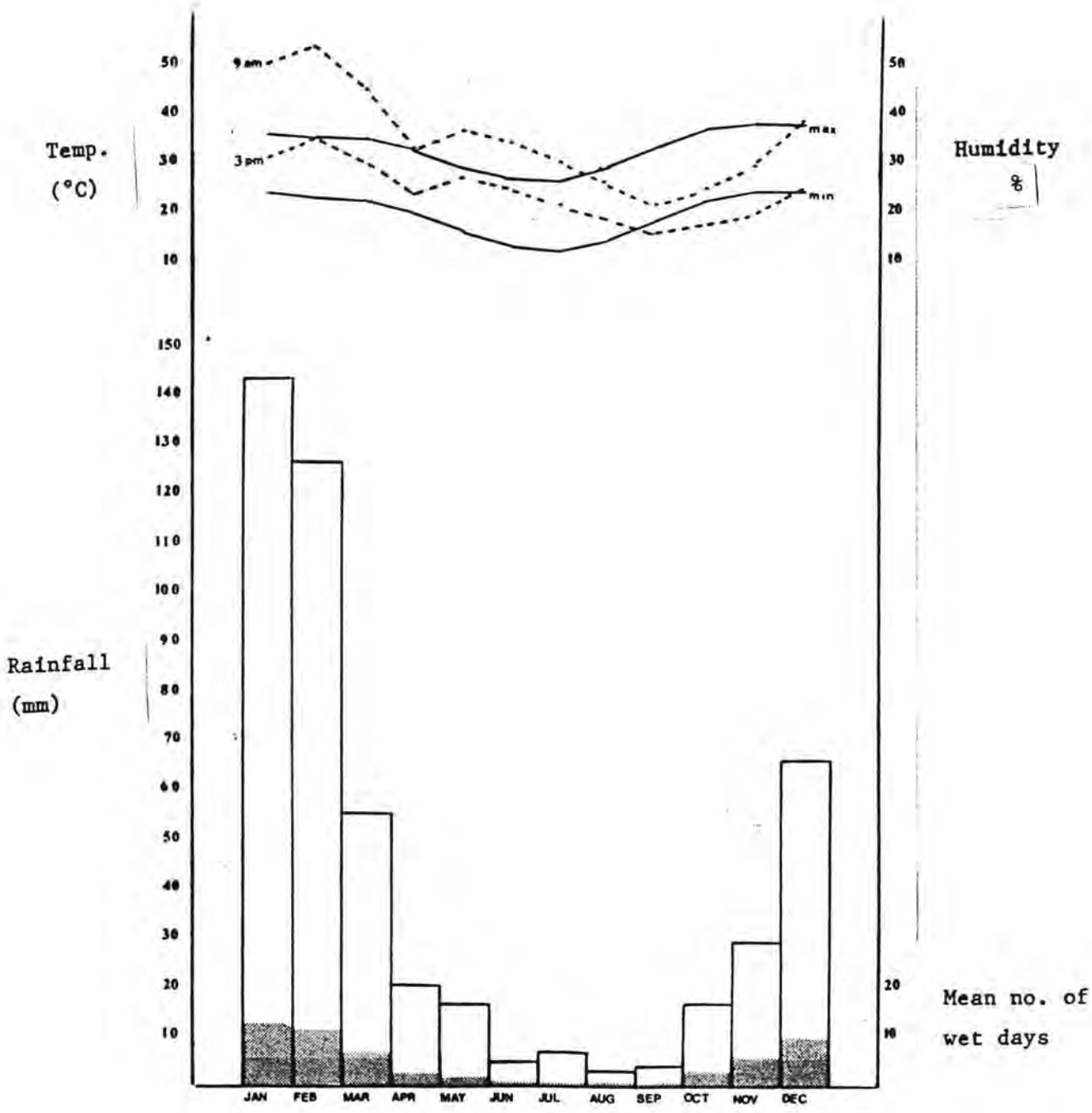


Fig. 2 Climatic Data for Halls Creek
(Source: Bureau of Meteorology, 1985).
Graphs shows averages calculated over 40 years.

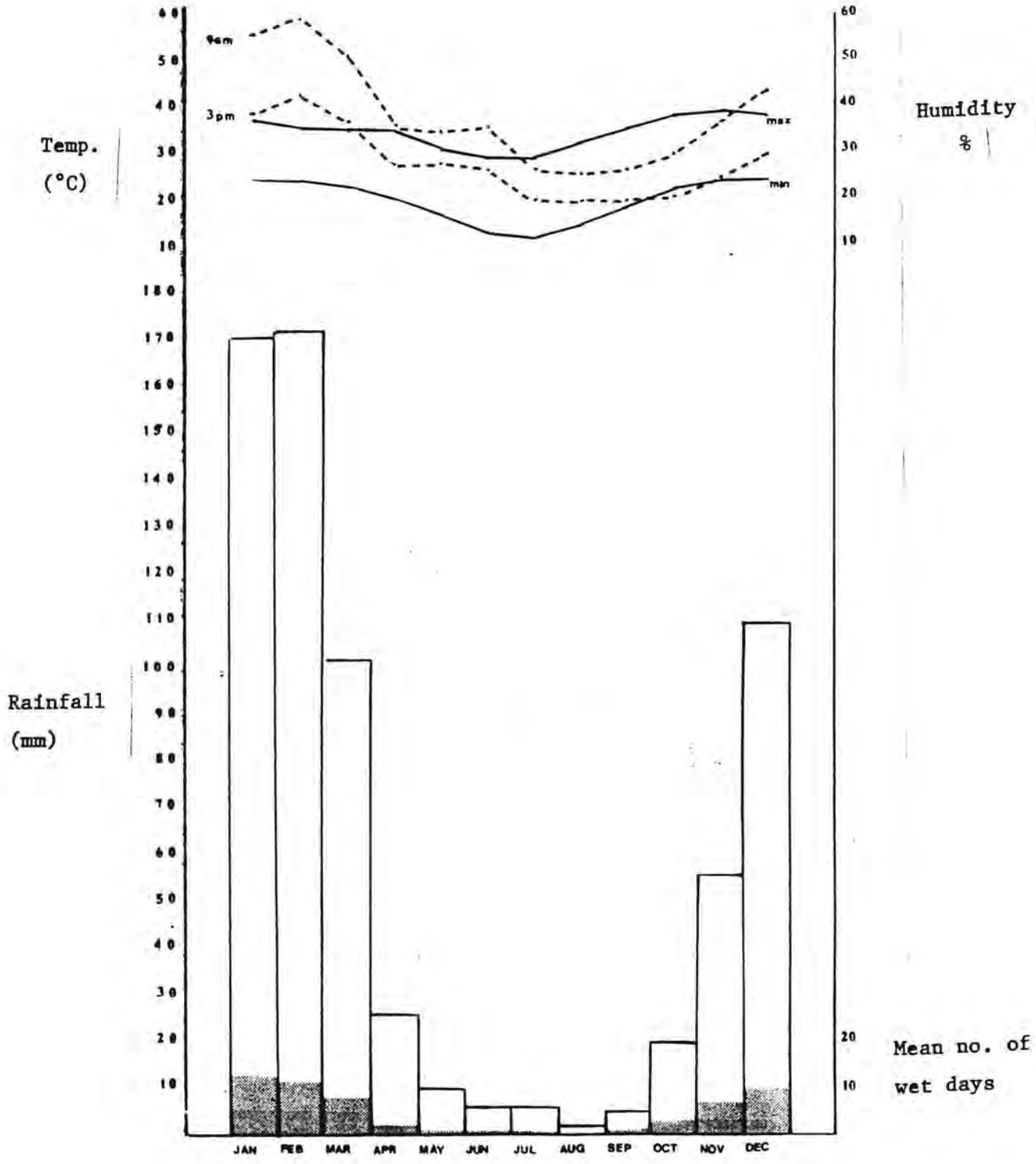


Fig. 3 Climatic Data for Turkey Creek
(Source: Bureau of Meteorology, 1985).
Graph shows averages calculated over 40 years.

period for natural pasture growth is approximately 10-12 weeks (Slatyer (1970).

Robinson (1970) noted that using average rainfall figures to complete a picture of the climatic conditions of the area is of limited value. Rainfall from December-March is critical for pasture growth; falls pre-season (October-November) may provide a 'green pick' but high temperatures and the sporadic nature of the rainfall limits its effectiveness (Robinson, 1970, Slatyer, 1970). Similarly, rainfall at other times of the year, has a limited value.

The effectiveness of rainfall in the area has decreased over the past 47 years. This has been attributed to the cost of the rainfall as run-off and evaporation.

1938 1938 1938 1939 &	Finucane) Jones) Finucane) Finucane) Sullivan)	Reported on the various mining areas of the region for the Ariel, Geological and Geophysical Survey of Northern Australia.
1948	Matheson & Teichert	Made a geological reconnaisance of the Cambrian rocks of the East Kimberleys and Ord Basin.
1949	Matheson & Guppy	Part of the Halls Creek Precambrian rocks were mapped as part of the Fitzroy Basin Region, by the Bureau of Mineral Resources.
1955	Traves	As a member of the CSIRO Land Research and Regional Survey Team in 1949 and 1952 mapped the Ord Victoria Region.
1958	Guppy, Lindner Rattigan & Casey	Bureau of Mineral Resources began systematic regional mapping of the Fitzroy Basin (1948-1952).
1959	Harms	Surveyed Kimberley District for BP Pty Ltd.
1961	Ruker	Mapped the area near Saunders Creek, Gordons Downs.
1964	Passmore	Reported on the water resources of the East Kimberley Region.
1967	Dow & Gemuts	Prepared map & explanatory notes of the Dixon Range Western Australian Results of mapping programme from 1962-1964.
1968	Veevers & Roberts Kaulback & Veevers	Described the Paleozoic succession of the Bonaparte Gulf Basin which overlaps the East Kimberleys in the North East.

2.0 GEOLOGY

2.1 PREVIOUS INVESTIGATIONS

(Adapted from Dow & Gemuts, 1969)

DATE	AUTHOR	COMMENT
1885	Hardman	Performed the first geological work in the Ord River area, 1883-1884. A Government geologist attached to the Kimberley Survey Expeditions discovered gold in the area.
1891	Woodward) Smith)	Reported on the geology of the goldfields in the Halls Creek area.
1920	Oakes	Discovered asphaltite at junction of the Ord and Negri Rivers.
1920	Maitland	Reported the finding of a 'bituminous substance' in the Ord and Negri Rivers.
1922	Mahony	Looked at the area for the possibility of finding petroleum.
1922	Blatchford	Reported the occurrence of the 'bituminous substance'
1924	Wade	Performed extensive work on the geology of the East Kimberleys. Reported on the prospects of finding commercial quantities of petroleum in the area.
1928	Blatchford	Reported briefly on gold mining at Grants Patch Centre, and the occurrence of galena on Speewah Station.

1969	Bureau of Mineral Resources & Geological Survey of W.A. (Dow & Gemuts)	Report prepared from the 1962-1964 programme to map the Precambrian rocks of the Kimberley Region.
1975	Thom	Reported on the geology of the Kimberley Region. Part of a Western Australian Geological Survey team.
1982	Beere	Surveyed the Bungle Bungle massif within the Study Area. Primarily studied the cryptoexplosive Piccaninny structure.
1984	Young	Studied the geomorphology of the Bungle Bungle massif. Work currently in press.

2.2 REGIONAL GEOLOGY

The Kimberley Region of north-western Australia can be divided into 3 major geological blocks based on Precambrian rocks (Fig 4).

1. The Kimberley Basin is located to the north and north-west of the study area, is composed of sedimentary and volcanic rock, deposited approximately 1900 to 1650 million years ago. The area has remained tectonically stable except for minor regional uplift.

2. The Halls Creek Province is a zone of metamorphic and igneous rock, bordering the eastern and south-eastern limits of the Kimberley Basin. The province may be subdivided into (a) the King Leopold Mobile Zone and (b) the Halls Creek Mobile Zone. This area has experienced continual renewals of tectonic activity, faulting and deposition.

3. Sturt Block in the East Kimberleys is dominated by a series of volcanics and undifferentiated sediments. The Hardman Basin, within which most of the study area is located, is part of the Sturt Block. The remainder of the study area, part of the Osmond Range, lies within the Halls Creek Mobile Zone.

2.3 GEOLOGY OF THE EAST KIMBERLEYS

The geology of the Sturt Block, and therefore the Study Area, is influenced by the activity of the Halls Creek Mobile Zone, a belt of severely folded and faulted metamorphic and igneous rocks extending from south of Halls Creek to Darwin in the Northern Territory (Dow & Gemuts, 1967). The mobile zone is bordered to the east by the major Halls Creek fault and is traversed by a complex network of minor transcurrent faults (Thom, 1975).

The oldest rocks of the East Kimberleys are the Halls Creek Group which were deposited, possibly in the Archaean, over the whole of the region. These were tightly folded, metamorphosed and intruded by basic sills and dykes. A second period of more intense folding and metamorphics followed in the Proterozoic, subsequently forming the Lamboo Complex, a series of igneous and metamorphic sediments consisting of intruded granite, dolerite and quartzite dykes, sills and other metamorphic rocks.

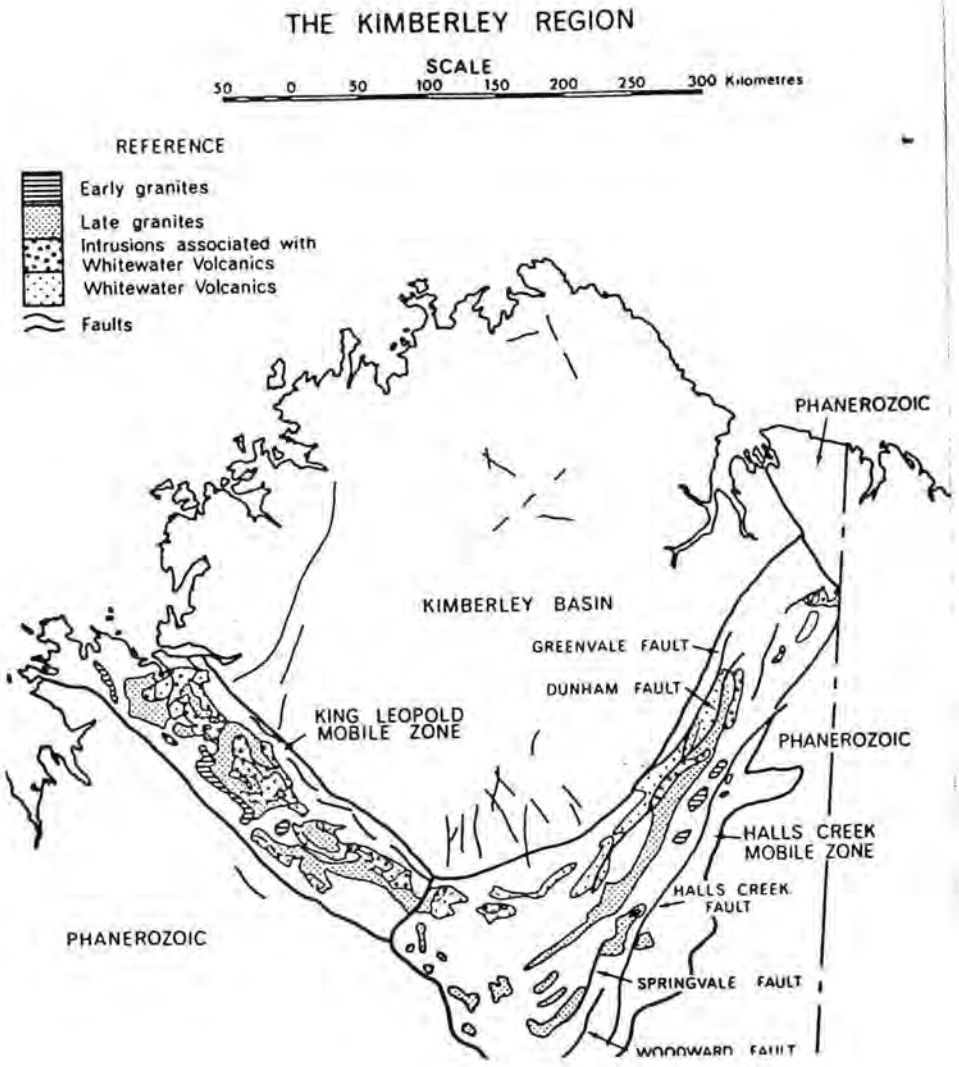


Fig. 4. The Kimberley Region showing 3 Major Geological Blocks. (Source: Thom, 1975).

During the early Carpentarian (1 800 million years ago) the type of deformation changed and the region reacted to stress by horizontal faulting along faults which parallel the mobile zone. Large areas of land, lying to the east of the mobile zone, were broadly warped. This transcurrent faulting has continued from the Mid Proterozoic into the Palaeozoic and possibly through into the Mesozoic. The early Carpentarian also marked a break from the tectonic and volcanic activity of the early Proterozoic with stable conditions which prevailed for the rest of the Precambrian. Only along the mobile zone did any metamorphic and volcanic activity continue after the Early Proterozoic.

The Osmond Range Succession, exposed as the Osmond Ranges, was laid down within the mobile zone during the Carpentarian (approximately 1 800 million years ago). The succession is interrupted by disconformities and angular unconformities (Thom, 1975) which consist of vertically tilted, faulted wedges of Red Rock beds. The accompanying faulting is thought to be tensional (Thom, 1975) and is accompanied by the intrusion of the Fish-Hole Dolerite. Sedimentation was influenced by faulting and it is possible that a land mass to the west of the mobile zone supplied the sediments.

Regional folding, faulting and erosion interrupted sedimentation at least three times during the Adelaidean (1400 million years ago). During this period, the land surface was also subject to two glacial phases separated by a long period of marine deposition.

The first glacial phase was followed by a term of mild folding, and an extensive period of erosion. Large areas of the sediments deposited during the previous glacial term were removed. Evidence of the second phase of glaciation has only been found to the west of the mobile zone.

During the early Phanerozoic (500 million years ago) sedimentary basins were formed by the subsidence of the land surface (Beard, 1979). The Ord Basin is thought to be a small part of a larger Regional Gravity Depression that possibly developed during a period of transcurrent faulting (Playford et. al, 1975). The majority of the reserve is located within the Hardman Basin, a part of the Ord Basin, which Playford (1975) has defined as being partly post-depositional synclines developed in Devonian sediments. The basin has been formed by the upward drag along faults (Dow and Gemuts, 1967).

2.4 GEOLOGY OF THE STUDY AREA

Towards the close of the Precambrian, the study area was uplifted and subsequently eroded. This was followed in the early Cambrian by extensive outpourings of Antrim Plateau Volcanics, a series of basalt flows up to 1 000 m deep, which covered most of the Ord Basin (Fig. 5). These volcanics form the basal layer of the Ord Basin (Playford et al, 1975).

This period of volcanic activity preceded a term of uplift and subsidence and late, mid Cambrian, marine transgressions. The transgressions resulted in the deposition of a series of sediments, defined by Traves (1955) as the Negri Group, unconformably over the Antrim Plateau Volcanics (Fig. 5). The Negri Group are a series of alternating shale and limestone sediments. The characteristics of the individual deposits constituting the series are noted in Fig 6. Special features are noted below:

(i) The Headleys Limestone is the basal layer of this sequence. This is a deep deposit, 35m-55m thick containing a high content of chert and other siliceous matter (Robinson, 1970). To the west of the Bungle Bungle massif, the Headleys Limestone outcrops as a near vertical wall approximately 10m high.

(ii) Nelson Shales is the oldest shale layer in the series overlying red and grey shales, ranging in thickness from 150m-180m.

(iii) Linnaker Limestone is a grey and brown limestone deposit overlying the Nelson Shales. It is high in organic content and intruded with minor shale beds.

The remaining sediments which are shown in Figure 6 have been largely removed by weathering and erosion.

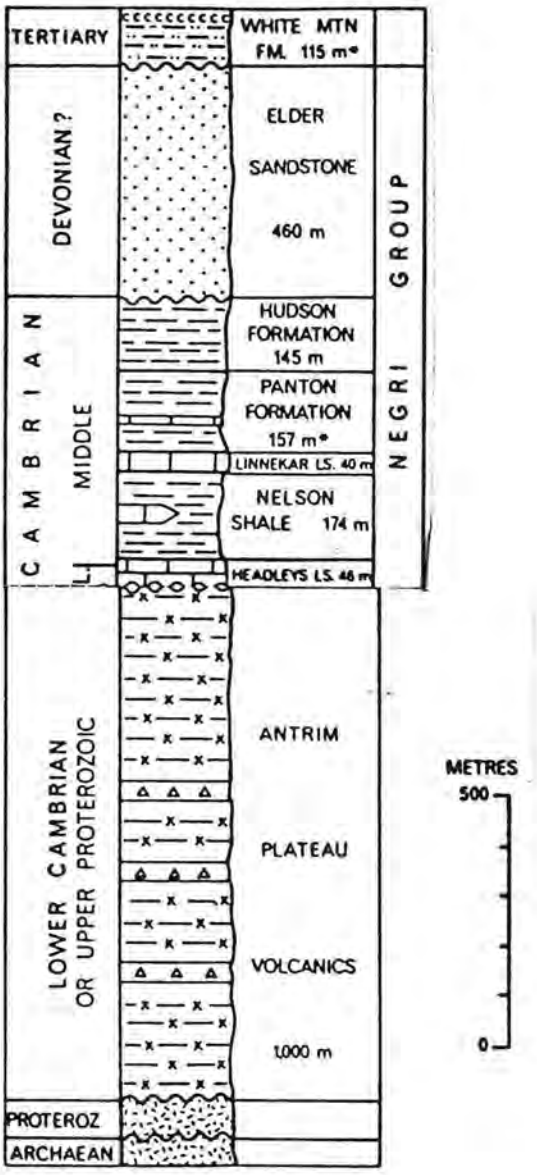


Fig. 5. Stratigraphic Column of the Ord Basin.
(Source: Thom, 1975).

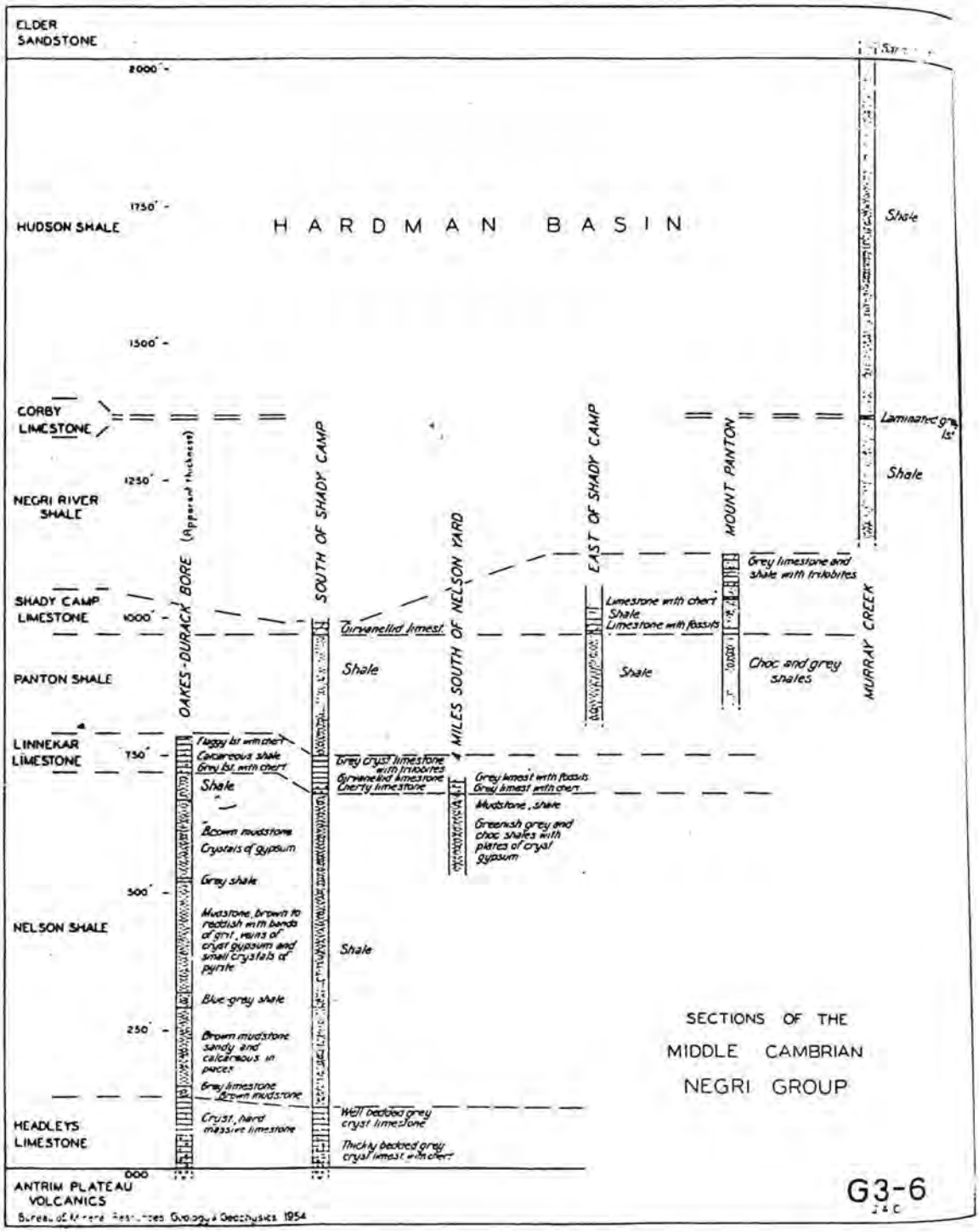


Fig. 6 Sections of the Middle Cambrian Negri Group.

(Source: Traves, 1955)

Unconformably overlying the Negri Group is a massive bed, approximately 450m thick, of white Elder Sandstone deposited during the Devonian (395-345 million years ago). There is no record of mid or upper Ordovician, Silurian or Lower Devonian sedimentation (Traves, 1955).

By the early Mesozoic, most of the region was a land surface. Extensive weathering in the Tertiary, resulted in the lateritization of the Antrim Plateau Volcanics. Towards the close of the Tertiary, uplift and mild folding occurred over the surface of the recently consolidated White Mountain formation and laterite, initiating the present cycle of erosion. This stripped most of the Tertiary laterite and weathered exposed, harder rock strata to give rise to fold mountains, cuestas, and plateaux. Softer rocks have been extensively eroded to form inland erosional plains. The alluvial cracking clay plains and fluvial silts and gravels adjacent to river systems are generally of Quarternary origin.

2.5 GEOMORPHOLOGY OF THE STUDY AREA

The nature of the underlying rock is one of the major factors determining the geomorphology of the area. Exposed more resistant rocks give rise to fold mountains and plateaux, in contrast to softer strata which are more extensively eroded. Aeolian erosion is presumed to have occurred during a period of aridity in early Recent times (about 10 000 years ago) (Paterson, 1970).

The terrain of the study area can be generally described as consisting of severely eroded, open plains and rugged upland areas of mesas, hogbacks and buttes. More specifically however, the Osmond Range consists of cuestas and hogbacks formed principally from Halls Creek sediments and the Lamboo Complex. The Range has been defined as a faulted anticline, where sediments have been tilted and folded. V-shaped and hanging valleys formed by erosion along joints and faults dissect these uplands.

The Antrim Plateau volcanics are a series of basalt flows, interbedded with tuffs, sandstone, chert and agglomerate which underlie the Hardman Basin. The volcanics have been exposed mostly in the northern and western limits of the study area where they have given rise to rugged uplands (Osmond Ranges and adjacent plains) that outcrop above narrow outwash plains.

The Negri Group, by a process of preferential erosion, has given rise to a characteristic cuesta-plain landform (de Salis, 1982). Where sediments are exposed to weathering, resistant limestone beds give rise to cuestas or small rises, in contrast to the soft shales which are extensively eroded and form alluvial plains. On the southern margins of the study area, exposed, gently sloping Headleys limestone has been dissected by many narrow sheer-sided ravines that have developed from erosion along joints.

The Devonian Elder Sandstone immediately overlies the Negri Sediments and is exposed generally in the north west of the reserve. Intense jointing and subsequent dissection and silification of the sandstone has produced a sheer-sided plateau (the Bungle Bungle massif) that rises approximately 200m above the surrounding plain and is deeply dissected by sheer-sided valleys and gorges. Mt Buchanan and Glass Hill are erosional remains of the original sandstone bed (refer also to the following section, "The Geomorphology of the Massif").

2.6 LAND SYSTEMS OF THE STUDY AREA

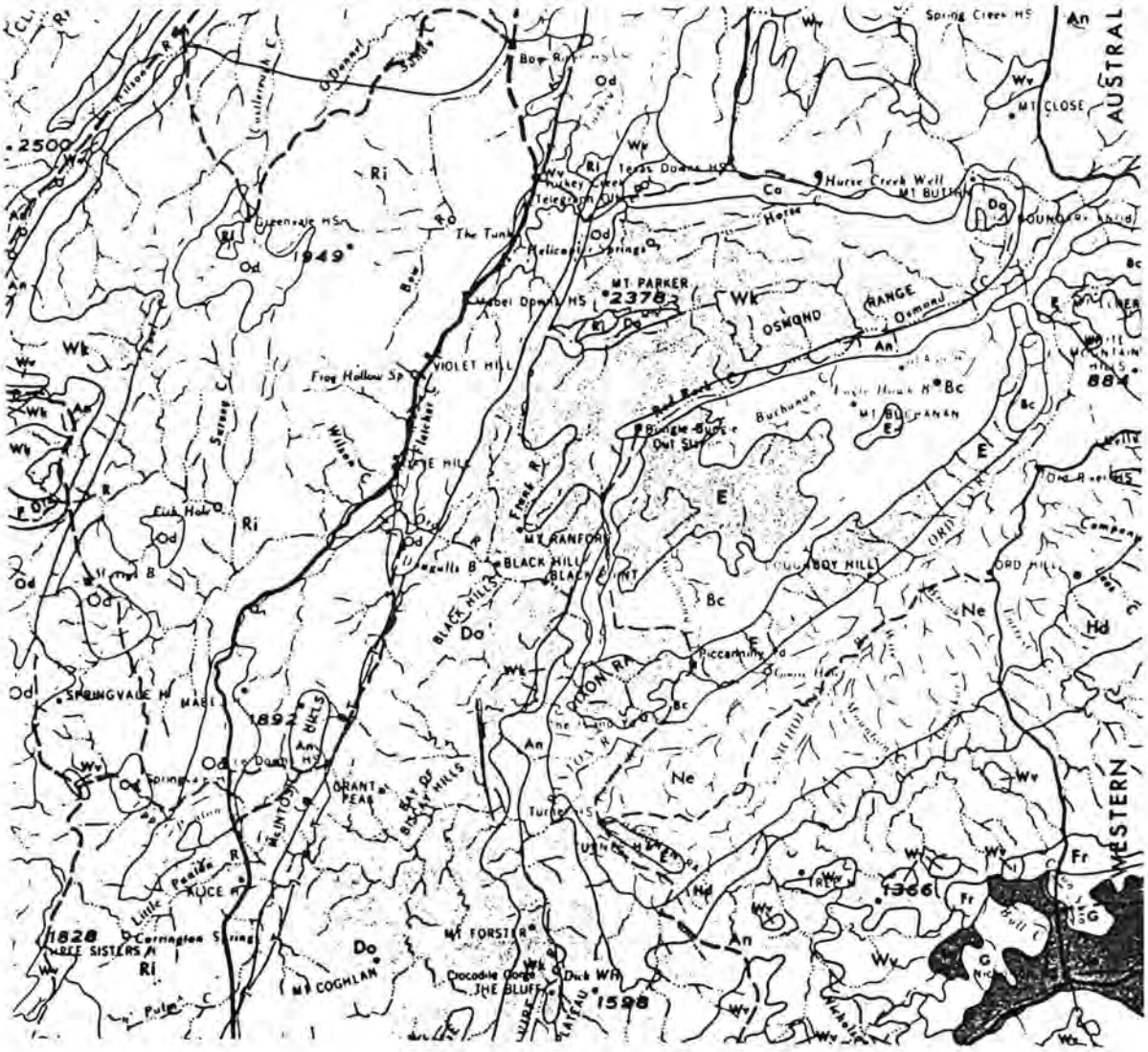
The distinct landforms of the study area can be divided into land systems based on differences in geology and geomorphology. The land systems used in this document are based on the original classification by Stewart (1967), as adapted by de Salis (1982). The distribution of these land systems across the study area is shown in Fig 7.

The Antrim Land System

The Antrim Plateau Volcanics form the basis of this land system which is located along the northern and western margins of the Hardman Basin. The volcanics have formed mesas, buttes and ridges above narrow outwash plains which lie along drainage lines such as Red Rock Creek and Osmond Creek (Fig. 8).

The Buchanan Land System

The Buchanan Land System is closely related to the Elder Land System, as Elder Sandstone forms the basis for both systems. This system is located west of the Ord River, in the central and north-eastern parts of the study area.



KEY:

An - Antrim Land System

Bc - Buchanan Land System

Hd - Headley Land System

E - Elder Land System

Ne - Nelson Land System

Wk - Wickham Land System

Do - Dockrell Land System

Approximate Boundaries of the Study Area

Fig. 7. Land Systems in the Study Area.
(Source: CSIRO, 1970).

The land system is comprised of 3 representative land units (See Figure 9).

(1) Uplands - sandstone outcrops in sandplains.
(2) Sandplains - formed from the erosional remains of the Elder Sandstone.
(3) Frontage plains - located along or across drainage lines.

The Headley Land System

The Headleys Limestone of the Negri Group forms the basis of this system, which lies in close association with the Antrim and Nelson Land Systems. The limestone characteristically forms cuestas which run along the southern and eastern margins of the Hardman Basin, parallel to the Ord River. This land system can be divided into 3 land units (See Figure 10).

(1) Upper slopes - basically limestone cuestas.
(2) Lower back slopes - the narrow undulating backslopes of the cuestas.
(3) Cracking clay complex - a transitional, slightly undulating land unit, located between the Headley and Nelson Systems.

The Elder Land System

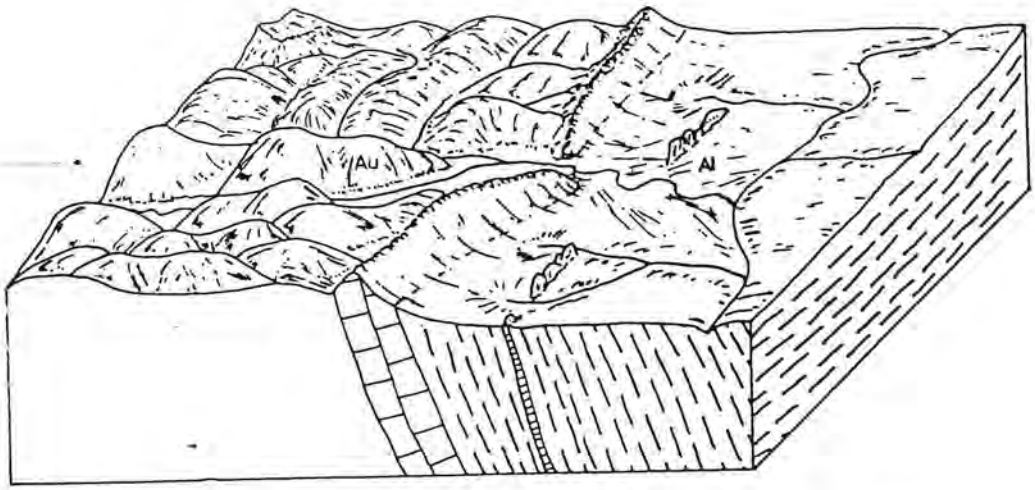
The Elder Land System is located in the north west of the reserve. Dominant landforms are a structural plateau and cuestas formed from Elder Sandstone. Three land units make up the system (See Figure 11):-

(1) Uplands - comprises of a rugged, inaccessible sandstone plateau, (the Bungle Bungle massif) that rises 200m above the surrounding sandplain. The plateau has spectacular sheer sides and is cut by deep gorges and valleys (Refer also Geomorphology of the Massif).

(2) Cuestas and Cuesta backslopes - located west of the Ord River and south of Osmond Creek. The cuestas, are not as pronounced as those found in the Nelson System.

(3) Lower Slopes - located on the footslopes of the sandstone cuestas. The unit is based on the Hudson Shales of the Negri Group which form gently rounded footslopes.

Fig. 8. Schematic representation of the distribution and geology of the Antrim land system



Unit Key

Au - Rugged uplands
Al - Lowlands

Geological Key

Antrim Plateau Volcanics

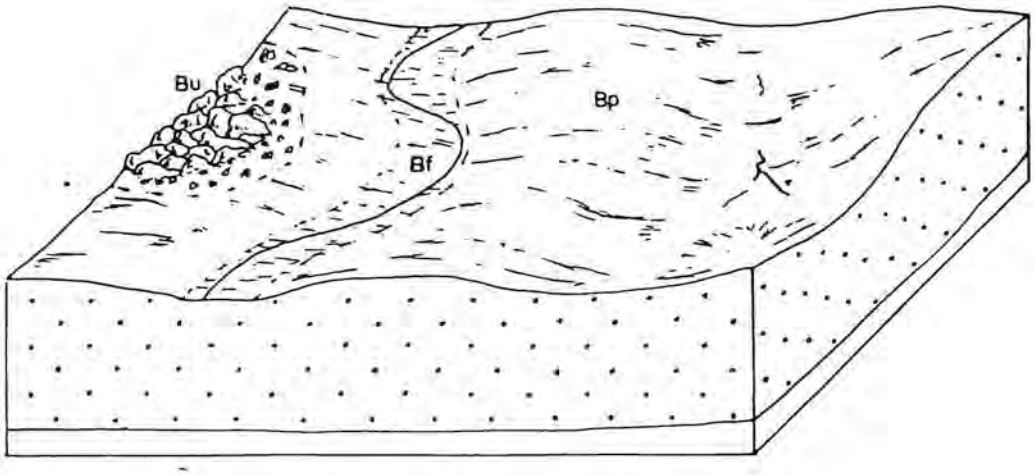
Negri Group

Negri Group shales

Other Negri Group limestones

Headley Limestone

Fig. 9. Schematic representation of the distribution and geology of the units of the Buchanan land system



Unit Key

Bu - Uplands
Bp - Sand plain
Bf - Frontage plain

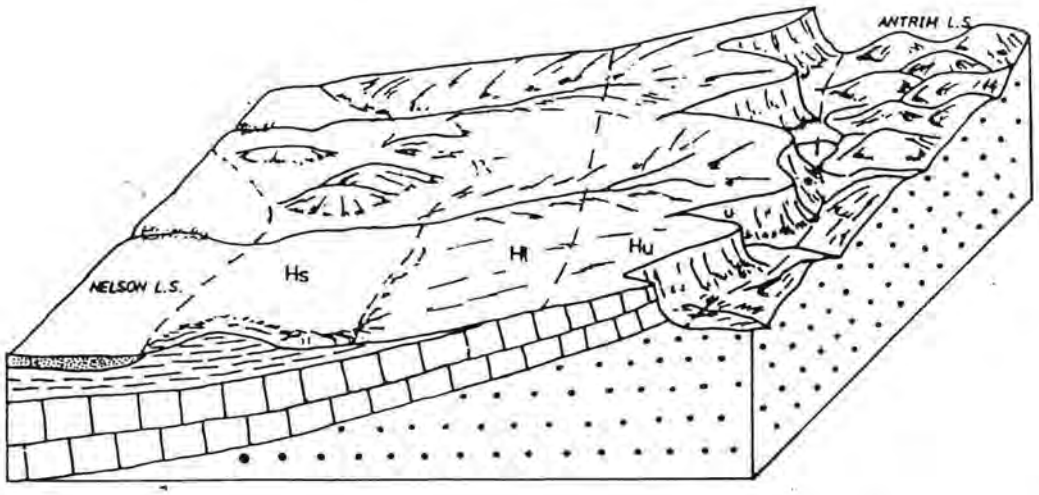
Geological Key

Elder Sandstone

Negri Group

(Source: de Salis 1982).

Fig. 10. Schematic representation of the distribution and geology of the Headley land system



Land Unit Key

Hu - Upper slopes
Hl - Lower slopes
Hs - Cracking clay complex

Geological Key

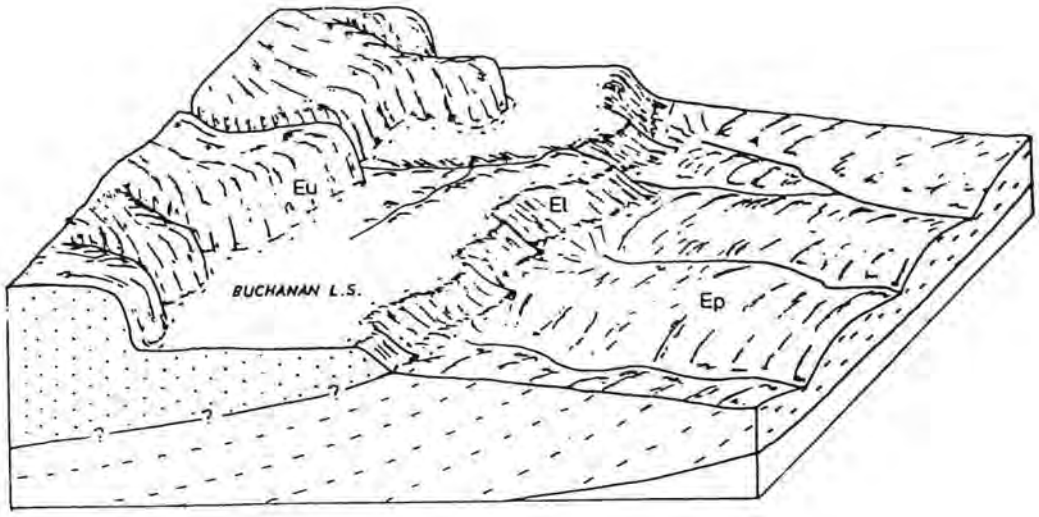
Antrim Plateau Volcanics

Negri Group

Nelson Shale

Headley Limestone

Fig. 11. Schematic representation of the distribution and geology of the units of the Elder land system



Unit Key

Eu - Uplands
El - Cuestas and cuesta backslopes
Ep - Lower slopes

Geological Key

Elder Sandstone

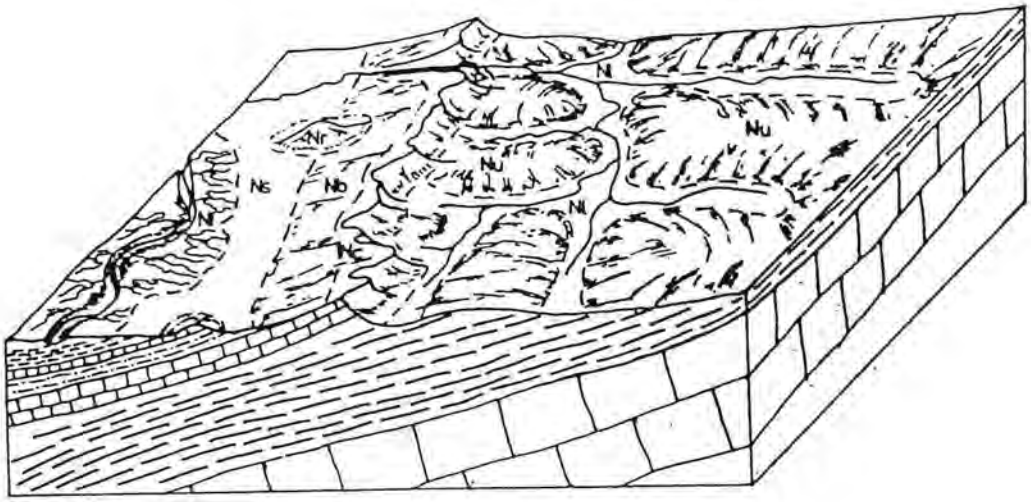
Negri Group

Hudson Shale

Other Negri Group limestones and shales

(Source: - de Salis 1982).

Fig. 12. Schematic representation of the distribution and geology of the units of the Nelson land system.



Land Unit Key

Nc - Cuestas
Nb - Cuesta backslopes
Ns - Cracking clay plains
Nu - Interfluve upper slopes
Nl - Interfluve lower slopes
Nf - Frontage plains
Nr - Low rises

Geological Key

Antrim Plateau Volcanics

Negri Group

Shady Camp Limestone

Panton Shale

Linnakar Limestone

Nelson Shale

Headley Limestone

(Source: de Salis 1982).

The Nelson Land System

Erosional plains formed from the Negri sediments are the basis of this land system which lies south of the Ord River. The Nelson Land System can be sub-divided into seven land units (Fig. 12):-

1. Cuestas - based on the cuestas developed from Linnaker and Corby limestone. They form a discontinuous line that runs parallel to the Ord River, between its junction with the Negri and Panton Rivers.

2. Cuesta Backslopes - comprised of rocky, gentle backslopes of cuestas usually associated with the cracking clay plains and frontage plains of the Nelson System.

3. Cracking Clay Plains - this encompasses flat extensive flood plains, located close to major drainage lines. The Quaternary alluvium which forms these plains is of mixed origin.

4. Interfluve Upper Slopes - developed from the soft shales, siltstones and mudstones of the Negri Group. It consists of moderately long, sloping interfluves (de Salis, 1982).

5. Interfluve Lower Slopes - is closely related to the interfluve upper slopes unit and is, similarly, formed on the soft shales of the Negri Group.

6. Frontage Plains - located adjacent to the drainage systems in the Hardman Basin. Deposits are of Quaternary origin. The unit consists of flow lines, banks, levees and levee backslopes (de Salis, 1982). Deposits which form this unit are of Quaternary origin. The unit consists of flow lines, banks, levees and levee backslopes (de Salis, 1982). It generally backs onto the Nelson cracking clay plains.

7. Low Rises - The low rises and hills that form this unit are found south of the Ord River between its junction with Linnaker Creek and the Panton River.

Wickham Land System

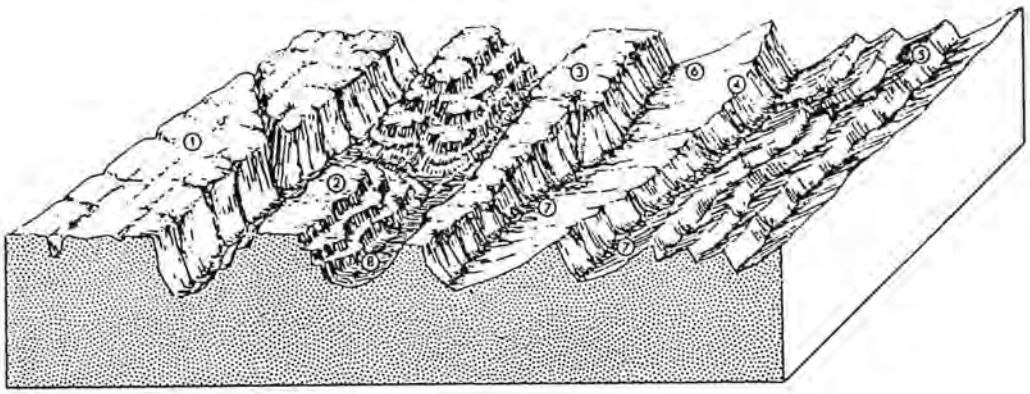
The rugged uplands of the Wickham system lie on the Halls Creek Mobile Zone (de Salis, 1982). It is composed largely of inaccessible ranges that run along the northern and western boundaries of the reserve (see Fig. 13).

The uplands are formed on shales, siltstones, sandstone conglomerates and dolomites of the Proterozoic period (de Salis, 1982). The relief typically consists of strike ridges and cuestas.

Dockrell Land System

This land system lies along the western boundaries of the reserve. It constitutes upland areas that are generally located outside the boundaries of the study area. The basis of this land system are the sediments and metamorphic rocks formed in the Archaean; the Halls Creek rocks and the Lamboo Complex. The terrain consists of fold mountains and ridges which run parallel to the mobile zone (see Fig. 14).

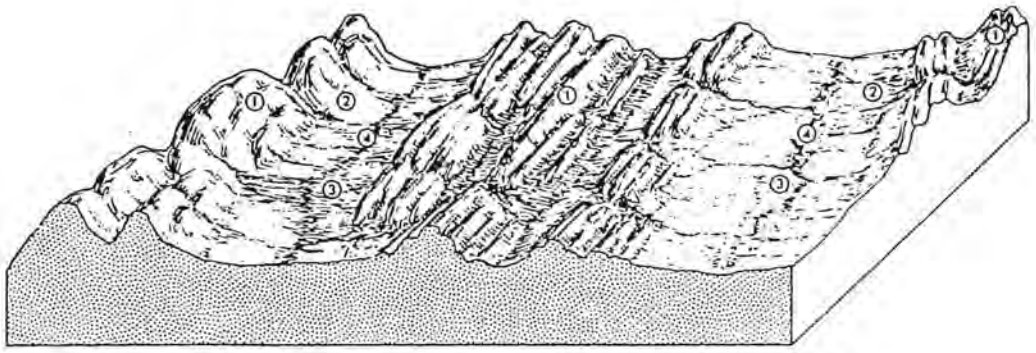
Fig. 13 Wickham Land System



Unit	Area	Land Forms	Soils
1	Medium	Structural plateaux of sandstone or quartzite with deep V-shaped gorges	Rock outcrop and shallow sandy skeletal soil
2	Medium	Structural plateaux with benches, formed on interbedded limestone, shale, and sandstone	
3	Small	Mesas, capped by hard sandstone overlying soft shales	
4	Medium	Cuestas formed on interbedded hard sandstone over shales	
5	Medium	Hogbacks and ridges	
6	Very small	Lower gentle slopes	Elliott—grey loam merging into yellow clay; some Tobermorey—shallow calcareous loamy soils
7	Very small	Gentle slopes adjacent to stream lines	Elliott and miscellaneous alluvial soils

Unmappable inclusions: Humbert.

Fig. 14 Dockrell Land System



Unit	Area	Land Forms	Soils
1	Large	Steep to moderately sloping parallel ridges and low hills	Rock outcrop with pockets of shallow gravelly soils
2	Medium	Gentle lower slopes	Elliott in northern higher-rainfall parts; Moonah in southern drier parts; commonly gravelly and shallow
3	Very small	Alluvial flats fringing stream lines	Elliott in north, Hooper in south

(Stewart et. al., 1970)

3.0 THE GEOMORPHOLOGY OF THE MASSIF

The Bungle Bungle massif has one of Australia's most unique and impressive landscapes. The terrain consists of plateau remnants, ridges and extensive pediments (Paterson, 1970, in Young, 1984a). The massif occupies 10% of the study area. It lies in the Hardman Basin and incorporates the Elder land system (Stewart, 1969; de Salis, 1982). The plateau is composed of Elder sandstone, siltstone, limestone and conglomerates; the latter are remnants of an alluvial fan from a mountain range that existed to the west of the massif. The conglomerates have often been released by preferential erosion. Boulder plains exist to the north of the massif; as the conglomerate content of the massif decreases (to the north and east) so the boulder plains become less frequent (Muir, 1983). Near vertical cliffs, delimiting the massif proper, rise abruptly from the surrounding plains to an approximate height of 200m. Scree slopes are almost absent (Muir, 1983). Deep gorges and valleys of varying width, with flat floors and sheer walls, cut into the massif. The terrain is spectacular as the massif is flanked by sandstone towers and complex systems of knife-like and sinuous ridges.

Jointing has influenced the tower terrain. Some joints have become eroded by streams, others have been hardened by silification so that they have a greater resistance to erosion. This has led to the formation of linear ridges both on the massif and on the adjacent plains.

The Piccaninny structure lies in the centre of the massif. It is an elliptical depression, with an overall dome form, with contorted bedding and zones of silicification. The structure is probably of crypto-explosive origin (Beere, 1983).

3.1 LANDFORM EVOLUTION

The Bungle Bungle massif is thought to be an erosional remnant of a once larger surface that can still be traced over much of the Kimberley. Stratigraphic studies have revealed that post-Devonian sediments were deposited in the Bonaparte Basin which presumably covered and compacted the Elder sandstone (Young, 1984b). However, the date at which dissolution of the sandstone began is unknown. It is thought to date back to early Tertiary times and possibly back to the late Cretaceous.

For at least part of its history, the massif has been subjected to humid tropical weathering. It is likely that most of the erosion of the sandstone occurred under such a regime (which extended from the late Cretaceous to the Miocene or early Pliocene).

Young (1984b) suggests that some of the surface features may also be the result of chemical weathering of moderate intensity occurring over a long period of time. Significant chemical weathering is also likely to have occurred during the Quaternary humid phases and continues today, at a reduced rate, during the wet season. Despite the uncertainty of the geological history of the Bungle Bungle massif, it appears to have been exposed to weathering for at least 20 million years.

The sandstone constituting the massif is extremely friable. Water percolating through the bedding plains has resulted in the mobilization of silica and clay and the subsequent removal of the sand grain matrix. The close interlocking of sand grains has imparted mass strength for tower formation, although the removal of the sand grain matrix has left the sandstone extremely weak.

Solutional loss from the sandstone has been critical in the formation of the terrain, however the main geomorphic forces has been physical weathering combined with erosion and subsequent disintegration of the sandstone.

A striking feature of the massif is the prominent orange and black horizontal banding - silica and algal skins that have formed by a process of solution and later deposition of silica and clays on the surface of the rocks. The white Elder sandstone below is usually uniform. The skins range in thickness from 0.1-1.0 cm. They stabilise the rock surface offering protection against weathering, but once broken, the sand grains below are easily removed. Algae are quick to colonise any fresh rock surface on the massif. Although they offer some protection against physical weathering they contribute to the chemical breakdown of the rock.

Dissection of the massif by streams has formed a complex system of valleys with flat floors, sheer walls and plateau-like divides. These valleys have gradually widened, reducing interfluves to ridges and towers. Pediplains have formed from further erosion of the towers and scarps (Young, 1984a).

Steam erosion is aided by the softness of the sandstone, the stream bedload and the high intensity of the rainfall. Lateral stream planation has occurred at some sites but has only been a minor contributor to the development of the pediments (Young, 1984a). The pediments have developed primarily from the retreat of valley sides and by the reduction of towers (Young, 1984a). Clumps of spinifex, which may alter the flow of surface run-off, may be significant in promoting pediplains. Maintainence of the abrupt angle between the towers and valley floors appears to be a function of the parent material and rate of weathering.

Changes observed in the landforms across the massif can be correlated to variations in its lithology and explained by differences in resistance to erosion. The towers at the southern edges of the massif have formed from fluvial or aeolian sandstone. The rock here is fairly uniform sandstone with minor pebbly beds (Young, 1984b). To the west the towers are replaced by cliffs and domes, a reflection of the increasing conglomerate composition of the massif. Along Piccaninny Gorge, the sandstone towers are superseded by a true runiform relief of vertical cliffs and joint bounded pinnacles. These features are the product of the increased resistance to erosion by a zone of silification.

4.0 SOILS

4.1 GENERAL SOIL RELATIONSHIPS

Much of the study area is characterised by steep uplands with immature skeletal soils, while deep mature soils are restricted to more gently sloping areas, such as the erosional plains. Past land use practices however, have resulted in the severe erosion and truncation of these soil profiles.

Soil type is determined by climate, parent material and drainage. In the better drained, higher rainfall zones red and yellow soils form on limestone, dolomitic and calcareous sedimentary rocks. Calcareous desert soils form in the better drained lower rainfall zones, whilst cracking clays develop in poorly drained areas. Sandy red and yellow soils and some lateritic podzolic soils develop on sandstone parent material. Table 1 shows the 5 profile groups defined by Stewart (1970), and the constituting great soil groups and soil families. Table 2, adapted from Robinson (1970), shows a classification of the soils found in the study area according to their parent material.

4.2 PROFILE GROUPS OF THE STUDY AREA

Stewart (1970) defined five general profile groups covering the range of soils in the Ord-Victoria area. These are discussed below. Additional information has been taken from de Salis (1982). The distribution of the Great Soil Groups in relation to the land systems of the study area are listed in Table 3.

1. Leached Gradational Soils

   Great Soil Groups - red earths with sandy or loamy surfaces
   - yellow earths with sandy or loamy surfaces

   These are sandy porous soils with a massive structure, but weak profile development. They usually develop from siliceous parent material, eg. Elder sandstone (Table 2); they represent the major soil groups of the Buchanan land system.

2. Cracking Clay Soils

   Great Soil Groups - grey, brown soils.

TABLE 1.

GENERAL PROFILE GROUPS WITH THEIR GREAT SOIL GROUPS AND SOIL FAMILIES

Source: Stewart (1970) Lands of the Ord-Victoria Area W.A. & N.T.
CSIRO Land Research Series No. 28

General Profile Group	Great Soil Groups	Soil Families
Leached gradational soils	Red earths-sandy surface	Blain, Cockatoo, Chunuma, Manbulloo
	Red earths-loamy surface	Tippera, Camil, Wonorah, Berrimah, Katherin, Frayne
	Yellow earths-sandy surface	Cullen, Pago
	Yellow earths-loamy surface	Elliott, Batten, Argada
	Lateritic podzolic soils	Koolpinyah, Florina
	Meadow podzolic soils	Marrakai, Card
	Acid swamp soils	Dashwood
Cracking clay soils	Grey and brown soils of heavy texture	Cununurra, Barkly, Argyle, Legune, Wildman
Texture-contrast soils	Red - brown earths	Moonah
	Solonetzic soils	Hooper, Flapper
Calcareous soils	Rendzina	Springvale
	Grey and brown calcareous desert soils	Tobermorey, Negri
Undifferentiated soils	Skeletal soils	-
	Alluvial soils	Ord, and miscellaneous
	Solonchak	-
	Aeolian sand	-

TABLE 2

SOIL CLASSIFICATION ACCORDING TO PARENT MATERIAL
(Adapted from Robinson 1970)

GENERAL PROFILE GROUP (STEWART)	(GREAT SOIL GROUP) SOILS FORMED	PARENT MATERIAL	DESCRIPTION
Undifferentiated	Skeletal	Headley	Surface: dark red-brown. Up to 100% gravel pH 8.5 Profile; shallow, High % of gravel throughout pH 8.5
Cracking clays	Grey Brown & Red Clays (Argyle family)		Surface: dark brown-brown. Up to 40% gravel & 30% fraggy limestone. Self mulching and gilgared, cracking, with severe crab-holes Profile; generally deep. Less than 5% gravel. Light clay at surface merging to a medium to heavy clay at depth pH 8.5
Calcareous soils	Desert Loam (Tobermorey family)	Linnekar and shady camp lime-stone	Surface: dark greyish brown - yellow/ brown. 40-50% gravel pH 8.5 Slow permeability Profile; shallow; Directly overlying limestone pH 8.0-9.0
Leached gradational soils	Sandy Red soils		Surface: dark reddish brown. 20-30% gravel pH 8.5 Profile; shallow; slight gravel. Directly overlies limestone. Sandy loam to sandy clay loam at surface, changing abruptly to clay loam,or light clay in the subsoil
Calcareous Soils	Grey, Brown and Red Shales (Negri family)	Calcareous Shales	Red soils on crests, upper slopes and protected lower slopes Surface: dark reddish brown. 5-90% calcrete gravel pH 8.5

			Profile; shallow; overlies soft weathering shale. Silty clay loam/light clay at surface merging to light clay in the subsoil. 20-50% calcrete gravel pH 8.5
			Red calcareous soils along drainage lines. Similar to above, but contain less surface gravel, and have generally deeper profiles. Usually severely degraded. In sloping areas they are often covered by recently deposited material.
Calcareous soils	Desert loams (Negri family)		Surface: dark red-brown. pH 7.5 some gravel. Profile; shallow, contains fine sandy clay loam at surface to light dark red brown clays in the subsoil. pH 8.0
Leached	Red Sandy	Elder	Surface: dark reddish brown. Contains up to 5% gravel. pH 6.5-7.0 Profile; deep. Little gravel. Overlies sandstone. Sandy loam at surface merging to sandy clay loam at depth Shallow phases of this soil are common These have 80-90% surface cover of nodules and sandstone remnants and frequently expose the underlying sandstone.
-	-	Alluvium	Major river levee soils. Surface: dark reddish brown. Little gravel Permeable. pH 8.0-8.5 Profile; deep. River stone or gravel may occur throughout. Sandy loam to sandy clay loam at the surface merging to sandy clay loam at depth pH 8.0

Cracking Clays	Grey Brown or Red Clays		Surface: dark reddish brown with some gravel. Self mulching, gilgared. pH 8.5 Profile; deep; Up to 10% gravel throughout, dark red/brown pH 8.5 Light clay at surface merging to heavy clay at depth. These are often covered by recent deposits eroded from nearby slopes.
			Stony, shallow soils on low rises associated with alluvials. Skeletal soil, some gravel content. Surface cover of basalt, limestone, chet quartz, shale stones and gravel.

These soils are typified by pronounced changes in their volume corresponding to changes in their moisture content. The seasonal swelling and contractions that thus occur result in a gilgai micro-relief and the formation during the dry seasons of deep cracks, which dissect the soil profile.

Cracking clays develop from a variety of parent material (refer Table 2). The Argyle family (Table 1) for example, are grey, brown and red clays that have formed from Headleys Limestone (Table 2).

3. Texture Contrast Soils

Great Soil Groups - red, brown earths and solonetzic.

This profile group was not recognised by de Salis (1982). Therefore, a detailed description of the soil groups is not available.

4. Calcareous Soils

Great Soil Groups - grey and brown desert soils.

These are generally shallow soils, formed from calcareous limestones and shales of the Negri Group (Table 2). Products of solution, commonly calcrete nodules, occur throughout the soil profile. These particles also form gravels on the soil surface. This profile group includes the Tobermorey and Negri familes (Stewart, 1970, Table 1), and comprises most of the Nelson land system (Table 1 and 2).

5. Undifferentiated Soils

Great Soil Groups - lithosols and alluvial soils.

These soils show little profile development other than the accumulation of organic material on their surface. They can be divided into 2 major soil types (de Salis, 1982).

a) Lithosols

These are the most extensive soil types in the study area; they are generally stoney soils exhibiting little morphological development. Lithosols consist mainly of freshly and imperfectly weathered rock fragments. They are the dominant soil type of the Wickham, Dockrell, Antrim, Elder and Headley land system (Table 3).

TABLE 3

DISTRIBUTION OF GREAT SOIL GROUPS IN LAND SYSTEMS

(Source: Stewart (1970) CSRIO Land Research Series No 28)

GREAT SOIL GROUPS										
		Red Earths		Yellow Earths						
Pasture Land	Land System	Sandy * Surface	Loamy Surface	Sandy # Surface	Loamy Surface	Cracking Clays	Red-brown Earth	Solonetzic	Calcareous Desert	Skeletal Soil
Rugged Hilly country	Wickham				m				m	D
	Elder	m	m							D
	Dockrell				m		m	m		D
Hilly country with useful lowlands	Antrim		m			m				D
	Headley								m	D
Three-awn plains	Buchanan	D	m	m						m
Arid short grass plains	Nelson					m			D	m

. D, dominant; S, subdominant; m, minor

* Blain, Cockatoo, Cnunuma and Manbulloo families

Cullen and Pago families

b) Alluvial Soils

These are young, relatively fertile soil which form on the alluvial deposits adjacent to major drainage lines. The morphological nature of these soils varies according to the nature of the parent material.

5.0 HYDROLOGY

Little work has been carried out on the water resources of the Study Area. The following serves as a brief introduction to the area's possible hydrologic resources. Stewart et. al. (1970) have briefly described the drainage pattern of the study area in his descriptions of each land unit.

The streamflow records of the Public Works Department contain information regarding the streamflow and chemical composition of the Ord River.

Surface water can be found in pools and springs of the river beds, but seldom lasts through the dry season, unless the pools are deep or supplied by ground water. The only drainage lines within the study area having permanent surface water flow are sections of the upper reaches of the Ord River and Linnekar and Osmond Creeks. Bores and wells are therefore necessary to supplement water supplies.

The occurrence of ground water in the east Kimberleys is dependent upon the morphology of the local rock, and influenced by the thickness and permeability of any overlying alluvium or weathered material. A range of rock types exist in the study area, each processing individual porosity, permeability and run-off characteristics. The permeability of the rocks and soil generally increases in the following order - metamorphic and igneous rocks, limestone, shale, silicified sandstone, basalt, dolerite, lightly cemented sandstone, sandy soil and lastly alluvium.

The vegetation cover may effect the hydrological cycle, with the more vigorous vegetation depleting surface and shallow underground water through transpiration.

The study area may be divided into a number of hydrological provinces, based on lithological groups and the structural features of the rocks in the area (Fig 15). Three provinces constitute the study area:-

- The Ord Basin Province,
- The Osmond Range Province, and
- The Halls Creek Province

Each province contains aquifers with characteristic hydrological properties.

5.1 HALLS CREEK PROVINCE

Permanent surface water is rare in this province. Greywacke, slate, shale and low grade metamorphic rocks of the Halls Creek Group are impermeable and therefore make poor aquifers. The granites, high grade metamorphics and basic intrusive rocks of the Lamboo complex are also impermeable, but they form aquifers where faulting or jointing has opened crevices sufficient for water storage. Water can also be located where deeply weathered, permeable crystalline rocks overlay the weathered bedrock. These features are not usually predictable from the surface.

Ground water from the bedrock and alluvium in this area is suitable for both domestic and stock purposes, although some saline water has been found in the schists of the Lamboo Complex.

The Halls Creek Province includes part of the Wickham and Dockrell land systems as defined by de Salis (1982).

5.2 OSMOND RANGE PROVINCE

The province is characterised by late Proterozoic to Adelaidean sandstone, dolomite, siltstone, shale and tillite. The area possesses numerous fresh waterholes maintained in gullies which dissect sandstone and dolomite bedrock. Osmond Creek is supplied with fresh water by the underflow from creeks which drain the southern areas of the province. Ground water in this province should be suitable for domestic purposes except where derived from the shales and siltsones (Dow and Gemuts, 1969).

The Osmond Range Province includes part of the Antrim and Wickham land systems.

5.3 ORD BASIN PROVINCE

The Ord Basin province is defined by the Palaeozoic volcanics and sediments of the Ord Basin (Dow and Gemuts, 1969), and is largely drained by the Ord River. Seepage through the alluvium adjacent to the river provides a

permanent which maintains waterholes along the Ord through the dry seasons. Some permanent pools are associated with faults and joints in areas where the rock are highly permeable to water.

The different rock types within this province possess individual hydrological properties and have therefore been treated separately.

Antrim Plateau Volcanics

There is no record of any bores or wells being sunk into the Antrim Plateau Volcanics in the study area, although adjacent areas have yielded good supplies of water from block joints. Here, most bores into the basalt are successful at less than 150 metres (Passmore, 1964).

Negri Group of Sediments

Ground water can be obtained from the limestone deposits in the basin, and possibly from the shale beds. The content and distribution of water bearing joints and cavities within the limestone is variable.

Surface indications of water bearing crevices are not usually obvious, consequently bores sunk into these deposits have often been unsuccessful. Significant supplies of water might be found at the boundary of the Headleys limestone and the Antrim Plateau Volcanics.

Water obtained from the Negri sediments usually has a high mineral content due to the high proportion of gypsum in the shales and the slow rate of ground water circulation. The water obtained from limestone contains up to 1130 ppm total dissolved solids (Passmore, 1964).

Elder Sandstone

Elder sandstone is highly permeable. It should make an excellent aquifer as in places it has a sufficiently large matrix to store large volumes of water (Dow and Gemuts, 1969).

Alluvium

Alluvium can be found in the beds of, and adjacent to drainage lines. Providing it is sufficiently deep, alluvium can store and thus yield significant quantities of water. The well at the Bungle Bungle Outcamp, for example, draws ground water from the alluvium in Red Rock Creek (Dow and Gemuts, 1969). In most areas, however, there is insufficient storage to

provide permanent water supplies. No well or bore has been noted at the Bungle Bungle Outcamp on maps currently available for the area. Red Rock Creek, however, is marked as having numerous pools and being subject to flooding. It may prove to be a permanent water source.

Several problems are associated with water extraction from alluvium. Passmore (1964) noted that:

> "Water can be extracted from alluvium along rivers where the alluvium is deep enough to have hydrological continuity with the underflow of the river. However, where the alluvium is located in the river bed, extraction would be difficult as the equipment and installations would be damaged during the wet season. This could be overcome by sinking spears into the river bed and by establishing pumping equipment on the river banks which could be disconnected during the wet season."

5.4 QUALITY OF GROUNDWATER:

Generally, the water available in the Study Area is of good quality and suitable for both stock and domestic purposes. The following discussion of the mineral content of ground water and its availability is based on the work of Passmore (1964).

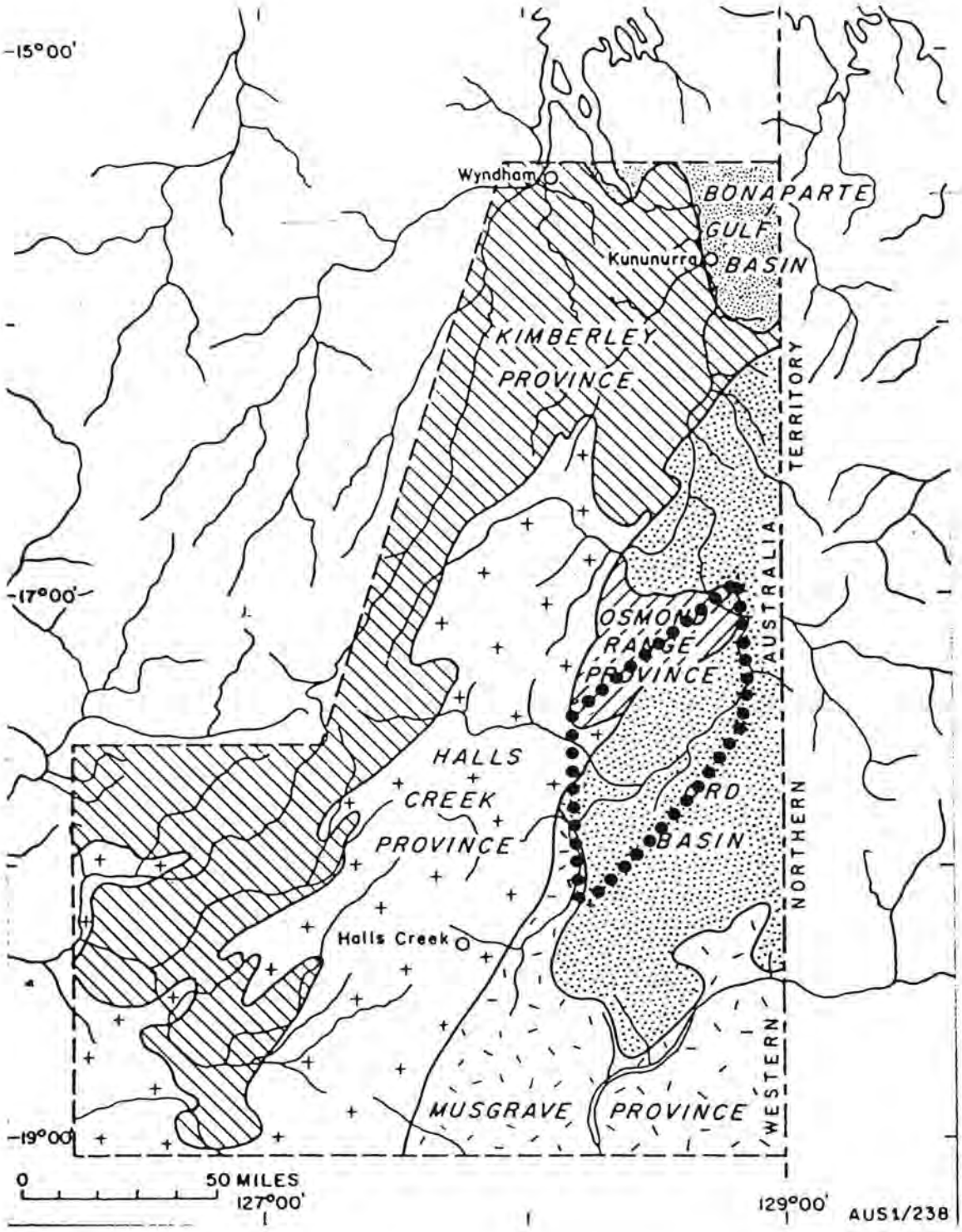
The concentration of minerals within ground water is influenced by the mineral content of the surrounding rock. The Negri sediments yield calcium and sulphate, whilst crystalline rocks yield magnesium and sodium. Siliceous sandstone, which has a higher resistance to solution, yields water with a low mineral content. In areas where water initially has a high salinity, further concentration by evaporation produces salinity levels which are too high for either domestic or stock use.

The production of carbon dioxide by organisms within the soil and its lime content are the primary factors determining the bicarbonate concentration of groundwater. Minor factors influencing the content include solution of carbon dioxide from the atmosphere; the ability of the soil to produce bicarbonate; and the action of hydrogen on calcium carbonate contained in the rocks. Water from siliceous sandstone contains the least bicarbonate, a reflection of its poor morphological development and low lime content.

The chloride and sulphate content of ground water is generally low, except in water derived from the shales of the Negri Group. The higher sulphate content of the Negri Group reflects the tendency of calcium sulphate to readily dissolve from the shales. The highest concentration of sulphate can be found in the waters of the Ord River.

The nitrate content of ground water usually reflects contamination from organic material, however, the concentrations for water within the study area are negligible.

The cations calcium, magnesium and sodium are commonly found in ground water of the study area. Water sampled by Passmore (1964) contained very little potassium as it is readily absorbed by moist clays.



●●●●●● Boundary of the Study Area.

Fig. 15. Ground water provinces of the Study Area.
(Source: Dow and Gemuts, 1969).

6.0 VEGETATION

Broad scale vegetation surveys which have included the study area, have been carried out by Teakle (1944), Gardner (1945) and Perry (1970). More recently Beard (1979) divided the Kimberley region into Phytogeographic regions, incorporating the study area within the Hall Botanical District. The Study Area was then sub-divided into the Osmond Range and Ord Plains provinces. A more comprehensive vegetation survey was carried out by de Salis in 1982 as part of the compilation of a resource inventory for the Ord Regeneration Area. The most recent work to date, has been carried out by K. Kenneally (1984), who surveyed the vegetation of the Bungle Bungle Range and surrounding areas. Muir (1983) has also conducted a preliminary vegetation survey of the study area.

An annotated list of plant species found in the Study Area is included in Appendix 1. The work of Scarlett (unpublished) 'The Ethnobotany of the Gidja People at Bungle Bungle Outcamp', has been incorporated in this list. It should be noted that the areas surveyed by Beard (1979) and de Salis (1982), extend beyond the Study Area.

The present condition of vegetation in the Study Area reflects past land-use practices, where uncontrolled grazing has resulted in the removal of covering vegetation and erosion of the more productive land adjacent to drainage systems. In turn, this has resulted in the introduction of undesirable plant species, such as Aristida latifolia (feathertops).

Scarlett (unpublished), briefly describes the vegetation of the Bungle Bungle massif, Osmond Range and adjacent plains. However, the data collated by de Salis has been used for the following discussion as it directly relates to the afore mentioned land systems and units.

De Salis (1982), classified the vegetation of the Study Area into 6 associations. The distribution of major pasture types across the land systems of the study area, is tabulated in Table 4.

TABLE 4

Distribution of pasture types over the land systems and land units of the Ord River Regeneration Area

Pasture Types	Frontage	Hard spinifex	BSP	Short grass	Kapok bush subclimax	Spinifex open woodland	Acacia shrubland
Nelson land system							
Nc - Cuestas		D		m	m		
Nb - Cuesta backslopes		C	m	C	C		
Ns - Cracking clays			D				
Nu - Interfluve upper slopes		m		m	D		
Nl - Interfluve lower slopes				m	D		
Nf - Frontage plains	D	m					
Nr - Low rises		m		m	D		
Headley land system							
Hu - Upper slopes		D					
Hl - Lower slopes	m	C	m	C	C		
Hs - Cracking clay complex	m	C	C	m	m		
Elder land system							
Eu - Uplands		D					m
El - Lowlands		m					D
Ep - Lower slopes and plains		m					D
Buchanan land system							
Bp - Sandy plains							D
Bu - Rocky uplands		m					D
Bf - Frontage	m						D
Antrim land system							
Au - Uplands		D					
Al - Lower slopes and plains	m	m	C		C		
Wickham land system							
Wk - Rugged uplands		D					
Dockerell land system							
Do - Rugged uplands		D					

D - dominant
C - Co-dominant
m - minor

(Source: de Salis, 1982)

6.1 FRONTAGE PASTURE TYPE

Composition

This association occurs along banks and levees of drainage lines. The flora present reflects the favourable moisture regime and high fertility of alluvium deposited in the area (de Salis, 1982). The amount of alluvium deposited along the drainage lines determines two distinct vegetation communities.

a) The vegetation of the upper reaches of drainage lines where, the high velocities of water flow limit alluvium deposition.
Although the banks are normally rocky, they support a fairly dense, fringing woodland. Tristania lactiflua (freshwater mangrove) dominates this area, although Eucalyptus terminalis (inland bloodwood), Lysiphyllum cunninghamii (bauhinia) and Terminalia arostrata (nutwood) are also present.

b) The vegetation of the depositional zone of the drainage systems where the lower velocity of water flow in the lower reaches of drainage systems allows for alluvium deposition and the formation of relatively fertile banks, levees and levee backslopes.
This association supports vigorous stands of birdwood grass. Shrubs such as Acacia farnesiana (prickly bush) are common. The area supports a tall diverse woodland, characterized by species such as Eucalyptus camaldulensis (red river gum), E. microtheca (coolibah), nutwood, Ficus coronulata (fig tree), Nauclea orientalis (leichardt tree) and Melaleuca leucadendron (paperbark).

On the levees and levee backslopes (i.e. away from the banks of the drainage lines) the vegetation becomes more open. The ground story is dominated by Chrysopogon fallax (ribbon grass), although minor species such as birdwood grass, Heteropogon contortus (black spear grass), Dichanthium fecundum (blue grass), Aristida browniana, A. inaequiglumis and A. hygrometrica (feathertops) are found. The presence of H. contortus or Aristida spp. usually indicates pasture degradation (de Salis, 1982).

Middle and upper storeys are generally lower and more open. The middle storey is dominated by prickly bush; although Acacia miniritchie is the dominant species of the Elder land system.

The upper storey is constituted by inland bloodwood, coolibah, bauhinia, Eucalyptus polycarpa (long fruited bloodwood) and E. papuana (ghost gum).

Elevated areas of coarse, well drained colluvium often support a sparse cover of Triodia pungens (soft spinifex), with minor Triodia sp. (hard spinifex). Such areas rarely support an over-storey.

6.1.2 Condition

Frontage pastures have been some of the most severely degraded areas in the study area. Its close proximity to permanent water has resulted in severe over-grazing and the formation of deep gully systems, many of which still have active heads (de Salis, 1982). Birdwood grass (an introduced species) has stabilized substantial portions of these gullies.

6.2 HARD SPINIFEX PASTURE TYPE

This pasture type dominates areas having steep, rocky terrain or high relief, and is also common on the lower arid plains. Thus it dominates the Wickham and Dockrell land systems; represents most of the Antrim system and is a component of the Nelson, Headley and Elder land systems.

6.2.1 Composition

This association is represented by a range of vegetation types ranging from grassland to low open woodland. Spinifex is the characteristic perennial grass. Hard spinifex is usually the dominant species, although soft spinifex maybe important in some areas. T. wiseana (limestone spinifex) is often supported on soils formed from calcareous parent material. The spinifex tussocks range up to 1.5m in height, and depending upon the species, soil depth and past fire and grazing practices, may form closed dense stands. Other grass species are not usually represented in this association except in areas where

past land use practices have resulted in pasture degradation and regression of spinifex stands. Such areas usually support annual herbs and sparse communities dominated by Aerva javanica (kapok bush), Chrysopogon fallax (ribbon grass) and some Enneapogon polyphyllus (limestone grass).

Smaller areas, based on heavier soils, support ribbon grass, blue grass, feathertops and Panicum decompositum (panic). The distribution of shrubs and trees within this association is variable.

6.2.2 Condition

This pasture type is generally stable. The dominant species, the hard spinifex, grows on rugged uplands and is unattractive to stock. Despite this, some spinifex appears to have regressed from some areas it would normally inhabit, such as areas along the limestone cuestas adjacent to the Ord River (de Salis, 1982).

6.3 BLACK SOIL PLAIN PASTURE TYPE

This association usually occurs on the grey cracking clay plains of the Nelson and Headley land systems, and on most of the lowlands of the Antrim System.

6.3.1 Composition

The dominant vegetation of this association can be divided into 3 minor communities.

A. The most widespread community is based on alluvial clays of the erosional plains. Basically it is a grassland with sparse middle and upper stories of shrubs and low trees. Astrebla pectinata (barley mitchell grass) is the dominant perennial grass. Ribbon grass, blue grass, weeping mitchell grass and bull mitchell grasses are also common. Annual grasses and forbes often constitute this association, including Iseilema vaginiflorum, Isilema sp. (flinders grasses) and Brachyachne convergens (couch). Shrubs such as Atalaya hemiglauca (whitewood) and Carissa lanceolata (konkerberry) constitute the sparse middle storey. Prickly bush is also found in depressions and drainage lines. Bauhinia (on slightly elevated

plains) and coolibah (bordering drainage lines) dominate the upper storey.

B. A transitional zone, between cracking clay plains and associated run-off upper slopes, (usually 50-100m wide) forms the basis of the second community in this pasture type. The lower storey is dominated by dense stands of feathertops, with barley mitchell grass, ribbon grass, blue grass and panic representing minor species. Prickly bush often constitutes the middle storey. This zone seldom supports an upper storey.

C. The third association of this pasture type lies on the elevated clay plains to the southwest of the regeneration area, outside the boundaries of the study area.

6.3.2 Condition

This pasture type is one of the most productive areas within the study area and accordingly has been heavily grazed in the past, particularly those areas close to permanent water. The association is currently in fairly good condition, particularly those areas which have been destocked for a number of seasons.

Vegetation degradation usually results in a shift of composition. Although in extreme cases, such as the Bungle Bungle area, there may be a complete loss of cover. Good colonizing species ("increaser" species, de Salis 1982) include Aristida latifolia (feathertops), and Flavena australasica (speedy weed).

6.4 SHORT GRASS PASTURE TYPE

This association dominates the lower slopes of the Headley land system, and is a small, though important, component of the Nelson land system. The pasture type is generally restricted to flat or slightly undulating areas with calcareous loamy soils.

6.4.1 Composition

This association is a sparse open woodland with a ground storey dominated by two species; limestone grass, an annual to short lived perennial, and Aristida contorta. Minor species constituting this association include couch, Sporobolus australasicus (fairy grass), Eragrostis sp. and Dactyloctenium radulans (button grass).

The middle storey is dominated by prickly bush. Other minor species include whitewood, and konkerberry.

Trees commonly found in this association include inland bloodwood, bauhinia nutwood, Gyrocarpus americanus (helicopter tree) and Grevillea striata (beefwood) and Terminalis arostrata.

Condition

The major species of this pasture type are annuals or biennials, adapted to surviving periods of drought. Consequently for much of the year, ground cover is poor.

Limestone grass is very attractive to stock and those areas it dominates are subject to preferential grazing with subsequent erosion. Over-grazed areas regress to an Aristida contorta (wind grass) dominated association followed by a major loss of cover.

6.5 KAPOK BUSH PASTURE TYPE

This association can be found on surfaces of severely eroded and truncated soil profiles in the Nelson, Headley and Antrim land systems. Calcareous desert loams or lithosols supporting this pasture type are invariably derived from limestones or calcareous shales.

6.5.1 Composition

Kapok bush pasture consists primarily of the introduced perennial grasses - kapok bush and birdwood grass. These species were introduced

as part of reseeding operations conducted by the Department of Agriculture in the 1960's. The species form a succession which can be divided into 3 major stages.

A. Kapok bush dominated stage.
   This is the primary colonizing phase where kapok bush is generally the only species present.

B. Kapok bush, birdwood grass and other species.
   Minor species present include Cenchrus aliaris (buffel grass), and the annuals, Trichodesma zeylanicum (camelbush), Ptilotus exaltatus (mulla-mulla), Pterigeron odorus, Salsola kali (roly-poly), fairy grass and wind grass. The most extensive area of this association can be found on the cultivated upper slopes of the Nelson land system.

C. Birdwood grass-dominated stage.
   The final stage is the climax succession of pure stands of birdwood grass and its distribution is very limited.

This pasture type is essentially a grassland (de Salis, 1982). However tree remnants suggest that the area may have originally been a sparse open woodland. Shrubs and trees present include inland bloodwood and prickly bush along the drainage lines, and thickets of Calotropis procera on the crests and slopes of the interfluves.

6.5.2 Condition

Most of the area supports the Kapok bush subclimax. The original vegetation has been completely removed, so there are no remnant communities on which to judge condition. In addition, degeneration has caused such massive changes to the soil that it may be unable to support the original vegetation. Treated areas most distant from permanent water are in the best condition. Bare ground is common in "untreated" areas close to water.

6.6 ACACIA SHRUBLAND PASTURE TYPE

This association comprises all of the Buchanan land system and most of the Elder System. Soils are derived either from the Devonian Elder sandstone or the Hudson shales of the Negri Group. They range from deep siliceous sands and sandy surfaced red and yellow earths to heavier textured loams and light clays.

6.6.1 Composition

This association can be divided into 2 communities, based on the composition of the understorey.

A. The first community is found on the sandy and sandy surfaced soils supporting a shrubland to open woodland. Spinifex is the dominant perennial grass. Individual tussocks are small, a reflection of soil fertility and fire history. Some areas are dominated by Eriachne obtusa (wire grass), E. sulcata, and Aristida browniana (feathertop). Other species present in the community include soft spinifex and Plectrachne pungens (curly spinifex). This is the most extensive community of the two.

B. The second community occurs on the heavier textured soils of the lower slopes of the Elder land system. Spinifex dominates the grasses in this community. Other species include ribbon grass, black spear grass and kapok bush.

Acacia (wattles) and Eucalypt species dominate the middle and upper stories of both communities.

6.6.2 Condition

This vegetation type is generally in good condition as it is far from permanent water and most of the vegetation is unpalatable to stock. The only exception is the lower slopes of the Elder land system.

7.0 FAUNA

Little is known about the fauna of the Study Area. Muir (1983) compiled an annoted species list for the birds he observed in the Bungle Bungle area. His data has been included in Appendix 2. No other fauna surveys have been carried out in the area to date.

The list of mammal species proposed to inhabit the Study Area has been extrapolated from the work of Kitchener on the Mitchell Plateau and in the lower reaches of the Ord River. The distribution maps of Blakers et al (1984) and Strahan (1983) have also been used to provide baseline data. It should be emphasised that these lists are highly speculative.

Amphibian and reptile species list was similarly compiled. However, Dr Berry of the W.A. Museum advised that "no attempt should be made to extrapolate from the subhumid north-west Kimberley to semi-arid east Kimberley... the Museum has, unfortunately, no data whatsoever from the area in question and has yet to undertake a survey of its herpeto fauna. It is anticipated that such a survey would turn up undescribed species" (Dr P F Berry pers. comm, 1985).

PART B: THE CULTURAL ENVIRONMENT

8.0 ABORIGINAL HISTORY

Aboriginal man is thought to have entered Australia some 40,000-30,000 B.P. from the Indonesian archipelago. It is generally agreed that their point of entry lay somewhere between the Kimberley area and Arnhem land (Shaw, 1979).

Shaw (1979) comments that the Kimberley region was probably one of the cradles of Aboriginal civilisation in Australia. In the time preceding European contact many changes in the Aboriginal way of life were initiated in this region to drift eastward (Shaw, 1979).

Little information is available on pre-European Aboriginal relationships and use of the land within the study area. The W.A. Museum Aboriginal Sites Department is currently researching into this area. A report prepared on behalf of the Warmun Community by Kirkby and Williams (1984) "Aboriginal land use in the Bungle Bungle Area. A Submission prepared for the Aboriginal Land Inquiry" is believed to contain relevant information. However the Warmun Community Inc. declined to provide CALM with their permission to access this report.

Scarlett (unpublished), has recorded some aspects of the association between Aboriginal people, their land, and the environment. The publication describes how this association has changed due to the impact of European settlement. In spite of the disruption European settlement in the area has caused the Aboriginal people have maintained their economic, social and religious ties with the land. This is evident in these peoples' detailed knowledge of the area and its associated resources.

The East Kimberley region was one of the last areas in Western Australia to be opened up for European settlement. Tegg (unpublished) notes that the entry of Europeans into the area heralded a period of violence against the Aboriginal people, which affects them today. During early years of contact, Aboriginal camps were attacked and 'dispersed' where they were seen as a threat to European settlement or in retaliation for cattle spearing (Scarlett,unpublished). Fugitive Aborigines often hid in Bunalulu - Bungle

Bungle Range. Bones of aboriginals murdered during these times are reported to be scattered around the massif.

Bolton (1953) records that there were no reports of stock killing by natives until after the wet season of 1885-86. After this, the expansion of European settlements began to encroach upon tribal hunting grounds of the natives whose culture forbade them to hunt on the lands of other tribes. Forced to starve or kill stock, they naturally chose the latter. There is truth in the contention however, that the natives enjoyed hunting and chasing the stock (Bolton, 1953). Even as late as 1889 the Magistrate of Wyndham, wrote....

> "That they (the Aboriginals) appear to be very numerous in the district, and have occassionally been seen in the vicinity of Wyndham, they are not at present very troublesome".
>
> (Bolton, 1953).

Aboriginal people were often employed as stockmen. They were paid in kind by such articles as food, tobacco or shelter, which Tegg (unpublished) comments is a reflection of their social status rather than the amount of work done.

European settlement in the area displaced natives from their traditional lands, which gave rise to a process of socio-cultural disruption and erosion (Christensen, unpublished). Scarlett (unpublished) notes that during the dry season, native workers were needed on stations. This was a time when natives usually gathered together, the wet season being a time of dispersal. However after European settlement the wet season was the only time when natives were free to join tribal gatherings or visit relations.

In 1967 after Aboriginal employees were granted award wages many native workers were forced to leave the stations. People with links to the Bungle Bungle area are now known to reside at Turkey Creek, Kildurk Station, Halls Creek, Katherine, Oombulgurri, Mistake Creek, Chimamens Garden, Nicholson Station and in the Bulla Community.

Many Aboriginal people who experienced these times believe that life was more meaningful and secure in the days prior to European settlement. This idea is strengthened by stories told by tribal elders, who still speak freely of the intertribal tensions and fights that followed the disruption of their

patterns of movement and land occupancy (Christensen, unpublished). Elkin (1932), estimates that in the first 10 years of European settlement, the total Aboriginal population fell by at least 50%.

9.0 EUROPEAN HISTORY

9.1 EARLY SETTLEMENT

Information about the early European history of the East Kimberley region is scarce, and where events have been recorded, documentation is often vague and conflicting. This section is based on the work of G C Bolton (1953).

The Study Area encompasses 3 sections of ex-pastoral stations: the Bungle Bungle Station and the northern sections of the Ord River and Turner Stations (Fig. 16).

The first European explorer to traverse the area was Alexander Forrest in an overland expedition (1875-1879) through Northwestern Australia to Katherine in the Northern Territory. Forrest wrote glowing reports of the Ord River Valley, claiming it to be a magnificent feeding ground extending as far as the eye could see. He continued that nothing would please him more than to see the area grazed by cattle or sheep (Hicks, 1938). On a brief reconnaissance to the north of the Ord River Forrest crossed Picaninny Creek until he reached a sandstone plateau (the massif?). He recorded in his diary that this area was rough, craggy and not promising.

The East Kimberley region was first colonized in the 1880's by overlanders at the frontier of the continuous spread of settlement moving across the Northern Territory (Bolton, 1953). These early settlers followed open range tradition of grazing - a system of no fences and uncontrolled stock movement. Pastoralists allowed their stock to wander through the area in search of good pastures. They returned little to the land, and once their cattle had grazed over and exhausted an area they would relinquish relevant lease holdings to take up others covering a slightly different area. Others would graze their cattle in areas where they had no lease holdings. The earliest pioneers of the region were the Buchanans, the Duracks and the McDonalds.

The first pastoral station established in the East Kimberleys was the Plympton St Mary, later re-named Ord River Station. The lessees of the land were a Mr J A Panton and a Mr W H Osmand, two Melbourne business men. The Buchanans managed the lease. In 1881 they initially took up the leases K542, K543 and K572-4. They continued to expand their holdings taking up the lease K718 and 50,000 acres of the land covered by leases K716, K717 and K718, which had been previously held by G C Loughnan and J Shepard. (Their total

holdings exceeded 2 million acres). The station was first stocked in 1884. Title records of Lands and Surveys show that the land of the future Turner Station (Fig. 17) was initially leased by Madden and Brennan. The leases were transferred to Osmand and Panton in 1886.

The severe drought experienced by Queensland in 1883, initiated the movement of disheartened stockmen in search of work into the 'new country'. These men, who pioneered trails over the Northern Territory into the Kimberleys, were shortly to be followed by others in search of gold. The possibility of the presence of alluvial gold had first been reported in the upper Ord by Forrest in 1879. A gold rush of 1886 to Grants Patch field, near Halls Creek, provided a market for surplus stock from the Kimberley Cattle Stations. The main rush was over by 1887 (Bolton, 1953).

A Tarrif Act introduced by the West Australian Government in 1886, imposed a tax or protective duty upon livestock imported for slaughter from the Eastern Colonies. It was designed to stimulate and protect the Kimberley cattle industry from the competitive Queensland cattle industry. The Act was amended in 1893 so that a duty was imposed on all livestock imported into Western Australia except for stud animals.

The Kimberley cattle industry began to expand in the 1890s. Gold discoveries at Coolgardie (1893), the completion of the Wyndham jetty (1894) and cattle race and yards at Derby promoted the Kimberleys as a major beef producing centre in Western Australia.

From 1893 to 1898 the state of the beef market drastically improved, and stockmen or station managers were encouraged to strike out on their own. These smaller individual enterprises were pushed into poorer marginal country, whilst the larger station owners took most of the more productive land around major rivers.

In 1894 Panton sold out his holdings in the East Kimberlies to Osmand, who then took up part of the lease 5/233 and leases K879, K880 and K923. A year later Osmand also took up K595 and K596 (C Clements pers. comm., 1985).

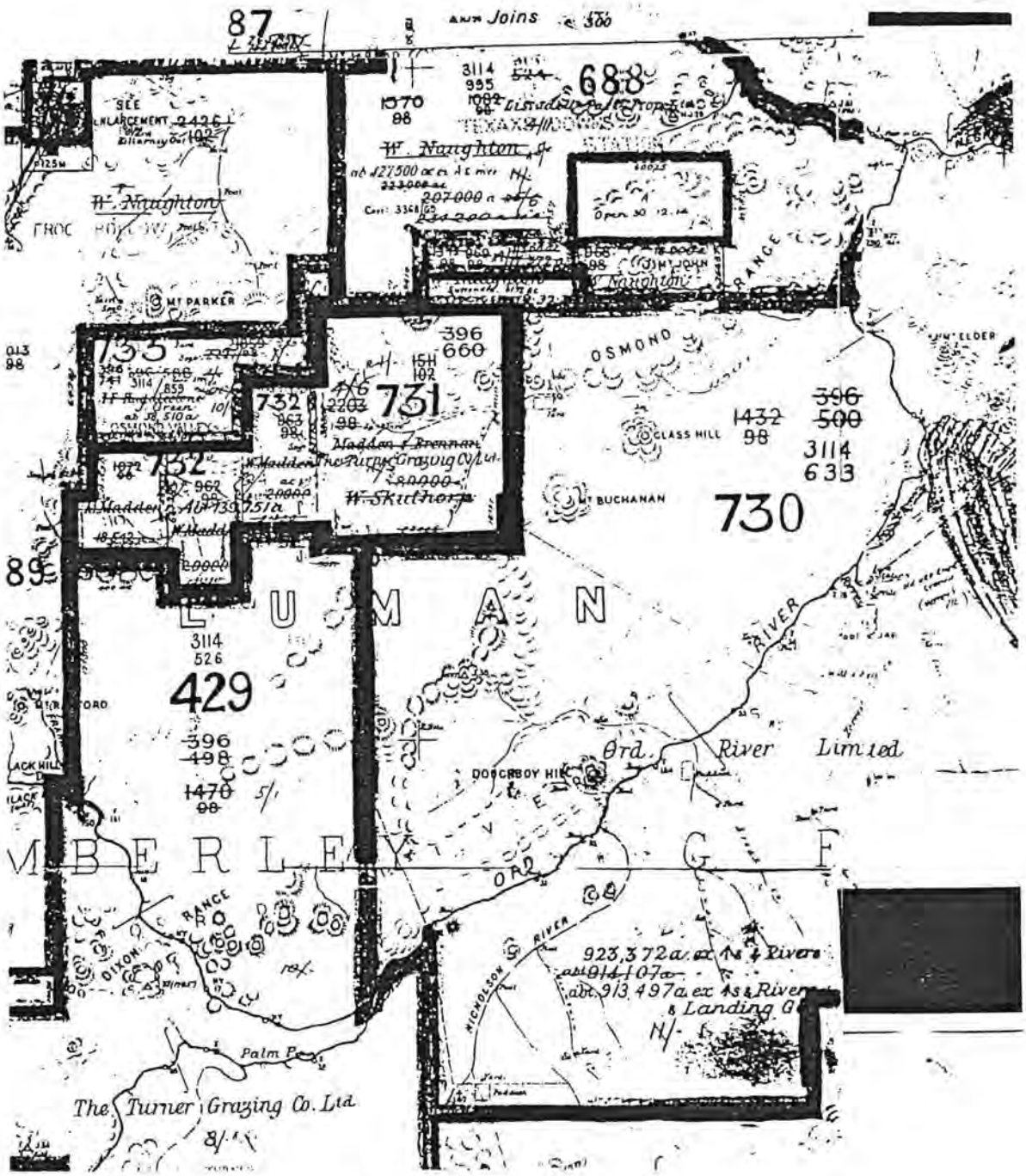


Fig. 16 Ex-pastoral Stations which covered the Study Area.
(Source: Department of Lands and Surveys).

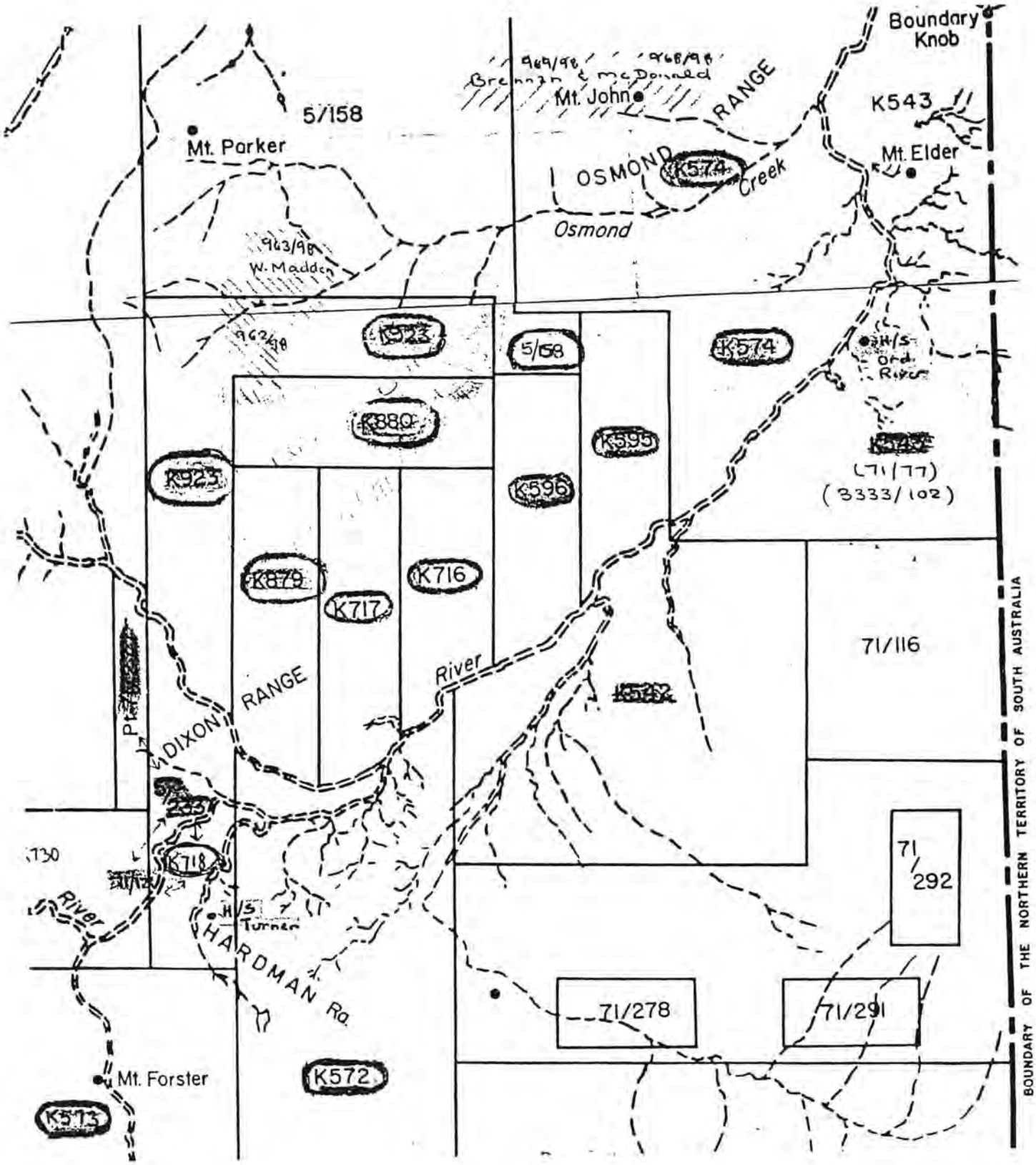


Fig. 17 Early Leases over the Study Area.
(Source: Clements, 1983).

Osmand died in 1901. Arthur Bennet, (the executor of Osmand's will) held the leases for Ord River Station until 1902, where upon they were transferred to Copely and Co (Bolton 1953, C. Clements pers. comm., 1985). (Lands and Surveys files have the date of transfer recorded as 1907). Copely and Co. was a partnership of Samuel and Benjamin Copely and James Paterson. Samuel Copely had made his fortune by pioneering the Perth suburb of Mt Lawley and selling other real estate.

When Copely took over the leases for Ord River Station, the property was in poor condition. Stock, infested by ticks, had bred indiscriminately and depastured much of the land along watercourses. In 1901-02, a general muster on the station collected approximately 47,000 head of cattle (Bolton, 1953).

Around 1904 a steady influx of white stockmen into the East Kimberleys started to fill the demand for station workers, reducing pastoralists' reliance on native labour. Copely would only employ European stockmen, as he held natives to be responsible for all cattle deaths. Prior to 1904 tension between Europeans and natives had been slowly increasing. The problem was fuelled by native killings of both stock and Europeans, their practice of burning large tracts of land whilst hunting and subsequent European reprisals. There were no reported killings of natives in the region until the 1890's (Bolton, 1953).

The 1898 Land Act consolidated many of the older land holdings in the region. The bill reduced the rent paid on the land if it was 50% stocked, and acted to insure against speculators taking up large areas of underdeveloped land. By 1905, many of the larger stations had assumed the approximate position held today.

Pastoralists soon began to realise that the bounty of the Kimberleys was not unlimited. Outbreaks of cattle tick, red water fever, Buffalo fly, Pleuropneumonia and severe drought severely affected the northern cattle industry.

In 1914 Copely and Co. sold out their holdings in the East Kimberleys to the Union Cold Storage Co. - a British firm controlled by the Vestey brothers. Bolton (1953) comments that it appeared that Union Cold Storage had all the facilities needed to place Australian beef on the English market.

Amendments made to the Lands Act in 1917 stipulated no one person could hold more than one million acres of land in any one land division of Western Australia. Consequently the Vestey brothers divided their land holdings so that the leases stood in the names of several individuals; small holders who entrusted the administration of properties to the Australian Investment Agency - managers of all Union Cold Storage Australian interests. In 1916 S Vestey transferred his lease holdings, the future Turner Station, to H E Powel. In 1921 the Vestey holdings were redivided, creating seven stations each with its own homestead. Ord River Station and Turner Station were two such stations. Homestead managers were mostly old stockmen. They were not required to initiate their own programmes for the development of the station, and were periodically visited by a travelling inspector and accountants. Local opinion regarded the homestead managers as little more than caretakers. Leases for Turner Station and Ord River Station were vested in the Turner Grazing Co and Ord River Ltd respectively (Fig. 16).

These leases were held by the Vesteys until the area was resumed by the Government in 1967, for the purpose of regeneration of the Ord River Catchment area and vested in the Department of Agriculture.

The pastoral history of the Bungle Bungle area and Osmond Ranges is fragmented. Thomas Berrie and J Newell of New South Wales originally leased the area containing the massif in 1882. They leased some 150,000 acres covered by the leases K879, K880 and K923 (Fig. 17). The leases were transferred to O'Connors and Stockdale in 1884. Stockdale also held the land to the north of the massif, covered by the lease 5/158. All of these leases were relinquished in 1886 (C. Clements pers. comm., 1985).

The land around and containing the massif remained as Vacant Crown Land until 1885 when Osmand took up the leases K879, K880 and K923. These new leases appear to have covered all but the northwest portion of the massif (C. Clements pers. comm., 1985) and remained in Osmand's name until his death in 1901.

The earliest records of Lands and Surveys indicate that the 80,000 acre lease containing the massif was held, later, by the Wilson Company trading for Alexander G. Troup. The lease, No. 1511, was possibly taken up in 1902. Upon Troup's death, around 1919, the lease was transferred to W M Navin and later in 1921 to Madden and Brennan.

Madden had previously (1907) taken up three leases to the west of 1511 - No's. 962/98, 962/98 and 1072/98-. The four leases were amalgamated (as 731 and 732) and operated as 1 station- Hazelvale, later renamed Bungle Bungle Station (Fig. 14). The lease was later transferred to Arthur Muggleton, then to Ernest Bridge and later to William Skuthorpe. Transfer dates in the original documentation are unclear. There are no formal records detailing the use of the station or when it was first officially occupied. Bolton (1953) records that it is possible that the early lessee's were 'battlers' - a breed of men who bought a station to dispose of it in the future for a profit.

In 1946 the Hazelvale Station leases were taken up by the Turner Grazing Company and operated as part of Turner Station. The area was resumed by the Government in 1967.

In 1975, Mr J Green, lessee of Osmond Valley Station applied for title to an area of land in the Regeneration reserve specifically defined as the former Bungle Bungle Station (Under Secretary for Lands in litt. to Director of Agriculture, 1975). His application was rejected as the area was considered non-viable, and it was considered any pastoral activity would interfere with the regeneration work currently underway.

The pastoral history of the study area, may be summarized as follows:

> "Major pastoral holdings in the East Kimberleys were held by absentee owners (often speculators) who preferred to spend their profits in business outside the district rather than reinvesting it into the land. Some areas of the East Kimberleys, which included portions of the land held by absentee investors, were known as the 'slum area of the Kimberley' not only because of the conditions of the homestead, but because they included some of the worst eroded and most under-improved land under settlement".
>
> (Bolton, 1953).

9.2 THE REGENERATION PROGRAMME

Medcalf (1944), as part of Richters 1944 expedition into the Ord River valley, made a study of the erosion problems of the area. The area studied was generally to the north of the reserve, but the report provides some general information on the effects of erosion in the area.

Erosion of most of the more productive areas of land in the East Kimberleys was well underway by the 1930's. However the problem was not recognised as being severe until plans to dam the Ord River were conceived. The regeneration programme was instigated in 1960, and initially operated in conjunction with the station lessees. However this method proved to be futile, so the area was resumed by the Government in 1967 and control vested in the Department of Agriculture. The primary aim of the programme was to encourage perennial grasses to cover the area, by reducing grazing pressures or reseeding bare areas. This involved stock control programmes based on mustering, fencing and feral animal control. In the long term the programme has not been implemented effectively, fences having fallen into disrepair, and stock control having only been attempted by general musters (de Salis 1982).

Prior to 1967 any attempts to muster the cattle were conducted by stations operating in the area. Following the gazetting of the 1967 Straying Cattle Act, which vested ownership of all cattle within the reserve with the Crown, these activities have been assumed by the Department of Agriculture.

Attempts to control stock numbers have had little effect due to failure to implement mustering programmes correctly; letting the programmes lapse; and a lack of adequate facilities to handle cattle turn-off numbers. These problems have been partially alleviated by the construction of yards at Linnaker.

Fencing was recognised as being essential for the long term control of stock. Most of the more productive country has been fenced, cultivated, and reseeded. The fences erected in the 1960s have not been maintained and following each wet season the flood gates have been washed away, permitting unrestricted stock movements.

Feral donkeys are a major source of grazing pressure within the reserve. Wild horses and camels also occur in the area, but not in any great number. Control of feral species is implemented in three ways:

(1) Aerial control programmes - helicopter shoots, run by the Agricultural Protection Board.
(2) Pet meat shooters - allows for high control but only in accessible areas.
(3) Shooting by station staff.

The regeneration programme aims at producing a new vegetation succession based on the introduced species of buffel grass, birdwood grass, and kapok bush. The programme has been reasonably successful in returning vegetative cover to a large proportion of the regeneration area. Areas indicating the most dramatic recovery are those that have experienced the least erosion. Some factors influencing the success of regeneration include: accessibility for cultivation machinery; run off; infiltration; and fertility of the soil.

9.3 RECENT INTEREST IN THE STUDY AREA

Interest in the Bungle Bungle massif was sparked in 1982 when Roger Garwood, a professional photographer submitted a series of photographs of the area to the W.A. Tourism Department. Public interest was stimulated following the airing of "The Wonders of Western Australia" featuring the massif (refer also to Tourism, Section 13.0).

> "Widespread media promotion in the late 1982 and early 1983 of spectacular landforms in a previously unpublicised area referred to as Bungle Bungle generated considerable public interest ... Much of the ensuing publicity inferred that the area either was, or should be a National Park.
>
> Responding to public interest and the unusual and arresting nature of the landscape at Bungle Bungle, the National Parks Authority at its meeting of 16 February 1983 resolved to write to the Environmental Protection Authority asking it to consider establishing a Working Group to investigate the Bungle Bungle area and adjoining lands.

> At its meeting of February 28 1983 the Environmental Protection Authority agreed to this request and asked the Department of Conservation and Environment to convene an informal interdepartmental Working Group."
>
> (Working Group, 1984)

The terms of reference of the Working Group Study was to "investigate and report on the status, vesting and purpose of the Bungle Bungle and adjoining land". These guidelines were later amended to allow the Working Group to look at management issues, but only at a conceptual level.

In accordance with the request of the EPA, a Working Group was formed with representatives from the Departments of Conservation and Environment, Agriculture, Fisheries, Lands and Surveys, Mines and Tourism and with representatives from the National Parks Authority and the Aboriginal Sites Department of the W.A. Museum. The Warmun Community Advisor was also included in the Working Group.

10.0 ABORIGINAL INVOLVEMENT IN THE STUDY AREA

Records detailing Aboriginal culture and history are scarce. General Aboriginal anthropological studies have been carried out by Elkin (1932), Kalberry (1939) and Tindale (1974). More recently, Christensen (unpublished), Kirby and Williams (unpublished), Rose (unpublished) and Scarlett (unpublished) have carried out some anthropological investigations of Aboriginal kin groups claiming traditional ties to the Bungle Bungle Range and adjacent areas.

10.1 CONTEMPORARY CLAIMS TO THE STUDY AREA

The Warmun Community Inc of Turkey Creek, claims to have made numerous attempts to gain title to their traditional lands, which includes the land of the study area. The requests precede any tourism interest in the area.

1972 Aboriginal claims for the Bungle Bungle area were initially raised in 1972 by Mr David Turner at a land rights meeting in Darwin.

1981 The first formal approach for title to the land was made to the Minister for Lands by Mr Turner and Mr Wallaby in 1981 at a meeting in Kununurra. This was followed by letters from the Warmun Community to the Minister for Lands, Agriculture and Community Welfare, all requesting title to land within the Study Area. The requests were denied on the basis that the cost of establishing small communities would be too high, especially as there was no guarantee the settlements would become self sufficient. The Government had also been advised by the Department of Agriculture that establishing a small community in the area would hamper the regeneration programme.

1981 Mr Turner approached the Aboriginal Land Needs and Essential Services Review committee at Wyndham.

1982 The issue of title to the area was again raised with the then Western Australian Premier, Mr O'Connor, when he visited Turkey Creek.

1983 Representatives from Turkey Creek visited Kakadu National Park and Coburn Wildlife Sanctuary in the Northern Territory. The purpose of the visit was to examine the system of joint management.

1983 The community made approached the Minister for Community Welfare and Aboriginal Affairs seeking title to the land, only to be informed the issue of land rights was currently being examined by the Aboriginal Land Inquiry and a decision would be made in view of their recommendations.

1983 The community made a submission to the Premier, Mr Burke, in an attempt to stop tourists visiting the Bungle Bungle area. The programme 'Wonders of Western Australia' had stimulated an avalanche of tourist interest and media exposure in the Bungle Bungle area. The traditional owners were disturbed in case the area were to be developed contrary to their needs and desires.

1983 A temporary Aboriginal settlement was established at the ruins of the Bungle Bungle outcamp by the traditional owners. Movements of the Aboriginal people are difficult to record, but it is believed they do not reside at the outcamp for the whole year, but they are there only when water is available.

1984 A submission was made to the Aboriginal Land Inquiry prepared by Ian Kirkby and Nancy Williams, on behalf of the Warmun Community. The report documented Aboriginal use of the Bungle Bungle area.

1984 Submission made to the Working Group by the Warmun Community Inc. commenting upon the draft report prepared for the EPA.

The major points raised by the Warmun Community to re-establish themselves on their traditional land are as follows:

1. The Warmun community has formed from numerous Aboriginal people who have lost their traditional lands and have had nowhere else to go. Many social problems have arisen from this concentration of people, who originally would have had very little contact, into a relatively small area.

2. Employment prospects for residents of the settlement are poor, consequently the probability of the community becoming economically independent are low. Tribal elders are becoming increasingly concerned over the 'enforced idleness of the young' (Tegg, unpublished).

3. Many residents of the settlement wish to return to their 'own' country, to get back to the old people (those who are buried on traditional lands) and old stories. Some believe that living away from their traditional lands is threatening to their families. By returning to their traditional lands, these people believe they will strengthen their culture and that the available bush food will benefit their diet.

4. The diverse background of the residents of the settlement means that there is no single expression of leadership, subsequently the community has problems in dealing with any issues that confront it.

5. Traditional lands are still rich in religious significance and protection of such areas remains high priority. Traditional owners believe that they cannot fully meet their responsibilities toward the land whilst removed from it.

6. From the point of view of the applicants for the Bungle Bungle area, there have been no gazetted reserves on their traditional lands.

7. The traditional lands of people at the Turkey Creek Aboriginal Settlement are under threat from developers such as mining companies. In most cases the prospective developers have not consulted with the traditional owners as to the location of sacred sites and consequently these sites could be at risk.

In support of the outstation movement, Tegg (unpublished) has suggested that the claimed increased costs associated with administering the outstations would be offset by the benefits of fewer social problems and improved living conditions. Services that would normally be required for an outstation included a teacher, provided there was the minimum 6-8 children of school age, and health services. The latter is normally provided by training local people to work in conjunction with the formal facilities at Turkey Creek.

In the case of the Bungle Bungle area it is envisaged that initially an extended family group, approximately 30 people, would live at the outstation. This is expected to increase in the future.

10.2 CLAIMS TO ABORIGINAL TRADITIONAL LANDS

Research into the Aboriginal claim for the Bungle Bungle area is presently being carried out by the Aboriginal Sites Department of the W.A. Museum. The work will provide valuable information on the composition and geographic distribution of major social groups in the years of pre-European contact. According to Tindale (1974) there are 3 Aboriginal language groups with traditional claim to the land encompassed by the boundaries of the Study Area (Fig 19). However, the patchiness of the historical records and unevenness of anthropological research, makes it impossible to establish the exact geographic boundaries of the language groups within the region (Christensen, unpublished).

The Aboriginal system of land ownership is based on a number of factors. The most generally accepted basis for a claim to land rights is based on descent, primarily patrilineal descent. However today, matrilineality has come to be almost as important. This process has been under way for some considerable time. Kalberry (1937), reported that Aborigines in the East Kimberleys maintained a claim to their mother's country referring to it as their 'half country' (Christensen unpublished). Recently J. & K. Wilson referred to a strengthening of the 'maternal line of inheritance' which enables 'continuity' in land succession (Christensen unpublished). Recent claims on the Bungle Bungle are primarily based on matrilineal descent.

Although descent is an important consideration other ties to the land are also considered in a true claim to land. These include attitudes toward the land and its custodianship.

10.3 ABORIGINAL EXPECTATIONS

In principle the traditional owners agree that the park will be jointly managed by themselves and representatives from the Department of Conservation and Land Management.

However, the traditional owners have raised several other points which need to be resolved before the management plan for the area is finalised. Points of concern are:

- The Warmun Community support the concept of joint management for the Study Area. However they believe the system should be structured to suit the traditional Aboriginal decision making process; that is, overriding powers should not be given to an elected chair person and council, and that the community should be given sufficient time and space to make any decisions.

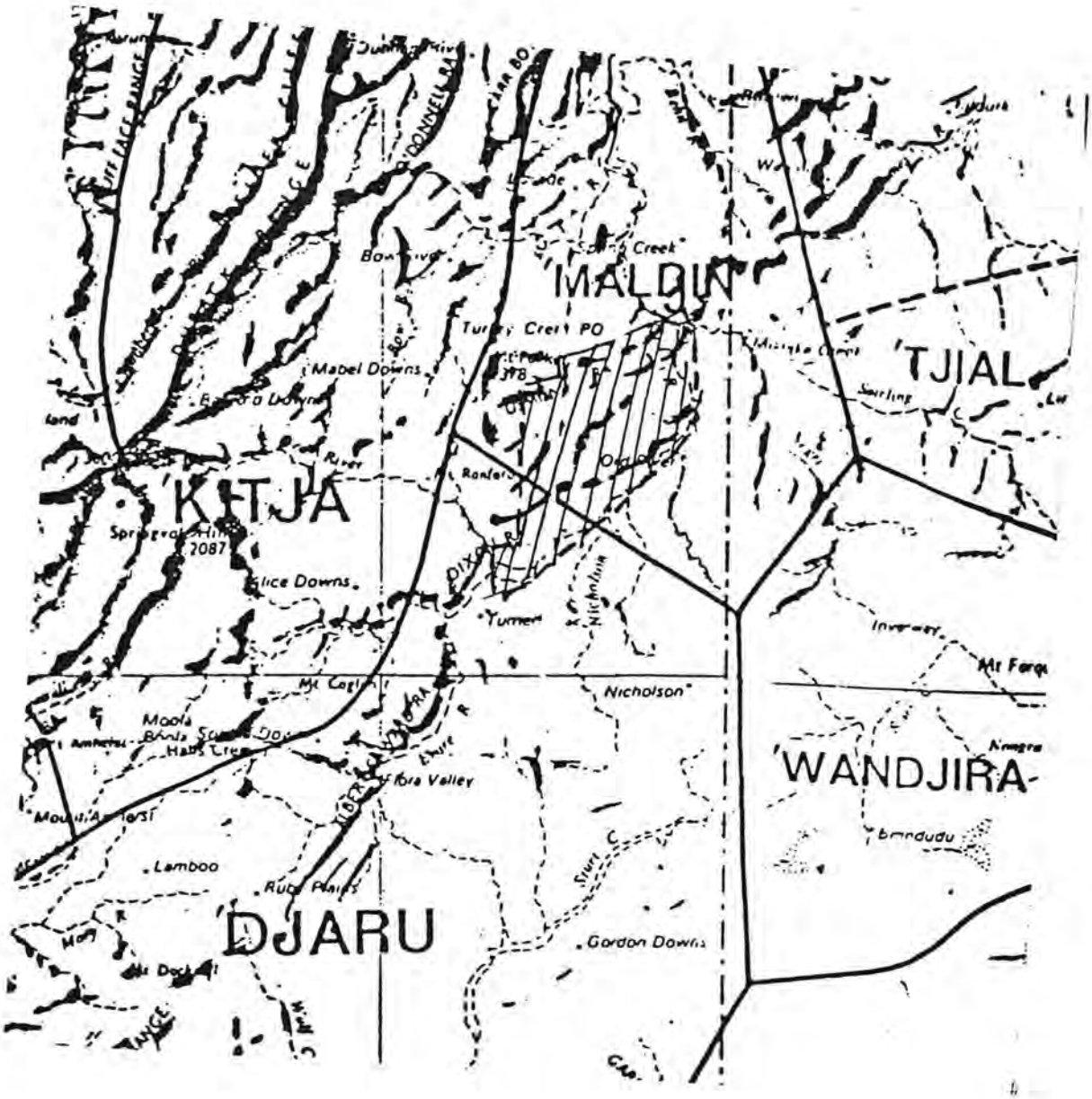
- The Warmun Community believe it is necessary to ensure that the Aboriginal people have sufficient funding to enable them to make 'informed' decisions regarding any development of the Park. These people also wish to be involved in the development of the management plan for the area. In order to ensure that they can provide a meaningful input into the plan they will require assistance. Accordingly the Community have written to the Standing Committee for the Environment requesting that resources be quickly provided. These resources include the provision of:
  - two advisory staff together with an office, telephone and vehicle to gather information and co-ordinate meetings for the traditional owners;
  - funds to enable access to experts in areas of park management, law and anthropology; and
  - funds to enable traditional owners to meet and make informed decisions.

  (P Milton, 1985)

- Traditional owners expect areas within the study area to be reserved for the exclusive use of Aboriginal people and that they will have access to sufficient hunting, gathering and fishing areas to satisfy their needs.

- The Warmun Community are receptive about the possibility of employment as Park Rangers. However, they feel they should receive preferential treatment with regard to employment related to the establishment and maintenance of the Park.

- The Warmun Community believe that Aboriginal people should have first option on tourist development in the area. They see the benefits that can be obtained from tourism and regard it as a way to gain economic independence and help overcome the problems associated with establishing an outstation. Aboriginal traditional owners will support some development of the Study Area providing that tourism is controlled, sacred sites are not damaged, hunting and fishing areas are not depleted, and the privacy of Aborigines living in the area is respected.



Key

Study Area

Fig. 18: Aboriginal Language Groups Distribution over the Study Area. (Source: Tindale, 1974).

11.0 MINING INTEREST IN THE AREA

Gold is the only mineral that has been produced in any significant quantities from the East Kimberley region. The area has a high mineral potential and is currently subject to extensive exploration by several mining companies. Interest in the mineral potential of the region started after the discovery of alluvial diamonds in creek sediments and the subsequent locating of a diamond bearing Kimberlite pipe at the headwaters of Smoke and Limestone Creeks.

11.1 ECONOMIC GEOLOGY

The following briefly describes existing and potential minerals in the study area (see Fig 19).

Copper

Indications of copper have been found in Lamboo Complex and Headleys Limestone. To date, findings have been small and of no real commercial value.

Gold

Gold was first found at Grants Patch field near Halls Creek. Most of the gold was produced before the turn of the century, and by 1890 most of the supplies had been exhausted. Since then there has been some commercial activity, with little reported success. Small quantities of gold have been found by European and Aboriginal fossickers (Dow & Gemuts, 1967).

Iron

Near vertical iron ore beds have been located at the head of Osmond Creek. They are of no real commercial significance as they are no more than 60 cm in width and tens of metres in length.

Lead

A private company has performed some geochemical surveys around the headwaters of Osmond Creek, and found disseminated galena in the dolomite of the area. However, mineralisation was very sparse and sporadic.

Several mining companies are currently exploring in the study area for minerals such as gold, diamonds, copper and uranium. Mining companies active in the area or holding exploration leases include Carpentaria Exploration Co., Afro-west Mining Ltd and Gem Exploration (see Fig 20).

The mineral potential of the Bungle Bungle massif is low although a Kimberlite pipe has been found which was thought to indicate the presence of diamonds.

The land surrounding the massif has a considerably higher mineral potentials (see Figure 19).

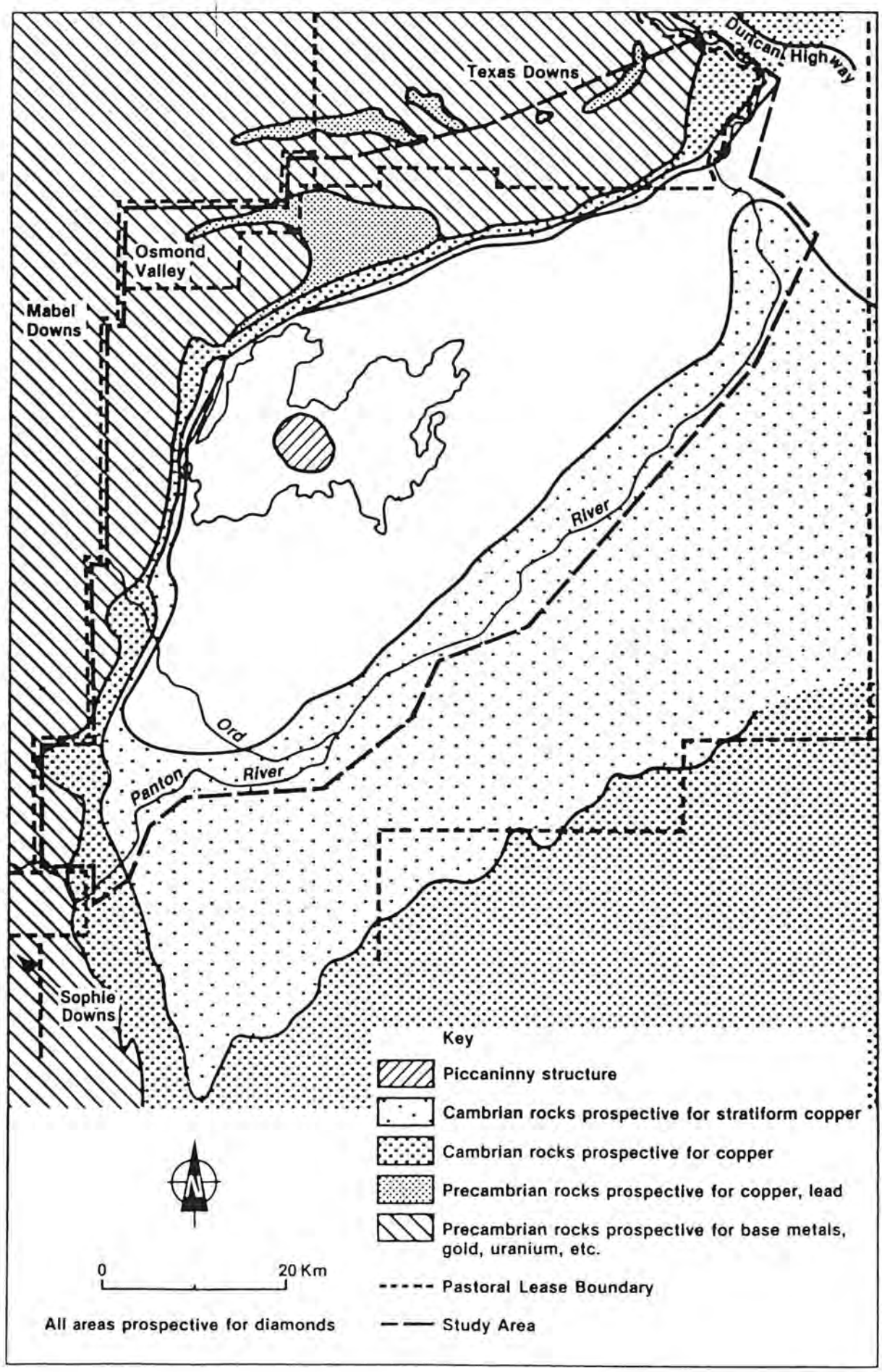
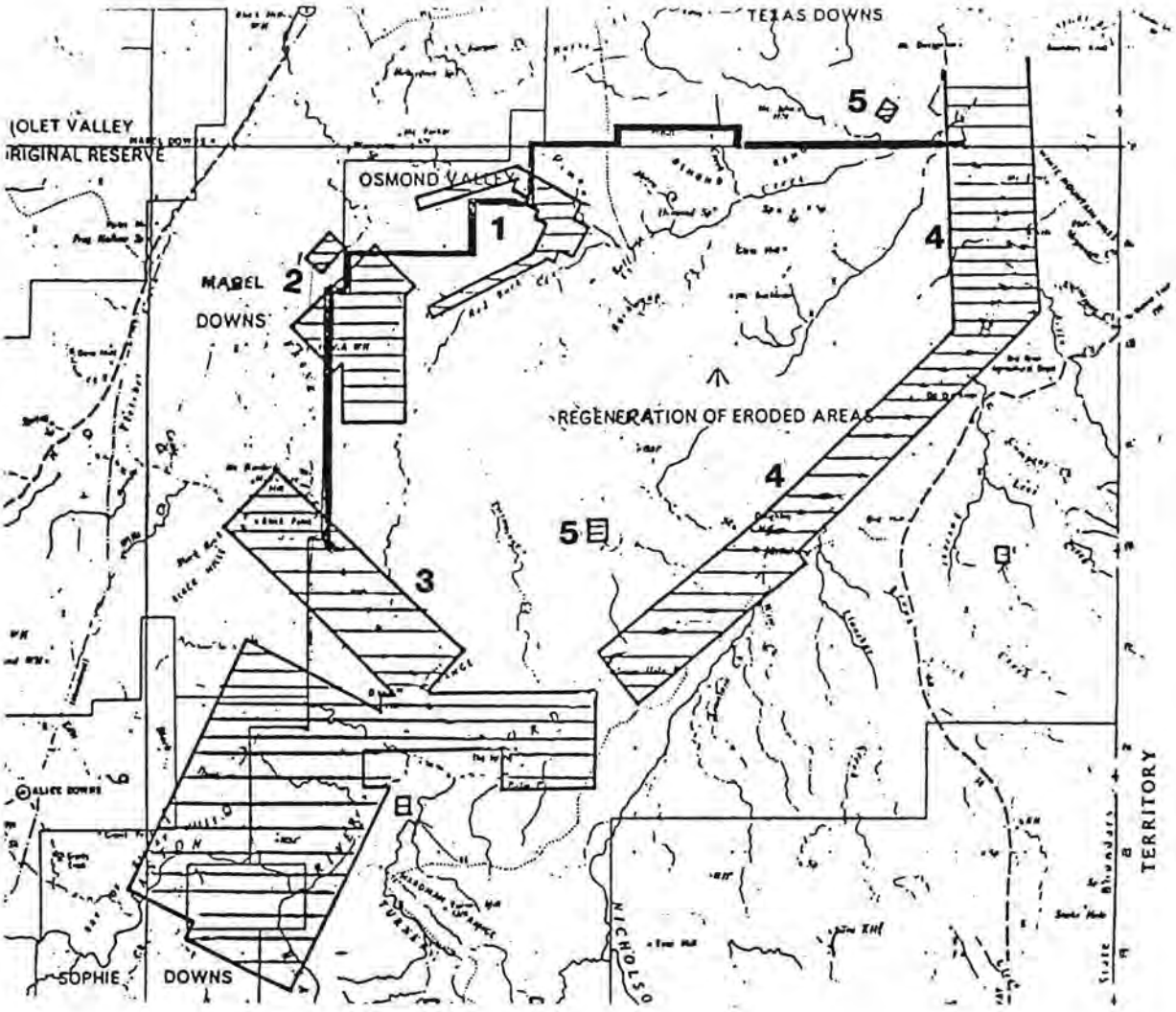


Fig. 19. Prospective Areas of Mineralisation.
(Source: Working Group, 1984).



Key:

Leases for

1. Copper
2. Base Metals: Cu, Au, Uranium
3. Copper
4. Copper, Gold
5. Diamonds

Fig. 20. Mineral Claims within the Study Area.
(Source: Department of Mines, 1985).

12.0 ACCESS

12.1 VEHICLE ACCESS

Vehicle access into and within the study area is presently limited by the absence of suitable routes. The Bungle Bungle massif is located east of the Great Northern Highway, but travel to the range is extremely rough and arduous. John Garlick in 'Western Way' (Sept-Dec 1983) comments.....

> 'The track leading to the Bungle Bungle is generally poorly marked, definitely four wheel drive material and follows a twisting route along and across valleys..... Although the track leading to the western edge of the Bungle Bungle massif is measured as 57km, perhaps a better indication of the effect and care needed in driving the route is better measured in terms of time. It takes 5-6 hours to get there!' (Author referring to Spring Creek).

Shultz (in litt. to R May, 1983) noted 5 tracks leading into the area, only two of which are trafficable. Of the other three tracks; "these routes are no longer in use and ... are virtually impossible to find for much of their distance" (C. Done pers. comm., 1985). The only tracks currently viable are Osmond Valley Track and Spring Creek Track (see Fig. 21). These routes were made by mining companies exploring in the region and do not necessarily follow the best path through the area. Furthermore, they were not intended to be permanent features, or to withstand continual traffic. These tracks are usually cut for 3-4 months of the year.

Because of the current lack of ground access within the study area, many individual tourist groups and tour operators have cut their own tracks through the area. This contributes significantly to degradation and erosion problems and establish as unsuitable user patterns.

Osmond Valley Track:
The turnoff onto the Osmond Valley Track is located on the Great Northern Highway approximately 2km south of the Turkey Creek Aboriginal Settlement. The track trends in a southerly direction from Turkey Creek to Palm Yards, after which it continues along the northern boundaries of the Osmond Range entering the Bungle Bungle Valley from the north (Fig. 18).

Schultz, in litt. to R. May (1983), commented that this track is probably subject to erosion problems and in its current state, will probably require regular maintenance every 2-3 years.

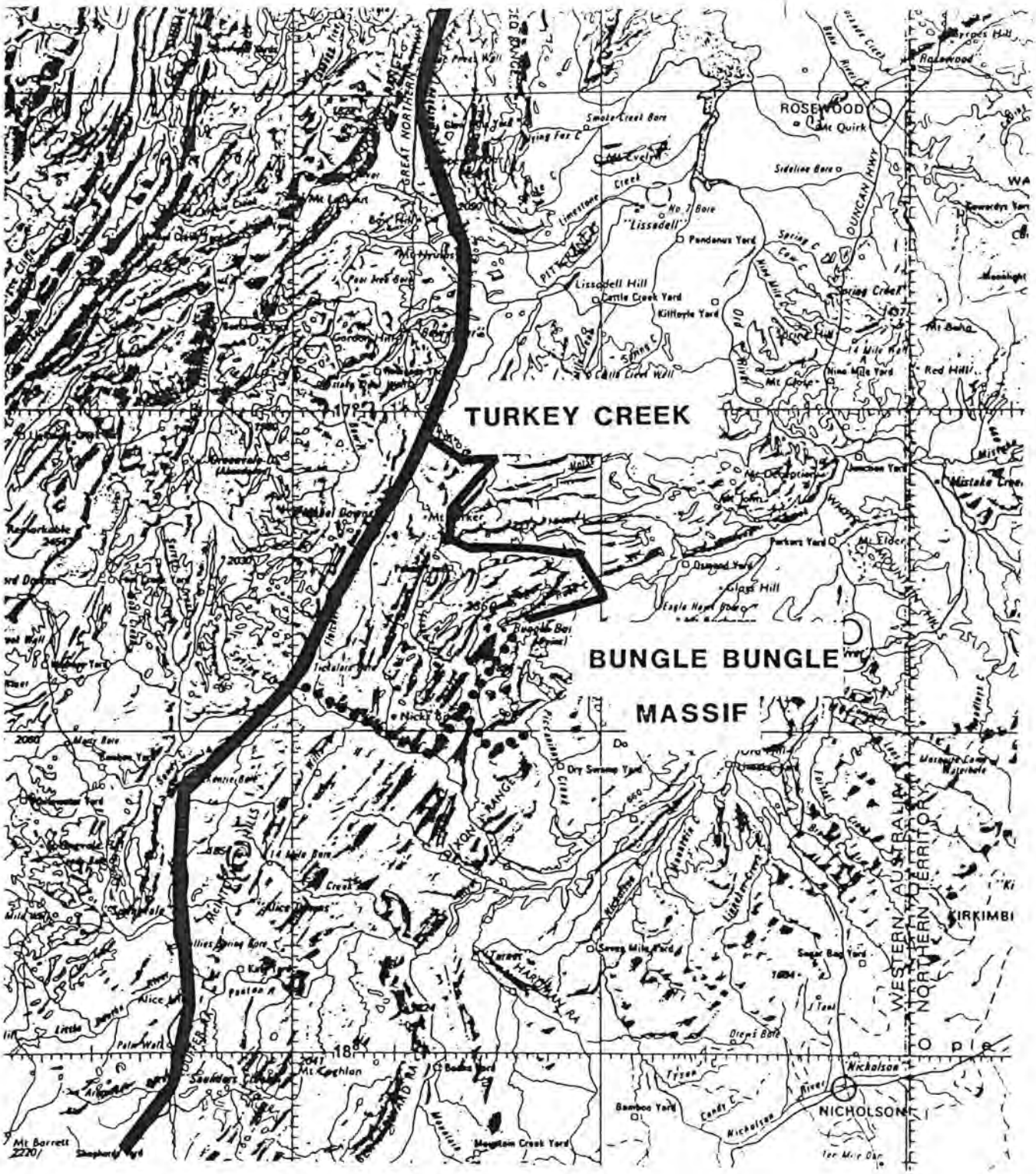
The Osmond Valley Track offers the tourist a variety of scenery - Winnama Spring, Palm Yard, gorges, pools and numerous creeks. Schultz (1983), noted that from Palm Yard to Bungle Bungle Valley there is no shortage of water.

Although access to the Bungle Bungle massif by this track involves travelling along a slightly longer route from the highway, it is the shortest route from Turkey Creek, the nearest service point.

Problems occur between Palm Yards and Bungle Bungle outstation where the track is based on black alluvial soils and cut by a number of creeks. The track could be realigned to avoid the black soils, which become boggy when wet, but at the creek crossings the track will require considerable upkeep to withstand tourist traffic. The alignment of the track creates an additional problem as it runs through Osmond Valley Station and the station owner does not favour tourist through-traffic (E. Herbert pers. comm., 1985).

Spring Creek Track:

Spring Creek Track is also known as the Sally Malay Track, or Tickalare Track. It starts on the Great Northern Highway, approximately 40km south of Turkey Creek and passes through Mabel Downs Station, to come within 11km (south-west) of Bungle Bungle Outcamp. Here, it divides into two tracks, one leading south, the other north. The former route runs along the southwest boundaries of the massif, terminating at Picanniny Gorge. It is cut by many steep sandy creek crossings. The northern track terminates at the Bungle Bungle Outcamp. It is based on sandy soils and similarly is cut by small creeks. As such, it could be subject to severe erosion problems. Although from a tourist's point of view it is not the most spectacular, the Spring Creek Track is used extensively by tourist groups and safari tour operators. It passes through some of the most severely eroded terrain in the area and along the sandplains at the southern edges of the massif, the track is already showing signs of breaking up (DCE File 23/83, 1984).



Key:

●●●●●●● Spring Creek Track

▬▬▬ Osmond Valley Track

▬▬▬ Great Northern Highway

Fig. 21. Access tracks into the Bungle Bungle Area
(Source: DCE File 23/83, 1984).

Problems also arise where this track passes through Mabel Downs Station. The owner's main concern is with tourists losing the main track, wandering across his property and interfering with his bore water supplies.

In its current state, Spring Creek Track will require annual maintenance to cope with increased traffic.

Vehicle access may be provided from a route tending west from the Duncan Highway. However as with access from the south, the route will necessitate the crossing of the extremely friable Buchanan land system which will not withstand continual vehicle pressures. Further, these routes could prove to be economically unrealistic as they are likely to be cut for 3-4 months of the year by the Ord River and will require annual maintenance, and as no road building materials are available the plains, materials will have to be transported to the area.

The Working Group have recommended that the only viable alternative was the provision of an aircraft landing strip (possibly located on the plains to the east of the massif) serviced by vehicle transport within the Park. The group believed that would provide a cost effective alternative to major upgrading of road access (Working Group, 1984).

12.2 INTERIM ACCESS PROPOSALS

To cater for, and to control in the short term (until a management plan has been devised) the increasing numbers of people visiting the area, a series of interim management proposals were jointly devised by the Working Group, regional representatives from the Departments of Conservation and Land Management, Tourism, Sport and Recreation and Regional Development and the Northwest. The proposals are to be jointly funded and implemented by these departments in association with the traditional owners (Hon. Ron Davies, Minister for Conservation and Land Management in litt. to the Minister for Tourism, 1985).

The proposed interim strategies include an information pamphlet explaining Government policy on the area, outlining its possible dangers and notes on precautions that the visitor should take. The sheet is provided in the interests of safety and to minimise tourist impact on the environment. Accordingly, requests will be made that visitors remain on specific, marked

access routes. The pamphlet will be distributed to travel agencies by the Tourism Commission; it will not be freely available to the public, and will be only given to those tourists who are determined to enter the area.

With the above strategies in mind, the Working Group agreed that an interim access track should be signposted and a camping area be provided some distance from the massif. The signs would not actively promote the area, but would be located so that they are visible only to those who are visiting the area. For example, the first signpost will be located well back from the highway, at a point on the track where it will be obvious only to tourists determined to reach the massif. Tour operators will be allowed into the area, providing they remain on the approved, designated tracks.

12.3 AERIAL ACCESS

Aerial tours over the Bungle Bungle Range are becoming increasingly popular. Air charter companies based in Kununurra have experienced a 600% increase in business in the 1984 season, of which 80-85% are flights featuring the Bungle Bungle massif. The potential for such tours is high as they provide an appreciation of the scale and complexity of the massif which is not readily achieved from the ground and allow year round access to the area. In addition, the massif is cut by steep-sided gullies and large tracts of impenetrable spinifex, both of which often block pathways. The rugged and dangerous rock walls which characterize much of the massif make exploring on foot extremely hazardous.

In economic terms the Working Group felt that the air-surface option should be facilitated as it will reduce the cost of developing the proposed park. These savings are significant when it is considered that an airstrip may be necessary to serve the Aboriginal outstation in times of emergency (DCE Files 23/83, 1984).

Other advantages of this option include:

- greater comfort and time savings travelling to the area.
- cost savings by the management agencies as fewer facilities have to be provided for visitors.
- minimal environmental damage.

Certain management issues need to be resolved. Air regulations will need to be defined for flights over the area and "access" zones may need to be defined to prevent aircraft circling over the Aboriginal outcamp.

13.0 TOURISM

13.1 REGIONAL TOURISM

Tourism in the Kimberley Region is currently annually valued as being worth in excess of $10 million. With appropriate management, the region has unlimited potential especially from April to October when dry warm days and cool nights offer ideal holiday conditions.

The most recent Kimberley Region Visitor Profile data, collated by the Department of Tourism using the Domestic Tourism Monitor programme (D.T.M.), has been included in Appendix 3. Several trends are evident:

- Most tourists to the Kimberley Region are from Western Australia. They are mostly middle class people, although in the past 4 years there has been a notable rise in numbers of professional people visiting the area.
- A major component of tourists to the Kimberleys are married couples with children. A significant number of people are over the age of 55.
- Most tourists use Hotel/Motel accommodation, whilst only a small percentage camp or use caravan parks. This contradicts data presented in "The Kimberley Regional Tourism Survey" (1981), where 43% of people used caravans and 33% camped.
- As the most popular months for tourism are April to May and July to September, it would appear most tourists time their visits to coincide with favourable weather conditions and the school holidays.
- The length of stay usually ranges from 1 to 4 days although approximately 13% have stayed in the area for more than one month.

13.2 TOURISM IN THE STUDY AREA

The first organised tours to the area was conducted by Airlines of Western Australia which conducted two heavily booked tours in March 1983. After receiving approvals from the Minister for Tourism, Minister for Agriculture and the Tourism Department, Ansett Western Australia in conjunction with Amensz Adventure Charters', began to run safari-type tours into the area shortly afterwards.

At the same time as the establishment of the Working Group, the then Western Australian Travel Centre began actively promoting the area, selling the

charter tours interstate. Similarly, the Western Australian Tourism Commission, in association with Western Australia. private tour operators, began to promote the area overseas, attending the International Tourist Bureau in Berlin and the Corroboree Tourism Promotion in London. In March 1984, the Government, responding to pressure from Aboriginal and conservation groups decided to discourage tourism into the area. The Premier for Western Australia on 1st May 1984 stated that:

> 'The position is that the Government is not prepared to encourage or endorse the promotion of tourism in the area until the working party set up to prepare a management and control plan for the region has conducted it's work in a satisfactory manner'.
>
> 'The policy is simply that the Government does not endorse or encourage tourism into the area until the management plan is worked out'.
>
> (W.A. Gov. Ass. 1/8/84).

Ron Davies in litt. to the Minister for Tourism (1985) commented that

> '...increasing numbers of tourists are attempting to gain access to the Bungle Bungle area and in several instances parties are known to have blazed their own tracks. There is therefore a need for defined routes, if this form of access is to continue'.

Currently, there is no documented information as to the numbers of individual tourists visiting the area, and their associated activities. The following gives an outline of the nature and number of tours into the area operated by tour companies.

(i) Hans Amesz Charter Tours:

These tours operate from May to September. Initially, in 1984, five tour groups each of 14 people were taken into the study area. For the 1985 tourist season, smaller tour groups of 9 people are planned to visit the area. Departures are scheduled for every 10 days. The tours include camping, climbing, and exploring over a period of 6 days. The parties depart from Kununurra and take approximately 1½ days to reach the massif. The tours enter the reserve along Osmond Valley Track and circumnavigate the massif (H. Amesz pers. comm., 1985). A base camp is usually established at Picaninny gorge, from which walking/exploring tours are conducted. The party leaves the area via Sallay Malay Track.

(ii) Centralian Tours

These tours are run by the Eastern States company on an infrequent basis. Only 3 tours were proposed for the 1985 season.

(iii) Other

The owner of the Turkey Creek Road House also runs tours into the Study Area. Currently this is only a small venture, the owner has only 1 vehicle, and probably runs one-off tours into the area (H. Amesz pers. comm., 1985).

Flights over the massif are very popular. The Working Group reported that air charter companies in Kununurra have increased business by 600%, of which 80-85% are flights which feature the Bungle Bungle Range. Ansett operates flights over the area, ex-Kununurra, for approximately $80.

13.3 TOURISM PROPOSALS FOR THE STUDY AREA

The Working Group suggested aerial flights over the area are the best way of viewing and appreciating the massif and other adjacent landforms. The potential for such tours is high as it facilitates year-round tourist access and allows a fuller appreciation of the area which is unobtainable from the ground. Further, the Working Group recommended that in the short term, tourism development should be based around aerial tours with guided and self-guided walking tours to specific parts of the Study Area. Existing roads should be left, with minimal upgrading for the next few years.

The Tourism Department believe that natural attractions such as the massif should be made accessible to all members of the public, rather than be reserved for a privileged few.

Accordingly the Tourism Department gave its support to the Working Group recommendation that the area be gazetted a National Park jointly managed by Aboriginal traditional owners, and that the area should be environmentally managed. However the department proposed that ground access should be controlled rather than prohibited.

The Ord Tourist Bureau envisaged that a single storey base camp would provide the only public facilities within the Study Area. This would include a visitor information centre, hotel/motel accommodation, caravan park, camping ground and any other appropriate service facilities. A light aircraft landing strip would be located nearby. The submission advocated the

development of private enterprise, with assistance from the Western Australian Tourism Commission, who should be prepared to develop and lease out the initial public facilities to ensure such facilities are provided. These recommendations are given in Appendix 3.

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