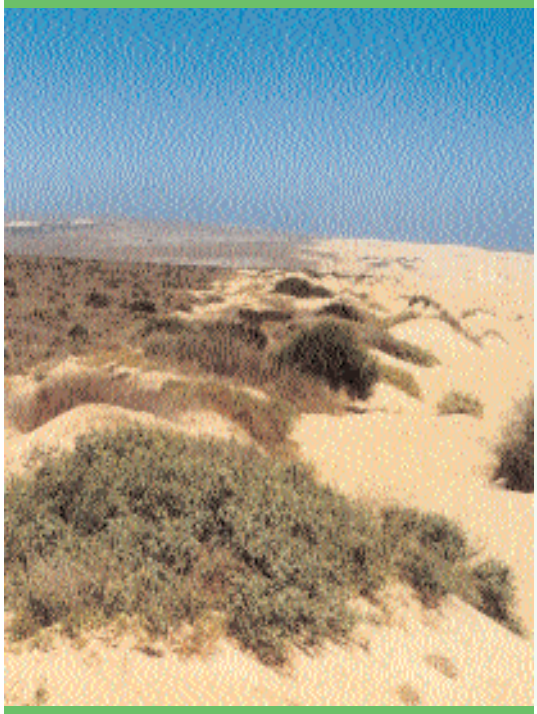

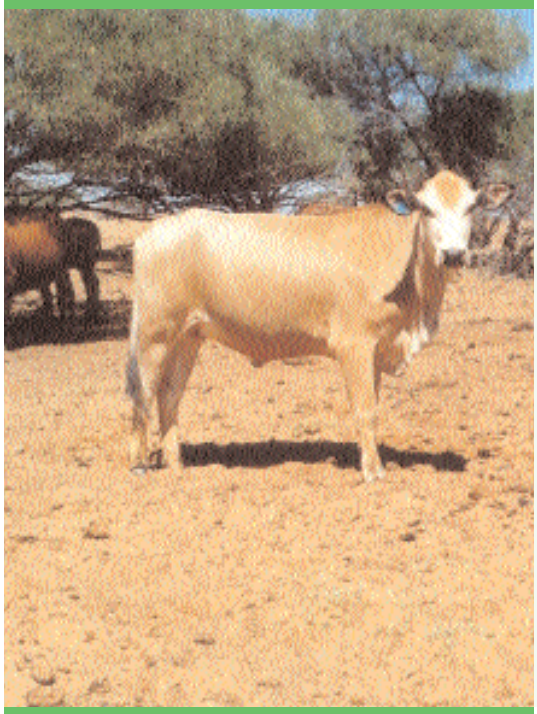

ENVIRONMENTAL PROTECTION and SUSTAINABILITY of the RANGELANDS in WESTERN AUSTRALIA

Preliminary

Position Statement No. 5

October 2002

Environmental Protection Authority

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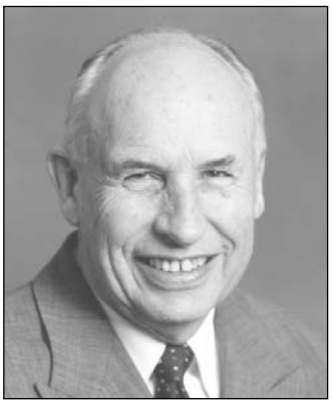
Cover photographs top to bottom:
Coastal dunes, Gascoyne region,
John Stretch, Department of Agriculture.

Spiny-tailed skink,
John Dell, formerly of WA Museum.

Cattle, Gascoyne region,
John Stretch, Department of Agriculture.

FOREWORD



The Environmental Protection Authority publishes a series of Position Statements to set out its views on matters of environmental importance. The Statements provide an avenue for the Authority to inform the public about environmental values and its vision for the future, as well as providing principles for environmental protection and sustainability on particular environmental matters. In 2002, the Year of the Outback, it is timely for the EPA to set out its view on the environmental protection and sustainability of rangelands in Western Australia through the release of a Preliminary Position Statement on Rangelands.

The Western Australian community faces significant challenges and opportunities in managing the State's vast rangeland area. Rangelands occupy 87 per cent (2 175 000 km^2) of the area of Western Australia, and contain a wealth of diverse native plant and animal species and habitats, unique geological formations, extraordinary landscapes and a rich heritage of Indigenous and Non-Indigenous culture and tradition. As a resource for grazing, mining, tourism and conservation, the rangelands can make a significant contribution to the State's well-being. However, as an environment-based resource, the condition and health of the rangelands are critical to the social and economic frameworks in the regions.

In the 200 years of European settlement, interaction between the livestock-based economy and the ecological system has not been kind to the environment. Parts of the rangelands are suffering from increased rates of land degradation caused by accelerated soil erosion, increased numbers and distribution of weeds and feral animals, reduced water quality and the decline and changes to native plant and animal communities. It is recognised that the social and economic sustainability of the rangelands and its industries largely depend upon the sustainable management of the natural environment.

The trend towards degradation and the development of State and National policy and community attitudes make it timely and appropriate for the EPA to give strategic attention to biodiversity and land conservation in the rangelands area. There is now greater knowledge of the limits of the environment's resilience and ability to recover and there has emerged an awareness of the need to use the environment within the constraints imposed by the fragile soils and climatic extremes. There is also a growing recognition that Indigenous knowledge, attitudes and experience of living in a sustainable relationship with the environment can inform present day land management.

The rangelands thus represent a significant opportunity to blend environmental protection and land use in a productive and sustainable manner. Policy steps have been taken by both State and National Governments to establish general principles.

The Western Australian Government released its *Policy on Rangelands* in 1997, stating that rangelands should be managed in an ecologically sustainable manner. The Commonwealth has established *National Principles and Guidelines for Rangeland Management* that promote improved rangelands land use and management.

The task is to establish operational protocols for implementing the principles of environmental protection and sustainability, to ensure that an adequate legal and administrative framework is in place, and to promote the development of meaningful criteria against which to assess environmental performance in relation to the rangelands as a natural resource.

The challenge is to encourage the concept of a duty of care for our lands and to develop an environmentally responsible approach that links government agencies and the community in resolving the difficult problem of achieving long-term environmental protection and sustainable management of largely natural rangeland ecosystems.

This Position Statement provides a set of principles for rangeland management to ensure sustainability and environmental protection of the rangeland ecosystems. These principles will assist the public, proponents, and decision-makers to focus on their responsibilities for managing the rangelands under their care. The principles will also provide the basis for the Environmental Protection Authority to evaluate and report upon the achieving of environmental and sustainability objectives and the protection of environmental values for the rangelands as a natural resource. The EPA is currently developing approaches to evaluating the environmental performance of natural resource management. This can only be achieved by the EPA working closely with natural resource management agencies to establish agreed environmental objectives, targets and monitoring programmes.

This Position Statement is termed Preliminary in that the Authority would welcome submissions which may be of assistance in correcting any omissions of importance or any errors of fact which the Statement may contain.

Any comments on errors of fact or significant omissions should be made to the Chairman, Environmental Protection Authority, PO Box K822, Perth WA 6842 by 31 January 2003.

Bernard Bowen
Chairman
Environmental Protection Authority

31 October 2002

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1. INTRODUCTION

Purpose

This Position Statement builds on previous statements made by the Environmental Protection Authority (EPA) on the rangelands and outlines the environmental attributes and values of rangelands, their pressures and environmental condition, management issues, principles and objectives for the environmental protection and sustainability of the rangelands and management responses required.

Defining the Western Australian rangelands as a natural resource

After nearly 50 years of modern, science-based research, survey and monitoring investigations, the rangelands are much better mapped, described, and understood than previously. There are now widely used definitions and detailed accounts of the Biogeographic Regions which comprise the rangelands. Surveys, maps and databases of the geology and geomorphology, soil types, vegetation, lands systems and hydrology are available at levels of detail relevant to the sustainable management of each land use. The rangeland fauna, however, is still incompletely documented across the state.

The southern, western and northern parts of Western Australia's rangelands coincide with the State's extensive land use zone, identified as those areas where the most common land use is pastoralism and where grazing by domestic stock on native vegetation is the major pressure (SoEAC 2001).

The climate varies from hot dry desert throughout the inland parts of the State, to semi-arid and more temperate areas with winter predominant rainfall in the south, to sub-tropical and tropical areas in the north with a distinct monsoonal wet and dry season. The overwhelming influence on climate is the non-annual El Niño Southern Oscillation (ENSO) cycle, featuring extremes of drought and flood, with the attendant fires and cyclones.

Most of Western Australia's rangelands are flat to undulating. Distinctive geological features include the Hamersley Ranges and the rugged Kimberley region in the north. Some of the oldest rocks on earth are found in the rangelands. As a result of the geological features, there are opportunities to extract minerals, but also the natural poverty of the soils may limit options for utilization.

Forty million years of relative climatic and geological stability have allowed Australia's plant and animal assemblages to persist, evolve and diversify in relatively small areas. The biota of the rangelands is characterised by an extraordinary biological richness and complexity and a very high degree of endemism. Vegetation includes the shrublands and woodlands south of the tropics, the hummock and tussock grasslands of the Pilbara, the inland sandy desert communities and the tropical savannas of the Kimberley.

The Environmental Protection Authority's role in the rangelands

The *Environmental Protection Act 1986* (as amended) (EP Act) established the EPA to protect the environment and prevent, control and abate pollution within the State of Western Australia. Through the EP Act, the EPA has a custodial responsibility for the environment, and all users of the environment (Government agencies, developers, land owners, lease holders, and the community in general) also have a responsibility for environmental protection.

As an independent statutory authority providing advice to Government, the EPA is mindful of the objective of the Environment and Heritage portfolio, as set out in the Machinery of Government Taskforce report, 'to value and protect our natural and built environment and manage natural resources in a way that balances their sustainable use, protects the environment and enriches the quality of people's lives, now and in the future' (Government of Western Australia 2001a). The EPA's role in this objective was reaffirmed by Government when it saw fit to facilitate an increase in the independence and strength of the EPA and to set out that 'The EPA will continue to undertake statutory functions related to environmental policy development, assessments, and sustainability audits' (Government of Western Australia 2001a). Subsequent operational interpretation of the EPA's role in relation to the portfolio's sustainability objective clearly separated the EPA's role as the environmental assessor from that of the natural resource managers in order to deliver clearer lines of responsibility and a clearer demarcation of objective-setter and outcome-deliverer. The Government highlighted the EPA's 'capacity to hold the resource management agencies accountable for delivering environmental outcomes' with a greater opportunity to develop policy for long term environmental planning (Government of Western Australia 2001b).

The EPA's role in the rangelands concerns environmental protection of biodiversity and soil conservation, and the evaluation of management of the pastoral areas as a natural resource.

National and State policies for the rangelands

In drawing up this Position Statement, the EPA was mindful of the National and State Government policies and strategies for rangeland use and protection. These include:

- *National Principles and Guidelines for Rangeland Management* (ANZECC & ARMCANZ 1999);
- *National Strategy for the Conservation of Australia's Biological Diversity* (Commonwealth of Australia 1996);
- *Policy on the Rangelands* (Government of Western Australia 1997);
- *Western Australian Natural Resource Management Framework Policy* (Government of Western Australia 1999b);
- *State of the Environment Report* (Government of Western Australia, 1998), and the Government's Response to the State of the Environment Report (Government of Western Australia 1999);

- *State of the Environment Report* (SoEAC 1996);
- *State of the Environment Report* (SoEAC 2001);
- *Sustainable Development in the Rangelands of Western Australia: a Position Statement* (EPA 1996); and
- *Focus on the future: Western Australian State Sustainability Strategy, Consultation Draft* (Government of Western Australia 2002).

The key feature of the National and State policies for the rangelands is ecological sustainability. The fundamental principle underlying the ecologically sustainable use of natural resources is that society should meet its needs in ways that ensure that the health and diversity of ecosystems are maintained and do not reduce the capacity of future generations to meet their needs. There is a need to develop new attitudes and practices for land management in order that natural and cultural heritage is not diminished and landscapes are not degraded (SoEAC 2001). The Consultation Draft for the State Sustainability Strategy (Government of Western Australia 2002) reiterated this principle of sustainability to which the State Government is committed.

2. THE RANGELAND REGIONS AND THEIR VALUES

2.1 The rangeland regions of Western Australia

Western Australia's rangelands (extensive land use zone) occupy 87 per cent (2 175 000 km^2) of the area of WA (2 500 000 km^2). There are 20 bioregions wholly or partly within the rangelands portion of Western Australia (NLWRA 2001a). The bioregions of the extensive land use zone of Western Australia are presented in Figure 1. Brief descriptions of their geology, climate, major vegetation groups and land uses are set out in Appendix 1 of this Statement.

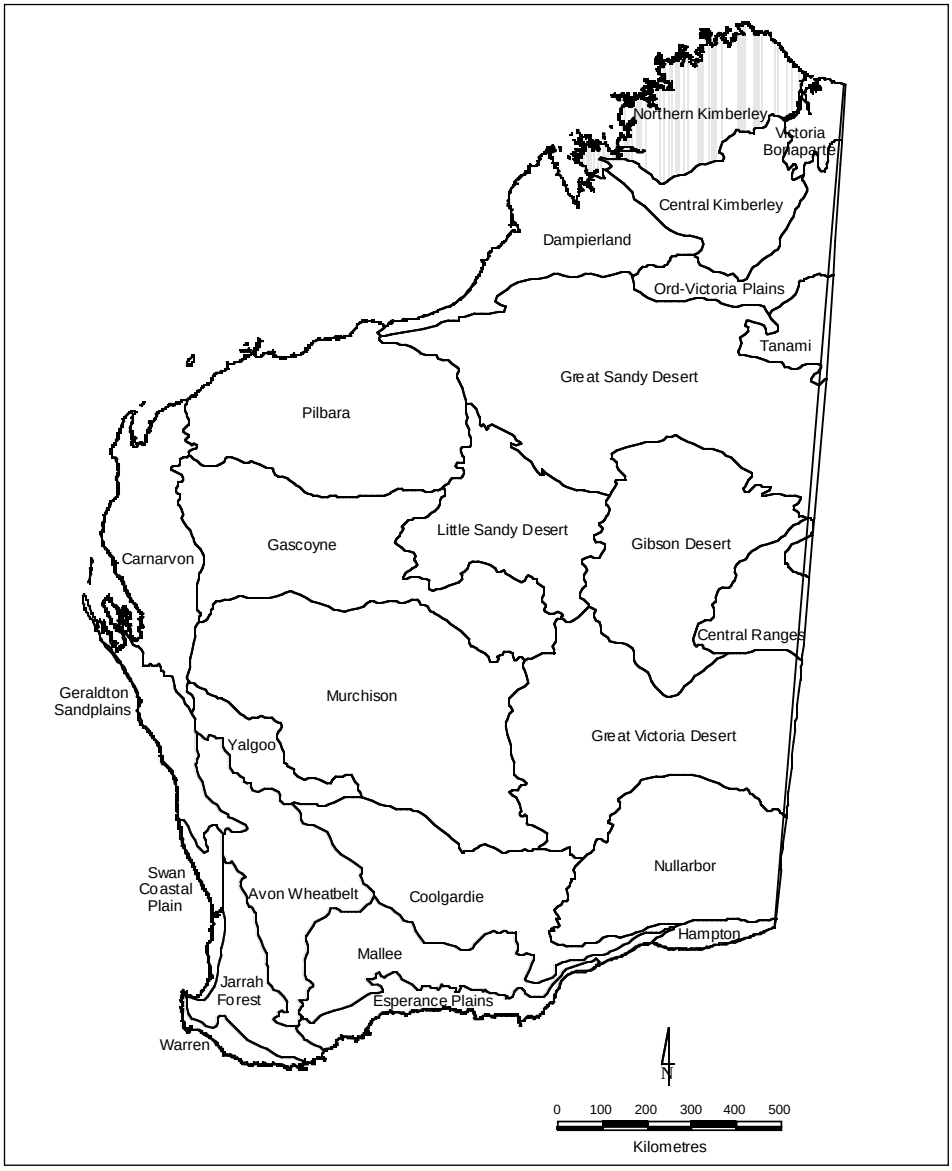

Figure 1 The Bioregions of Western Australia

Intensive land use zone Extensive land use zone

(From NLWRA 2002b)

2.2 Land tenure, land uses and demography of the rangelands

Land tenure in the rangelands is predominantly Crown leasehold or vacant Crown land, together with areas of Indigenous land in the desert regions adjacent to the NT and SA borders and in the Kimberley region. Rangelands also include the World Heritage Area of Shark Bay. Low intensity human use in the rangelands has generally led to forms of land tenure that are different from those of the more closely settled areas of the State. Freehold land is confined mainly to towns. About half of the rangeland area, located in the far interior, is either Indigenous land or Unallocated Crown Land. The other half of the rangeland area is mainly allocated as pastoral leasehold land, and under current tenure provisions most existing leases expire in 2015. At the beginning of 2001, there were 504 pastoral leases in WA (covering 980 000 km^2) held by Aboriginal Communities (56), mining companies (44), CALM (11), individuals (231) and companies (162) (Southern Rangelands Herald 2001).

Pastoralism is the dominant land use across about 45 per cent of the rangelands, with a greater proportion of sheep in the south and cattle in the north. About 60 per cent of the 504 pastoral leases is held by families or small family companies. Amendments to the *Land Administration Act* provide for permits to be issued for small scale diversification into tourism, horticulture and other non-pastoral activities, provided they are supplementary to the pastoral activity. Intensive horticultural production occurs on the alluvial plains of areas such as the Gascoyne and Ord rivers.

The findings of the *Australian Natural Resources Information 2002* (NLWRA 2002a) in relation to rangelands indicate that, since the 1950's, land set aside for conservation purposes has increased, land reserved for Indigenous use and benefit (covering a variety of titles) has increased, and total freehold and leasehold land has remained substantially the same, with nature conservation and Native Title holdings coming principally from 'unallocated' lands.

The rangelands are sparsely populated. Although they cover 87 per cent of the State's land area, they are occupied by only 10 per cent of the State's population, with numbers generally dwindling as people in Australia shift to the larger cities and the coastal zones. Population mobility features prominently across the rangelands.

2.3 Natural Assets, Goods and Services of the rangelands

Underpinning the array of social, economic and cultural values and functions of the rangelands are the essential processes undertaken by the environment that are critical to life on earth. These processes are known as 'ecosystem services'. CSIRO developed a conceptual framework (Figure 2) to illustrate the role of ecosystem services in maintaining the 'natural assets' and in supporting the production of 'goods', including economic, social and cultural activities (SoEAC 2001).

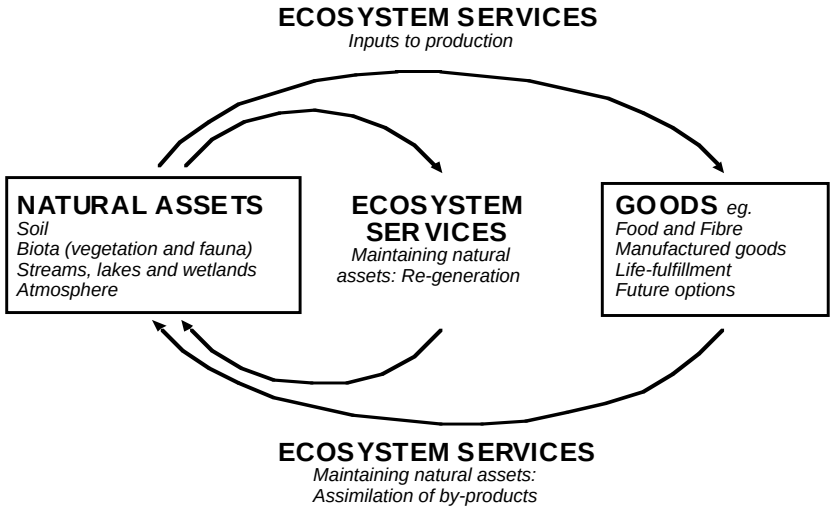

Figure 2 Conceptual framework illustrating the central role of ecosystem services in maintaining natural assets and supporting the production of goods of value

(SoEAC 2001, after Natural Assets: An inventory of ecosystem goods and services in the Goulburn Broken Catchment in Victoria)

The **natural assets** of the rangelands that are collectively maintained by ecosystem services are soil, biota, water and atmosphere.

In their natural state, rangeland soils are generally shallow and infertile and have a fragile structure. There are pockets of exceptions such as the alluvial plains associated with the delta areas (Gascoyne, Carnarvon, Pilbara, Kimberley and Ord). When soil surface is inadequately protected by vegetation, it is prone to erosion by wind and water and leaching of vital nutrients. As soil is rich in cryptogamic plants, fungi, bacteria and invertebrates and provides the structural support and source of water and nutrients for plants, erosion may result in significant reductions of productivity. Changes in land use and climate also have consequences for soil productivity and biodiversity.

The plants and animals of the rangelands of Western Australia have evolved various mechanisms to ensure their survival in the difficult and greatly varied environments. They are successful at cooperating in large complex ecosystems to maximise efficiency in nutrient recycling and living with aridity and the erratic ENSO cycle. Hence the dominance of certain morphological features of Australian plants such as sclerophylly, and the success of genera that have developed such water-saving features. Native vegetation contributes to the natural values, resources and processes of biodiversity, soil and water resources, hydrology, land productivity, sustainable land use, and climate change. It also contributes to natural and cultural heritage, and Indigenous people's interests. The conservation of native species, particularly perennial species, and the processes they support, is critical to the sustainability of primary industries and to providing opportunities for diversification in land use.

The maintenance of healthy inland wetland systems and water sources is essential for the survival of invertebrates, plants, animals, bird and fish species.The surface and near-surface locations of water sources are essential for maintaining the habitats for particularly diverse biota, and it is these water sources that receive most attention from grazing stock. Calcrete aquifers and limestone or karst cave systems need additional consideration as the habitats for stygofauna or troglobytic fauna. Formal surveys and informal local knowledge attest to the unquantified water resources of the rangelands.

The key **ecosystem services** that maintain the natural assets in a state of ecosystem health/functioning include soil formation and fertility, nutrient cycling, water recycling, waste assimilation, oxygen production, pollination and carbon sequestration. These services maintain the heritage and directly support all the communities and industries of the region, including tourism, recreation and aesthetics.

The major **goods** produced by the rangelands include mineral, pastoral and horticultural products, natural products and water supply.

Mineral extraction

Mining is economically the most significant rangeland industry and includes gold from the goldfields to the Pilbara region, iron ore in the Pilbara and diamonds in the Kimberley.

Pastoral products

Just under half of the rangelands of Western Australia support some 504 pastoral businesses that produce meat or fibre, mainly for export. In recent years, the pastoral beef industry has developed significant changes in its market requirements and the grazing management practices being used in parts of the northern pastoral areas. Aided by better than average seasonal conditions, many pastoral beef enterprises have proved increasingly profitable while sheep stations generally continue to struggle for viability. In economic terms, both mining and tourism are more significant industries in the rangelands. Nevertheless, this habitation across the rangelands also supports a social, transport and communications infrastructure, weed and feral animal control, and fire management.

Horticultural products

Western Australia's major drainage diversions sponsor an intensive horticulture industry around the alluvial plains of the Gascoyne and Ord Rivers. The alluvial plains associated with the ephemeral rivers of the Gascoyne bioregion (the Gascoyne, Ashburton and Wooramel rivers only flow when substantial rain is received) support a major horticulture industry centred on Carnarvon. Large areas are also devoted to horticulture associated with the Ord irrigation scheme and centred around Kununurra. The horticulture industry in these areas capitalises on out-of-season markets in southern Australia and emerging international markets and generate in excess of $90 million per annum.

Natural products

Flora and fauna harvesting is developing in the rangelands, demonstrating that rangeland use is changing. Encouragement towards more sustainable land use systems is likely to include greater use of native perennials, some forming the basis of grazing systems, others generating a range of products including timber, fuelwood, craftwood and pulp, cut flowers, essential oils, native seeds, bush foods, herbs, solvents and pharmaceuticals, all of which will provide benefits of rehabilitation, regeneration and carbon sequestration. Research is underway to investigate the potential of carbon credits as an economic driver for the use of native trees in the rehabilitation and revegetation of severely degraded alluvial land in the arid zone, where technically feasible and economically attractive means to effect rehabilitation are otherwise generally absent.

Water supply

Over the range of climatic zones water supplies are critical in underpinning the industries in the rangelands (mining, pastoral activities, horticulture and human settlements).

At times these values have been mis-managed with threats to local ecosystems, such as cattle grazing the natural waterways and water-holes in the northern parts of the rangelands. A major issue for the mining industry is the disposal and management of waste water from mining operations.

Heritage

Societies have a powerful need to feel and express a sense of place. Australia is in the process of re-defining its cultural identity through changing attitudes to land and landscapes and this is particularly evident in the increased recognition of the Indigenous people's long and rich cultural linkage with the rangelands. The rangelands are the focus of many Indigenous aspirations concerning access and ownership of land, for economic independence and for social and cultural purposes. Throughout the rangelands there is a broad range of cultural, archaeological and ethnographic sites, artefacts and rock art which are of significance to Indigenous people. The pastoral lifestyle, traditions and heritage of the rangelands and the image which the outback represents are also important to the cultural identity of Australian society and is associated with the historical predominance of pastoralism as the economic driver and user of land, water and biota.

Tourism, recreation and aesthetics

Emerging new attitudes are placing increased and changing value on landscape aesthetics and native vegetation and fauna. As an industry, tourism is economically more important than pastoralism. The emptiness and aridity of the rangelands, the opportunity for recreational pursuits such as bush-walking, bird-watching, camping, fishing and sight-seeing in general is an attraction to many tourists seeking a wilderness experience. The rangelands include not only an arid interior, tropical north and temperate south, but also varied landscapes such as massive ranges, hardpan

plains, river flood plains and wetlands, dunes and breakaways, caves and rock formations, and great lengths of coastal area, the most notable of which are the Ningaloo Marine Park, Shark Bay World Heritage Area and Nullarbor cliffs.

Rangelands are thus inherently important for a range of environmental, social and economic values. Accommodating the various and often incompatible rangeland activities and uses can be achieved, essentially by conserving the natural environment and sustaining the values of rangelands for future generations. The long-term protection of their natural assets and ecosystem services is required through State, National and International agreements and provides the context for all ecologically sustainable management.

3. THE RANGELANDS - ISSUES FOR MANAGEMENT

The approach of the Consultation Draft for the State Sustainability Strategy in WA incorporates the concept of the inter-dependence of natural assets, ecosystem services and the production of goods of value. It recognises that WA's economic strength is underpinned by use of its natural resources, that is, the production of minerals and agricultural products, but WA's 'ecological footprint' indicator suggests that the economy is not using the natural resources sustainably. The task for the Government is to ensure that the economy is more ecologically and socially sustainable. The task for rangeland managers is to ensure that the rangeland environment is more ecologically sustainable.

3.1 The importance of scale in managing ecological sustainability and sustainable production in the rangelands

Fundamental to effective rangeland management is recognition that the land use and management systems required to achieve an ecologically sustainable landscape do not necessarily coincide with those required to achieve an economically sustainable enterprise. Given the scale at which grazing enterprises operate, however, landscape and enterprise can be closely linked. Nevertheless, sustainable ecological function requires that the unit of consideration be the landscape rather than the enterprise.

Ecologically sustainable land management allows for the maintenance of a landscape's ecological functions and, among other things, the persistence of its biodiversity. This requires a scale of study, which extends beyond the paddock, farm or lease to the landscape, characterised by its underlying geology and hydrogeology, landforms and soils, plants and animals and their interaction.

Stafford Smith (1994) noted the challenge of addressing sustainability at different scales demonstrated by the need to maintain sustainable grazing at the enterprise scale along with ecologically sustainable management at a regional scale, incorporating the regional maintenance of biodiversity and other values that cannot be covered at the individual property scale.

Sustainable production leads to management of the land in a way that its economic productivity (food, fibre) can be maintained in perpetuity. To achieve this goal, some

ecological characteristics may be modified to ensure productivity. Thus sustainable agriculture can not maintain every species on every hectare. For instance, in the Pilbara, the introduced buffel grass (*Cenchrus ciliaris*) is an important component of productive pastoral systems on alluvial plains, and it has effectively displaced many native species. While it is a valuable component for sustained production, achievement of ecological sustainability at the landscape scale requires identification of habitats on the alluvial plain where buffel grass is excluded in favour of the natural biodiversity. In this situation, buffel grass can be regarded as an environmental weed.

Historically there have been shifts in attitudes to introduced species. For example, the early camel riders in the rangelands introduced Ruby Dock (*Acetosa vesicaria*) into the inland areas as the fruit was used for padding the saddles on the camels. This species is now actively controlled in rehabilitation and disturbed areas on mining leases.

3.2 Pressures on the rangeland environment

The SoEAC approach to environmental management uses the pressure-state-response framework. However, the natural climate variability of the rangelands provides the background to this framework. Rainfall is a major driver of processes and functions in the rangelands, but it varies substantially from year to year and from place to place. There is the natural seasonal variability, the less predictable extremes in seasonal conditions associated with cyclones and the overlaying ENSO effect which has a cycle of from two to eight years, along with much variability within the cycles. This means that not all years have a flush growing season. These causes of variability need to be expected and accepted by management practices.

Thousands of years of traditional Indigenous land use practices modified Australia's vegetation, mainly through the impact of fire. But the most significant and rapid changes in rangeland vegetation and landscapes have occurred in the 200 years since European settlement. Whilst rangelands are dynamic environments, containing ecosystems with the capacity to adjust to the natural stresses associated with climate variability and poor nutrient recycling ability, the additional pressures from human activity have, in particular locations, used up the excess natural resilience and productivity of rangeland resources and are compromising the natural assets and ecosystem services.

The areas of the rangelands subject to the greatest pressure are the border area between the intensive and extensive land use zones, the coastal bioregion of the Geraldton Sand Plains, coastal Carnarvon and Pilbara and inland Gascoyne and Murchison bioregions. By far the most significant pressure in these hot spots is grazing. Over-stocking, inappropriate fire management, poor water and soil management practices, along with the introduction of weeds and feral animals, have resulted in land degradation and biodiversity loss and a consequent reduction in natural and pastoral productivity.

Grazing

Excessive grazing reduces vegetation cover and leads to land degradation, particularly soil erosion. Soil erosion is initiated and accelerated primarily because of the loss of perennial vegetation which, when in good condition, plays a pivotal role in stabilising the fragile soil structure. Examples of severe degradation are:

- stripping of the surface soil, particularly of the sandy surface layer, and its transport to the river systems;
- sealing of the surface and the inability of rainfall to infiltrate;
- severe erosion and gullying in narrow alluvial valleys and on fragile soils;
- eutrophication of many waterways and creeklines;
- stripping of the levée embankments on the major rivers;
- major shifts in perennial species composition;
- elimination of perennial cover in some plant communities;
- a significant increase in the cover of indigenous woody weeds in grasslands and shrublands; and
- an invasion of exotic perennial grass species in certain areas, particularly on calcareous soils and on river banks.

With evidence of soil structure decline, inherent soil infertility and loss of biodiversity, many Australian scientists and agriculturalists have concluded that there is a mismatch between the Australian environment and the introduced agricultural systems. This mismatch should be addressed firstly by considering climate variability, the properties of the soil, water and biological resources and how they interact, then making an assessment of the level of resilience to the pressures such as grazing and fire, and lastly a calculation of sustainable carrying capacity.

Horticulture

Environmental issues of concern in relation to the flood plains of the horticultural areas are soil erosion, vegetation degradation, biodiversity loss, reduced water quality, introduction of exotic flora and fauna, pesticides and waste management. There have been additional environmental impacts as a result of the horticulture development associated with the Ord River Irrigation scheme. These include clearing of 14 000 ha of native vegetation, inundation of 76 500 ha and altered flow regimes and water quality for the Ord River downstream of the dams. There is a high use of pesticides which has particularly impacted on the biota of the black soil plains.

Fire

Fire is an integral part of rangeland management and has shaped much of the vegetation and ecology of the rangelands. The frequency of fires used by Indigenous people to hunt and manage vegetation sometimes changed vegetation types (for example, open savanna replaced open forest). Non-Indigenous settlement and grazing have led to a generally lower frequency of burning and less fuel in the understorey. Appropriate use of fire as a management tool can control woody weeds and act to regenerate some native species.

Feral animals and weeds

Feral animals and weeds provide further cause for concern in their impact on ecosystem health and biodiversity over many areas of the rangelands.

Invasive weeds displace native species and their habitats, reduce grazing productivity, increase management costs, and some are unpalatable or poisonous to livestock. Of the 20 weeds listed as nationally significant, four species affect the rangelands: athel pine, mesquite, prickly acacia and parkinsonia. Of particular concern to Western Australia is parkinsonia, a thorny shrub that infests large areas, primarily along waterways. Preventing spread is difficult as seed is easily and rapidly dispersed by wind, animals and floodwaters.

The major species of introduced animals affecting rangelands are goat, rabbit, pig, donkey, camel, horse, cat and fox. Impacts on biodiversity include predation, competition for food and shelter and displacement of native species. Impacts on grazing production include competition with livestock for food and shelter, predation on stock, land degradation, especially in localised areas of high feral population, and spread of diseases.

Mining

Mineral exploration is a lesser pressure, generally involving low impact activities. However the use of mechanised equipment during the extraction process causes intensive localised environmental disturbance and, without appropriate quarantine preparation, can introduce and spread weeds and threatening processes. In terms of the scale of the rangelands, mining operations usually involve small areas of land, although the impacts on these small areas may be substantial. With the development of technology, mining is reaching greater depths, in some cases to below the water table, and requiring more water abstraction, placing greater pressure on the groundwater and aquifers and the ecosystems they support, both surface and subterranean. It is not apparent that mining has had an impact on biodiversity at landscape scale except, perhaps, where genetic variation may be very large over very short distances, as in stygofauna populations in the Pilbara, or where geographically restricted species are associated with specific geological features.

Despite the natural resilience of rangeland ecosystems, pressures, particularly grazing, have led to significant changes in the state of the environmental values at site and landscape level. Examples of uses, associated pressures and resultant states are shown schematically in Table 1.

Table 1 Examples of uses, pressures and the resultant states

Use	Extensive grazing, native products harvesting	Intensive mining, water abstraction, horticulture	Tourism, recreation, aesthetics, cultural, conservation	Unallocated Crown Land, Native Title
Pressures	• Excessive herbivory • Altered fire regimes • Excessive harvesting of fauna • Weed and pest incursion • Seasonal variation	• Land clearing • Excessive water abstraction • Weed and pest incursion • Seasonal variation	• Altered fire regimes • Inappropriate waste management • Localised disturbance • Weed and pest incursion • Seasonal variation	• Altered fire regimes • Weed and pest incursion • Seasonal variation
Changes to states	• Loss of ecosystem function and productivity • Loss of regional and local biodiversity	• Loss of site-based and localised biodiversity	• Site disturbance, particularly fragile areas (eg. coastline, water courses)	• Loss of regional and local biodiversity
Significance of changes (more * indicates greater changes)	*** Serious and extensive over a considerable area	** Generally very localised, but intensive	* Generally very localised, but low impacts overall	** Moderate and extensive

3.3 State of WA's rangelands

The term 'landscape health' describes the condition of natural ecosystems and associated biodiversity values from a nature conservation perspective. Broad indicators of landscape health include soil erosion, vegetation extent and clearing, land use, fragmentation of native vegetation, hydrological change, weed infestations, feral animals, threatened ecosystems and species, regional biota extinctions, changes in fire regime. Various combinations of these indicators are used to make assessments of environmental condition.

For example, on the basis of a survey of native plant species diversity as an indicator of rangeland condition, Wilcox and Cunningham (1994) concluded that only 40 per cent of the rangelands are in good condition, 34 per cent are in fair condition and 26 per cent are in poor condition. Surveys by Payne et al (1982, 1987, 1998) of rangeland condition as the measure to describe the value of the land for grazing, indicated a similar result (see Table 2). Grazing productivity and landscape health are clearly linked.

The summary information in Table 1, setting out the uses, pressures and resultant states, is supported by the following sections. They present some results of case studies by Payne et al (1998), based upon surveys of vegetation condition and the

extent of soil erosion. Pastoral leases held for grazing purposes occupy about 940 000 km^2 of the State. The rangeland condition surveys cover 661 840 km^2 of rangeland which has been put to pastoral use (including minor amounts of Unallocated Crown Land). The current condition of the pastoral resource of the State is shown in Table 2 and is described in more detail in Appendix 1 of this Position Statement.

Table 2 shows that the condition of the pastoral rangelands has declined since settlement with only 39 per cent now regarded as being in good condition. About 1 per cent of the area so far surveyed (6 778 km^2) is severely degraded. In most instances it is the most productive terrain that is also the most degraded.

Table 2 Condition summaries for regional rangeland surveys (Payne et al 1998)

Region	**Area (km^2)**	**Severely degraded eroded* (km^2)**	**% of each region**	**Range condition class# % of each region**		
				Good	**Fair**	**Poor**
Gascoyne	63 400	1 205	1.9	32	53	15
West Kimberley	89 000	2 000	2.2	20	50	30
East Nullabor	47 400	0	0	50	10	40
Carnarvon Basin	74 500	647	0.9	45	32	23
Murchison	88 360	1 560	1.8	21	37	42
Roebourne Plains	10 216	233	2.3	51	27	22
N E Goldfields	100 570	452	0.4	39	22	29
Sandstone-Yalgoo	97 710	145	0.2	45	32	23
All areas	661 840	6 778	1.0	39	34	27

NOTE: * The severely degraded areas are those where the eroded surfaces are larger than 40 ha. The surfaces are usually stripped and gullied and have little, if any, standing perennial vegetation.

\# The rangeland condition class is derived by combining scores for vegetation condition and the extent of accelerated erosion.

The diversity and scale of landscape components often mean that extensive impacts (such as accelerated soil erosion, eutrophication of waterways and creeklines, overgrazing by stock or feral animals, increase in woody weeds, loss of species) will be distributed very unevenly throughout very different rangeland habitats and parts of the ecosystems. This is evident in a closer analysis of the rangeland condition data for the Carnarvon and Ashburton areas (Table 3), although the picture would be similar across the rangelands as a whole (see also Appendices 1 and 2). Table 3 shows the percentages of five classes of land in three stages of grazing potential over both regions.

Table 3 Rangeland condition class for areas of varying grazing value in the Ashburton and Carnarvon Basin (Payne et al 1987; Payne et al 1982)

Grazing value#	Grazing area (km^2)	Vegetation condition (%)		
		Good	Fair	Poor
Very high	5 620	32	35	33
High	34 745	42	32	26
Moderate	51 788	51	33	16
Low	20 452	51	38	11
Very Low	23 012	89	9	2

NOTE: # Grazing value is an attribute of land capability for pastoral purposes when the land is in good condition.

The high and very high grazing value lands are those which are inherently of greater fertility, have better overall water relations and greater accessibility. It is these areas that demonstrate the greatest condition decline. Another feature of ecological function in the pastoral rangelands is one that the vegetation condition data for these areas does not reflect. Many rangeland landscapes in Australia are dominated by areas of infertile soils with poor water retention characteristics, and with only small pockets of fertile and productive land scattered through them. This is the case with the Western Australian rangelands, with the exception of the flood plains of the major rivers of the north.

The link between rangeland condition decline and loss of biodiversity is less evident. While there are a number of fauna species either presumed threatened or extinct across the rangelands, there is no evidence for loss of any flora species. Further, it appears that fauna loss is equally serious in ungrazed and grazed areas, suggesting that pressures other than grazing are contributing to these losses, such as infestation by feral predators (including cats, goats and camels). Although flora species loss at landscape scale may not be evident in grazed areas, loss of ecosystem function has reduced the vigour and resilience of many localised rangeland habitats and communities, some irreparably so. For example, many perennial species, as well as annual species, have been markedly affected by the non-selective grazing habits of goats.

3.4 Managing the production of goods of value in the context of natural pressures

Pastoral productivity

The decline in rangeland condition can be primarily attributed to a failure to match grazing use of the land to its long-term capability and to fluctuations in seasonality.

Behind this one cause lies an array of issues that have resulted in poor grazing use and management. These include:

- inadequate knowledge and understanding of the functionality of the natural systems;
- inadequate recognition of the natural variation and complexity of the rangelands and their varying capacity to support pastoral activities;
- economic and social drivers for increased short-term returns achieved at the cost of long-term productivity;
- an inability to distinguish changes in range condition over time from seasonal fluctuations;
- inadequate supervision and intervention by government; and
- the tenure requirements of the *Land Administration Act* that discourage diversification and the complex Government approvals required to pursue diversification.

Sustainable pastoral management in leasehold areas is required by the *Land Administration Act* and depends upon lessees recognising the extremes in pasture availability and adjusting stocking rates and adopting land management strategies which encourage the regeneration of land adversely affected by natural and enterprise pressures. The *Land Administration Act* needs to incorporate a mechanism for required audit of sustainable land management. In this way, a productive and stable pastoral resource would be maintained.

Mining, water abstraction, horticulture and other intensive land uses

Mineral extraction and horticultural activities have also placed strains on the fragile environments of the rangelands, particularly on those isolated but extremely important fertile and well watered zones which are embedded in a background of arid and infertile sandplains and dunefields. However, there has generally been some success with modern environmental management applied to more recent intensive developments, such as minesites and their associated waste disposal. Furthermore, better management applied to outback towns and main roads, key sites within the conservation reserve system, has also generally met with some success.

Intensive impacts from horticulture have remained largely confined to areas with exceptional land and water resources, such as those in the Gascoyne and Ord irrigation areas. New economic and technological possibilities for intensive agriculture continue to arise and will require full and objective environmental assessment at both strategic and project levels.

Tourism, recreation, aesthetics and cultural uses

Some localised erosion also results from un-managed tourist access. For example, four-wheel drive vehicles can cause damage to mangrove populations along creeks which then results in erosion, and vehicle tracks can cause subtle changes to surface hydrology, drainage and sheet flow. More obvious effects can be seen in vehicular

disturbance of coastal and desert sandhills, sometimes leading to irreversible 'blowouts', particularly in coastal regions.

Tourism and eco-tourism developments herald new planning and land management challenges associated with increasing mobility and numbers of tourists. Tourism brings large numbers of people into direct contact with ecosystems they might not previously have visited, and introduce people to areas of environmental knowledge and awareness they might otherwise have missed. Tourism raises issues of public access to pastoral leases, management of Indigenous sites, maintenance of infrastructure, fire and emergency services, and these need to be given attention.

Unallocated Crown Land and Native Title

About half the area of the State's rangelands (approximately one million km^2) is either not used or managed for any defined purpose or is occupied under Native Title. Most of this land consists of the extensive hummock grass sand plains of the Gibson Desert and the Great Victoria Desert, east of the pastoral leasehold land. Less obvious areas occur in the eucalypt woodlands west of the Goldfields, and along the coast east of Israelite Bay.

Widespread occupation by Indigenous peoples occurred over many millennia and only ceased in some places within the last 50 years. Indigenous people relied on these lands for food and water and were skilled users of fire in the spinifex sandplains to manipulate environments so that they were conducive to vigorous populations of small marsupials and reptiles, which were important sources of food. Indigenous people still live in these regions, centred on scattered fixed settlements in the Gibson and Great Victoria Deserts.

As there is no history of recent widespread occupation, there are few data on the condition of the environmental values of this land. The recorded observations are made only in general terms and are not specific. Nor is there information on the actual extent of habitat change and decline. There are, however, indications that where there has been cessation of Indigenous fire practices across the land and the invasion of these areas by feral grazing animals and predators, the environment has been greatly affected. As a consequence, the habitat for some animal species has suffered and populations of some plant and animal species have been placed under pressure. Many animal species are now extinct throughout these parts of the rangelands. This result of a withdrawal of prior management illustrates the importance of ensuring that all the rangelands are actively managed.

4. LAND USE AND MANAGEMENT PRINCIPLES FOR ENVIRONMENTAL PROTECTION AND SUSTAINABILITY OF THE RANGELANDS

The Western Australian rangelands provide significant challenges and opportunities for environmental protection. On the one hand, past use has left a legacy of land degradation, exotic species invasion and localised extinction of species. On the other, the environment is still largely 'natural', with land clearing confined to small areas

associated with mines, towns and irrigation areas. The principal task for management is to build on the opportunities provided by this 'naturalness' in developing and implementing systems for sustainable habitation that are able to accommodate the multiple objectives for enterprises and landscapes.

The principles set out below recognise the shared responsibility for environmental protection in the rangelands between Government, regional communities, individual land users and managers. The need for close collaboration between these sectors is essential. Environmental protection and sustainability will only be achieved when decision-makers at one scale are aware of, and sensitive to, the objectives being addressed at other scales.

Implicit in these principles is a general commitment to multiple use of much of our rangeland in that it is normally possible to achieve sustainability and a measure of environmental protection on a piece of land while at the same time using it for grazing and/or tourism and/or native products harvesting. Furthermore, recognition of the need for conservation of regional biodiversity (in terms of comprehensiveness, adequacy and representation) will require additional land to be added to the conservation estate.

Principles

i) Environmental protection and sustainability to be achieved irrespective of economic conditions at the enterprise and industry scale

All land in the rangelands must be managed to meet community expectations for environmental protection at landholding and landscape scale, irrespective of economic conditions at enterprise and industry scale. This includes land held under freehold and leasehold tenures (eg pastoral leases, mining leases), Aboriginal land reserves established for various purposes managed by Commonwealth, State and Local Governments, and Unallocated Crown Land that has no defined purpose at present.

ii) Environmental and sustainability objectives to be set, and standards and criteria established

Sound rangeland management requires clear environmental and sustainability objectives to be set at national, state, regional and landholding scale, with standards and criteria established so that these objectives can be achieved. Those responsible for land management at all scales must be aware of their responsibilities and requirements to contribute to the achievement of these objectives. In general, the protection of ecosystem function across all landscapes, associated with the conservation of biodiversity at regional scale, is the base management requirement within which other land uses may be accommodated.

iii) All enterprises to be managed in an environmentally sound manner

All enterprises in the rangelands, both public and private, should demonstrate the ability to manage the proposed use in an environmentally sound way through:

- a clear statement of the environmental objectives;
- a sound plan that sets out how the environmental objectives will be met;
- a demonstrated commitment to implement the plan;
- monitoring to see if the environmental objectives are being met;
- adapting management accordingly; and
- being able to report environmental performance in the public arena.

iv) Biodiversity to be conserved through both reservation and off-reserve conservation

Regional biodiversity should be conserved through the establishment of a comprehensive, adequate and representative reserve, complemented by off-reserve conservation as required. Significant opportunities exist for establishing partnerships for off-reserve conservation management with private, corporate (eg mining companies) and government (eg defence) landholders and managers.

v) Cultural heritage to be protected

The cultural heritage of the rangelands is a vital asset and should be protected on behalf of the owners of that heritage and all Australians. This applies to heritage sites and materials of both Indigenous and Non-Indigenous origin.

vi) Landowners and managers to assume responsibility for environmental performance

Current landholders and managers should assume responsibility for the managed land that has lost environmental values due to previous poor practices. At a minimum, current landholders should prevent further loss of environmental values and stabilise ecosystem function in those areas affected.

vii) Stewardship of the rangelands to be shared between users

As there is a complex mosaic of private and public interests in the rangelands, it is essential that a shared stewardship of the rangelands is built between coexisting industries, community groups, land users and the wider Western Australian community. The basis for this stewardship should be an equitable distribution of the costs of environmental protection between the different beneficiaries, including landholders, other users of that land, community interest groups and the general public. Additional work is required to establish protocols for these shared commitments to environmental benefits.

viii) Accurate and interpretable information on environmental condition and trends to be used at all levels of management

Landholders and managers at all levels should respond to early indicators of environmental change and changing trends in relation to environmental management objectives. This requires all landholders and decision-makers to invest in ensuring access to accurate and interpretable information about trends in the condition of locally and regionally important environmental values.

5. THE EPA'S ENVIRONMENTAL OBJECTIVES FOR THE RANGELANDS

The principles set out in section 4 translate into the following operational objectives for environmental protection in the rangelands:

i) Protection of biodiversity in the rangelands

High conservation value habitats and ecosystems should be protected by establishing, managing and maintaining a comprehensive, adequate and representative system of conservation reserves, by entering into co-operative agreements with existing landholders to conserve essential habitats and ecological systems outside the reserve system (off-reserve management), by the identification and reservation of areas which should be set aside for conservation, and by the creation of links between the reserves.

ii) Ecologically sustainable use and management of productive capacities

Full information on land capability, productive capacity and best management practices should be provided to existing and intending landholders. Rangeland regeneration and rehabilitation requirements for the landholding should be implemented to develop sustainable land use systems. The EPA supports continuous improvement using this approach. This will require that best management practices should be developed and implemented for each landholding.

iii) Effective monitoring and audit

Key, salient environmental parameters should be identified to enable monitoring to be developed to indicate the changing environmental condition of the rangelands. These need to include parameters for measures of biodiversity, ecological processes and ecological functioning.

6. ACHIEVING THE ENVIRONMENTAL OBJECTIVES - MANAGEMENT RESPONSES

6.1 Government

As described in Section 2, most of the land in the rangelands is held under some form of leasehold tenure, being mainly pastoral and mining leases, with smaller areas leased for special purposes, such as tourism facilities. These leases often overlap, with multiple use being the outcome. For example, the same piece of land may be held under separate leases for grazing and mineral exploration. These tenures and the leasehold agreements are administered variously by a range of State and Local Government Agencies, as shown in Table 5. This situation provides government with many opportunities to influence land use and management in the rangelands. The EPA is working with the agencies shown in Table 5 to set clear standards and performance targets that will contribute to the achievement of the environmental objectives presented in Section 5.

Multiple use of rangelands, with environmental protection and sustainability as the base level of management, is an achievable objective for much of the State's rangelands. For example, the destocking of properties by mining companies and of land acquired for the conservation estate, which is vested in the Conservation Commission, combined with the reduction of watering points and improvements to land management, is contributing to the achievement of the State's environmental objectives. In some areas, the objective of maintaining pastoral use is not compatible with environmental protection and regional conservation of biodiversity in the long term.

The recent article by Stafford Smith et al (2000) highlighted the natural variation in the landforms, soils and ecosystems and the capacity of the different regions to maintain a sustainable pastoral industry. Historically there has been a tendency to pay little attention to the complexity of the systems and the differences between regions. As differences are identified over time, all parties involved with the management of these systems need to adopt more appropriate management regimes, while at the same time ensuring equitable treatment of current landholders.

In some rangeland areas multiple use could be fostered by the Government acquiring leases for the general community benefit and paying the rangeland community for appropriate active land management, in accordance with agreed plans, to ensure ecologically sustainable use and that the long-term expectations of the general community are met.

Table 5 Examples of tenure and government responsibilities in the rangelands

Tenure	Authority with prime responsibility	Statutory powers	Supporting agencies	Environmental requirements
Pastoral lease	• Pastoral Lands Board • Soil and Land Conservation Council	• Land Administration Act 1997 • Soil and Land Conservation Act 1945	• Department of Land Administration • Department of Agriculture	• Ecologically sustainable pastoral industry • Ensure lessees meet conditions specified in the Act • Ensure activities do not degrade soil and land
Mining lease	• Department of Minerals and Petroleum Resources	• Mining Act	• Not applicable	• Ensure lessees meet environmental requirements • May refer proposals to EPA
Conservation lease (various categories)	• Conservation Commission of Western Australia	• Conservation and Land Management Act 1984 • Wildlife Conservation Act 1950	• Department of Conservation and Land Management	• Manage for purpose of conservation
Special leases	• Department of Land Administration or Local Government	• Land Administration Act 1997 • Local Government Act	• Not applicable	• Ensure lessees meet specified environmental requirements, or general requirements (if no specification)
Unallocated Crown Land	• Department of Land Administration	• Land Administration Act 1997	• Department of Conservation and Land Management	• Manage for purpose of conservation

6.2 Pastoral leaseholders

The pastoral industry and individual landholders face significant challenges in meeting their environmental obligations. A century of pastoral use has changed the environment in many ways, including changes to vegetation and soil characteristics,

the introduction of feral pests and weeds, altered fauna dynamics because of the provision of artificial water supplies, and altered fire regimes. While these are all impacts that need to be addressed, the long-term decline in the terms of trade for wool and meat production is limiting the funds available for investment in environmental protection. While the EPA recognises these difficulties as well as recognising that alternative mechanisms for maintaining people in many areas may be required, it is important that landholders link their day-to-day management decisions with the need to effect improvement in the land and vegetation resources on their leases. Actions include:

- Careful grazing management that will improve rangeland condition over time;
- Protection of water-bodies;
- Implementing sound fire management;
- Feral pest and weed control;
- Cooperation in regional conservation initiatives; and
- Monitoring and reporting trends in range condition.

Dealing with the areas of land that require more intensive intervention is problematic. Given that it is unlikely, for economic as well as for technical reasons, that deteriorated land will be rehabilitated within a meaningful timeframe, the EPA believes that the community should use the present condition of the land as a minimum base from which all ongoing and future use should be planned and managed. Furthermore, the particular needs of severely degraded areas require special recognition in government environmental management programs.

The network of pastoral leases and their occupants play a strategic role in the Western Australian community, and this will expand on the basis of an implied social contract between them and the wider community. Examples of these contractual arrangements are:

- While acquisition of a conservation reserve estate is a critical requirement, sound grazing management can meet a range of the State's conservation requirements without further intervention. Further, it is likely that meeting all of the conservation needs in the rangelands will require significant 'off-reserve' activities to be conducted on pastoral land. Where this involves pastoral leaseholders managing part of their leases for conservation purposes, the community should recognise their contribution.

- The rangeland community carries out a range of activities in addition to pastoral activities, from which the community as a whole benefits. The presence of people experienced in bushcraft who are living in remote areas provides a resource which can be of assistance to government agencies as they carry out their functions (eg general environmental management) and in providing a network of habitation to support travellers. The benefit to the community of these services is difficult to estimate but is significant.

6.3 Mining leaseholders

While mining and mineral exploration activities have a relatively small spatial impact on the land resources, the impact can be intense at site-based scale. Environmental requirements in the mining industry are set by government with individual operators being required to demonstrate compliance. These requirements have stimulated significant investment in environmental research and development by the industry, which has had spin-off benefits for other land users and those in the rangelands.

The mining industry is now a significant holder of pastoral leasehold land, even though grazing is not core business. For these rangelands, there are real opportunities for general management strategies to incorporate wider conservation objectives for these lands.

6.4 Other land users and managers

Tourism

Tourism is estimated to be worth about $200 million to the region. While welcome, increased human activity heightens the risk of environmental impact through the introduction of exotic species and degradation. It is important that tourism operators, local authorities and government cooperate in establishing management plans that will protect areas of high attraction.

Indigenous People

Prior to European settlement in the early 1800s, which was driven mainly by the demand for gold and grazing land, Indigenous people had occupied the rangelands for perhaps 60,000 years and have created a rich legacy of rock art, and other archaeological heritage and oral traditions. Since Native Title was recognised, Indigenous people have become important partners in mining and tourism development and are also significant pastoral leaseholders. Indigenous people are significant natural resource users and managers within the rangelands, and they and other landholders have common interests and responsibilities in relation to natural resource management. In addition, given their skills and knowledge of the land, Indigenous people can make a unique contribution to decision-making about the sustainable management of these lands.

For Indigenous people, the natural and cultural values of the land, water and vegetation are interwoven. In this regard, their objectives for the land may not be primarily grazing production or mining, but usually heritage and community development considerations are more important. Natural resource management plans must incorporate opportunities to use their landholding to achieve a wide array of public and private benefits including environmental protection, preservation of cultural practice and important places, protection and re-establishment of plants and animals used for bush-foods harvesting and in medicine, nature based and cultural tourism and Indigenous community development. The knowledge, skills and aspirations of Indigenous communities, as stakeholders, need to be recognised.

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GLOSSARY

For the purposes of this Position Statement the following definitions apply:

adequate - (in the context of conservation through reservation (see also CAR below)) ensuring the size, number and arrangement of ecosystems and reserves that optimise the chance of long-term survival of ecosystems and their continued evolution.

biological diversity - the variety of life forms: the different plants, animals and micro-organisms, the genes they contain, and the ecosystems they form. It is usually considered at three levels: genetic diversity, species diversity and ecosystem diversity (Commonwealth of Australia 1996).

biogeographic region - a complex land area consisting of a cluster of interacting ecosystems that are repeated in similar form throughout (Thackway & Cresswell 1995).

CAR - comprehensive, adequate and representative reserve system. It is defined as a system of ecologically viable protected areas, the establishment of which is central to the conservation of Australia's biological diversity, as observed in the National Strategy for the Conservation of Australia's Biological Diversity (Commonwealth of Australia 1996).

comprehensive - ensuring the full range of communities are included in a reserve system, as distinguished at a particular scale (EPA 1996).

conservation - the management of human use of the biosphere so that it may yield the greatest sustainable benefit to present generations, while maintaining its potential

to meet the needs and aspirations of future generations. Thus conservation is the positive, embracing, preservation, maintenance, sustainable utilisation, restoration and enhancement of the natural environment (Department of Conservation and Environment 1987).

ecological sustainability- the use of natural resources to meet society's needs in ways that ensure that the health and diversity of ecosystems are maintained and do not reduce the capacity of future generations to meet their needs (SoEAC 2001).

ecosystem - a defined community of organisms, their interaction, and their physical surroundings (Commonwealth of Australia 1996).

ecosystem services - essential processes, provided by the environment, that are critical to life on Earth, including soil formation, nutrient cycling, clean water supply, pollination and waste assimilation (SoEAC 2001).

extensive land use zone - those areas, where the most common land use is pastoralism and where grazing by domestic stock (on native vegetation) and, to a much lesser extent, repeated burning are the major pressures (SoEAC 2001).

intensive land use zone - those areas where the greatest disturbance has been native vegetation clearance and replacement with exotic crops, pasture and forest vegetation (SoEAC 2001).

land capability - the inherent qualities of the land resource and its components.

landscape health - the condition of natural ecosystems and associated biodiversity values from a nature conservation perspective.

land suitability - land suitability takes land capability information and other information (such as rainfall, environmental sensitivity) and looks at the overall suitability of a piece of land to accommodate a particular kind of development. It is useful for site selection and can also underpin the manner in which a particular type of development is carried out, so that the environmental limitations or constraints are fully recognised.

natural assets - those elements of the natural environment (soil, biota, water, atmosphere) that are maintained by ecosystem services (SoEAC 2001).

rangeland condition - a measure to describe the value of land for grazing, as distinct from **environmental condition** - the state of natural ecosystems and associated biodiversity values based on indicators of landscape health.

rangelands - native grasslands, shrublands and woodlands that cover a large proportion of the arid and semi-arid regions, and also include tropical savanna woodlands; regular cropping is not practised and the predominant agricultural use, if any, is grazing of sheep and cattle on native vegetation (SoEAC 2001). In Western Australia the rangelands generally coincide with the extensive land use zone.

representative - that the full range of assemblages, species and genetic variation that occurs in plant and animal communities across the landscape is represented in the reserve system (EPA 1996).

APPENDIX 1 The Bioregions of Western Australia's rangelands, with brief descriptions of their geology, climate, major vegetation groups, land uses and condition

(NLWRA 2001b; Payne et al 1987; Curry et al 1994)

Northern Kimberley

This bioregion consists of dissected plateaus and estuaries with a dry, hot, tropical climate with summer rainfall. It is dominated by tropical eucalypt woodland/grasslands with mangrove group, grasslands and rainforests on the coast. The major land uses are traditional indigenous uses, nature conservation (Prince Regent Nature Reserve and Drysdale National Park), minimal uses (vacant crown land, reserved crown land - Aboriginal and defence reserves) and grazing.

This vast, arid, tropical savannah contains spinifex sandplains, great rivers with their floodplains, cracking clay plains with Mitchell grass and other tussocky grasses, rocky uplands, mountains and tussock grasslands. The sandplains, tussock grasslands and the rocky uplands are in fair to good condition.

Victoria Bonaparte

This region extends into the Northern Territory and consists of a number of basins and the interior is dominated by the Victoria River Plateau, a large, highly dissected plateau up to about 350 m above sea level. The climate is semi-arid with a dry, warm monsoonal climate. It is dominated by tropical eucalypt woodland/grasslands, tussock and hummock grasslands and mangroves and lakes. The major land uses are grazing, nature conservation, minimal use (vacant crown land) and irrigated agriculture (cropping, modified pastures and seasonal horticulture).

The fertile and well-watered valleys contained within the rocky uplands of the levée embankments, and with the fragile soils of the upper valley systems have been modified, as many of the tussock grasslands which protected the soil surface in these landforms have disappeared, leaving annual grasslands and bare slopes. Invading buffel and Birdwood grasses have stabilised some unstable surfaces, but in doing so, have reduced the frequency of many native grasses.

Frequent fire, flood and infrequent, but sharp, droughts impose stresses on the vegetation. Pastoral management frequently does not take into account these hazards to landscape stability and, in consequence, vegetation associations suffer.

Ord Victoria Plain

This bioregion extends into the Northern Territory and consists of level to gently undulating plains with scattered hills and a climate which is dry, hot and tropical with summer rainfall. It is dominated by tropical eucalypt woodland/grasslands, tussock and hummock grasslands, other grasslands and acacia shrublands in the far west. The major land uses are grazing, minimal use (vacant crown land, other reserved crown land) and nature conservation.

The most pressing conservation issues concern the narrow, but fertile and well-watered valleys contained within the rocky uplands of the levée embankments, and with the fragile soils of the upper Ord River Valley and its tributaries, the Negri and Linnekar Rivers. The original tussock grasslands which protected the soil surface in these landforms have disappeared, leaving annual grasslands and bare slopes. Regeneration can occur where the slopes are not excessive and where active erosion is not widespread, provided management systems change. Invading buffel and Birdwood grasses have stabilised some unstable surfaces, but in doing so, have reduced the frequency of many native grasses. Where the slopes are steep, gullying and further erosion are likely to continue until slopes are naturally reduced.

Frequent fire, flood and infrequent, but sharp, droughts impose stresses on the vegetation. Pastoral management frequently does not take into account these hazards to landscape stability and, in consequence, vegetation associations suffer.

Central Kimberley

This bioregion has hilly to mountainous terrain and parallel ranges with a dry, hot, subhumid to semi-arid summer rainfall. It is dominated by tropical eucalypt woodland/grasslands, tussock and hummock grasslands. The major land uses are extensive cattle grazing, minimal use (vacant crown land, reserved crown land - Aboriginal and defence reserves) and traditional Indigenous uses.

This vast, arid, tropical savannah contains spinifex sandplains, great rivers with their floodplains, cracking clay plains with Mitchell grass and other tussocky grasses, rocky uplands, mountains and tussock grasslands. The sandplains, tussock grasslands and the rocky uplands are in fair to good condition.

Dampierland

This bioregion consists of sand plains, coastal plains, alluvial plains and ranges with a dry hot semi-arid climate and summer rainfall. It is dominated by acacia shrublands with smaller areas of hummock grasslands, tussock grasslands and the mangrove group. Very small areas of heath and eucalypt woodland also occur. The major land uses are grazing of native pastures and very small area of modified pastures, minimal use (vacant crown land, reserved crown land - Aboriginal reserve), traditional Indigenous uses and nature conservation.

The hummock grasslands are relatively unaffected by past use and are very stable. However, the more favoured areas within the spinifex which have better water relations and soils of higher fertility have been degraded with perennial tussock grass being lost and replaced by spinifex. In some instances the land has changed from perennial grasslands to herb fields. Elsewhere it has been invaded by a range of introduced grass species, which, while conferring stability on the land, have caused irrevocable changes.

In other situations, where the local minor depressions in the relief which are so essential for the maintenance of these foci of biological activity and plant growth have been obliterated by the processes of degradation, it is unlikely that rehabilitation will

occur spontaneously even if animals are removed. Such landforms will require costly intervention if they are to regenerate, and this degree of intervention is likely to be regarded as uneconomic by today's pastoralists.

Tanami

This bioregion extends into the Northern Territory and consists of hills and ranges with sand plains with an arid tropical climate and summer rain. It is dominated by hummock grasslands, tussock grasslands and other grasslands and salt lakes. The major land uses are grazing and minimal use (vacant crown land).

This region has not been subject to prolonged grazing pressure. In general terms it is in fair range condition, exhibiting few of the scars of erosion and neglect found in the remaining pastoral areas.

Great Sandy Desert

This bioregion extends into the Northern Territory and includes extensive sand plains, dune fields, lakes and remnant rocky outcrops with a temperate-tropical climate. It is dominated by hummock grasslands with some areas of acacia shrublands, heath, chenopod and samphire shrublands and salt lakes. The major land uses are minimal use (vacant crown land, reserved crown land - Aboriginal reserve), traditional Indigenous uses and nature conservation (Rudall River National park).

This region has not been subject to prolonged grazing pressure. In general terms it is in fair range condition, exhibiting few of the scars of erosion and neglect found in the remaining pastoral areas.

Pilbara

This bioregion consists of mountainous ranges and plateaus, alluvial plains, granite and basalt plains with an arid climate and summer rain. It is dominated by hummock grasslands and acacia forests and woodlands. Smaller areas of acacia shrublands, tussock grasslands, chenopod and samphire shrublands, salt marshes, mangroves and eucalypt woodland occur along water courses. The major land uses are extensive cattle grazing, minimal use (vacant crown land, reserved crown land - Aboriginal and mining reserves), traditional Indigenous uses and nature conservation.

The hummock grasslands are relatively unaffected by past use and are very stable. However, the more favoured areas within the spinifex which have better water relations and soils of higher fertility have been degraded with perennial tussock grass being lost and replaced by spinifex. The cracking clay soils of the Roebourne Plains are degraded in parts and the deltas of the major rivers, together with the flanking plains, have been altered significantly. In some instances the land has changed from perennial grasslands to herb fields. Elsewhere it has been invaded by buffel and Birdwood Grasses which, while conferring stability on the land, have caused irrevocable changes.

Some underlying effects of degradation in the Pilbara are of particular concern. Where erosion has exposed saline sub-soils the changes and losses in vegetation are

in practical terms irreversible. In other situations, where the local minor depressions in the relief which are so essential for the maintenance of these foci of biological activity and plant growth have been obliterated by the processes of degradation, it is unlikely that rehabilitation will occur spontaneously even if animals are removed. Such landforms will require costly intervention if they are to regenerate, and this degree of intervention is likely to be regarded as uneconomic by today's pastoralists.

Central Ranges

This bioregion extends into the Northern Territory and South Australia and consists of ranges and sand plains with an arid climate and summer and winter rain. It is dominated by acacia forests and woodlands, hummock grasslands and acacia shrublands. The major land uses are traditional Indigenous uses.

This region has not been subject to prolonged grazing pressure. In general terms it is in fair range condition, exhibiting few of the scars of erosion and neglect found in the remaining pastoral areas.

Hampton

This bioregion consists of dune systems on a coastal plain backed by a stranded scarp with a semi-arid climate with winter rainfalls. It is dominated by mallee woodlands and shrublands and chenopod and samphire shrublands. The major land uses are sheep grazing, minimal use (vacant crown land) and nature conservation. The principal changes on the Nullarbor are associated with plant community changes, including a shift from perennials to annual species, a loss of some perennial species and major species changes in the herbaceous semi-perennials which occur beneath the shrubs, much of which has resulted from changes to fire regimes and grazing pressures from introduced species such as the rabbit.

Nullarbor

This bioregion extends into South Australia. It is dominated by chenopod and samphire shrublands (bluebush and saltbush) and eucalypt open woodlands in the south west. Small areas of acacia open woodlands, acacia forests and woodlands and hummock grasslands occur in the north. The major land uses are sheep grazing, minimal use (vacant crown land) and nature conservation (Great Victoria Desert Nature Reserve).

The principal changes on the Nullarbor are associated with plant community changes, including a shift from perennials to annual species, a loss of some perennial species and major species changes in the herbaceous semi-perennials which occur beneath the shrubs, much of which has resulted from changes to fire regimes and grazing pressures from introduced species such as the rabbit. The northern Nullarbor has been developed only since the 1960's and there are still large areas not developed as the availability and economics of providing water are very limiting.

Coolgardie

This bioregion consists of granite rocky outcrops, low greenstone hills, laterite uplands and broad plains. There are no major rivers or creeks within the bioregion. Numerous salt lakes of varying size occur across the region. It has hot summers and mild wet winters. It is dominated by eucalypt woodlands, eucalypt open woodlands in the east, other shrublands, heath, acacia shrublands, chenopod and samphire shrublands, mallee woodlands and shrublands. Small areas of acacia forests and woodlands and hummock grasslands occur in the north. The major land uses are minimal use (vacant crown land), grazing of native pastures and some nature conservation and native forestry. Very small areas of cropping and grazing of modified pastures occur in the west.

The Goldfields eucalyptus woodlands have a relatively short history of pastoral use (staged development after 1900) with the area having a built in environmental constraint of no potable groundwater. This means the pastoral industry has to be reliant on limited natural waters and built dams and it has not proved possible to 'drought proof' the country. Pastoral industry impacts are generally less than in other areas and relate to changes in abundance and structure of the more palatable plant communities with greater impacts adjacent to artificial waters. Where grazing has occurred for longer periods (eg Southern Goldfields Woodland leases), was more intense (eg adjacent to mining areas and Kalgoorlie-Boulder) or in specific, more sensitive habitats, impacts on vegetation have been more substantial and some soil erosion and degradation has resulted (eg Fraser Range).

Introduced weeds (declared and environmental) occur more frequently in developed pastoral areas and in disturbed areas associated with infrastructure development. Grazing following extensive fires north of Kalgoorlie (in 1975/76) has resulted in a greater abundance of native woody weed species.

Great Victoria Desert

This bioregion extends into South Australia and is characterised by dunes and swales with local occurrences of playa lakes, associated lee-sided mounds (lunettes) and rocky areas. The climate is arid, warm to extremely hot in summer and mild to warm in winters. Rainfall generally occurs in the winter and summer. It is dominated by hummock grasslands, acacia forests and woodlands and mallee woodlands and shrublands. Chenopod and samphire shrublands and casuarina forests and woodlands occur near salt lakes with some acacia shrublands in the north. The major land uses are minimal use (vacant crown land, reserved crown land - Aboriginal reserve), traditional Indigenous uses, nature conservation and grazing.

This region was settled generally fifty years later than other pastoral regions and has not been subject to prolonged grazing pressure. In general terms it is in fair range condition, exhibiting few of the scars of erosion and neglect found in the remaining pastoral areas. The effects of fire regimes has led to some changes in perennial and annual species.

Murchison

This bioregion consists of low hills, mesas of duricrust separated by flat colluvium and alluvial plains with an arid climate with winter rainfall. There are three major ephemeral wetlands within the bioregion, including Lake Barlee, Annean Lake and Wooleen Lake. It is dominated by acacia forests and woodlands, acacia shrublands, hummock grasslands and chenopod and samphire shrublands. Small areas of eucalypt woodlands and open woodlands, other shrublands occur. The major land uses are sheep and cattle grazing, minimal use (vacant crown land, other reserved crown land) and some nature conservation.

This land was first settled in the 1860's with many stations being established along the rivers and their tributaries by 1875. Attracted by the shallow water supplies in the river systems, early settlers exploited the plains of the rivers where the saltbush communities were most prevalent. These communities were also those most susceptible to accelerated erosion, and invasion by indigenous woody weeds.

The area is in poorer range condition than any other area surveyed. Curry et al (1994) report a loss of perennial plant diversity and density, and a serious loss of palatable perennial plant diversity and density. Areas of land in the poorest condition showed a loss of both vegetation structure and cover, many of the taller shrub species being eliminated, with their place being taken by species such as prickly acacia and needle bush. The saltbush/bluebush communities, the hardpan mulga shrublands and the calcrete shrubby grasslands were shown to be the most degraded. Accelerated erosion is widespread.

Yalgoo

The region is characterised by sand and alluvial plains, lateritic breakaways, low ranges and salt lakes. Broad alluvial valleys separate the breakaways and low ranges. The climate varies from semi-desert to Mediterranean. It is dominated by acacia shrublands, acacia forests and woodlands, hummock grasslands and smaller areas of eucalypt woodlands and chenopod and samphire shrublands. The major land uses are sheep grazing, minimal use (vacant crown land) and nature conservation.

The area is in poorer range condition than any other area surveyed. Curry et al (1994) report a loss of perennial plant diversity and density, and a serious loss of palatable perennial plant diversity and density. Areas of land in the poorest condition showed a loss of both vegetation structure and cover, many of the taller shrub species being eliminated, with their place being taken by species such as prickly acacia and needle bush. The saltbush/bluebush communities, the hardpan mulga shrublands and the calcrete shrubby grasslands were shown to be the most degraded. Accelerated erosion is widespread.

Geraldton Sandplains

This bioregion consists of undulating lateritic sand plains. The coastal climate is Mediterranean with mild wet winters and hot dry summers. Inland areas experience a semi-desert climate with low unseasonal rainfall, hot summers and mild winters. The

great variation in rainfall, from north to south, results in a considerable variation in vegetation and land use. In the north, acacia shrublands, other shrublands, heath, casuarina forests and woodlands and small areas of hummock grasslands, mallee communities, eucalypt open woodlands and chenopod and samphire shrublands occur. The southern part includes heath, low closed forests and closed shrublands, acacia shrublands and eucalypt woodlands and open woodlands. The major land uses in the north are grazing of native pastures and in the south a mixture of grazing of native and modified pastures and cropping (cereals). Nature conservation (eg Kalbarri National Park, Shark Bay World Heritage Area) occurs throughout the region.

Although potable and stock water supplies were difficult to obtain, recourse having to be made on the coast to artesian supplies at great depth, the area was opened up in the 1870's and by 1900 for sheep. Not surprisingly, large tracts of the accessible alluvial land of the extensive floodplains were subjected to very heavy grazing and now exhibit quite serious degradation problems.

The most marked changes have been in the floodplains and tributary drainage plains. Productivity has suffered, habitat has been lost, rainfall infiltration has been lowered and there is scant prospect of the situation being reversed. Invasions of buffel grass on the sandy banks of some of the floodplains have restored some of the productivity but have, at the same time, permanently altered the floristic composition of these lands, the native grasses and shrubs being largely suppressed by the fiercely competitive exotic grasses.

The coastal dunes are fragile and subject to erosional forces. Their continued uncritical use for pastoral purposes should be questioned, along with the unsupervised use resulting from tourist pressure. Significant blowouts on the coastal dunes are of concern as their containment will be difficult. They are particularly numerous on the south west of the island and already exhibit a tendency to migrate across the island.

Carnarvon

This bioregion has low gentle undulating relief and open drainage. The coastal areas are semi-desert with winter rainfall and Shark Bay has a Mediterranean climate. Further inland, the climate is arid with winter rainfall. It is dominated by other shrublands in the south and hummock grasslands, tussock grasslands and chenopod and samphire shrublands in the north. Acacia shrublands, acacia forests and woodlands occur throughout the region. The major land uses are sheep grazing, minimal use (vacant crown land, other reserved crown land, reserved crown land - defence reserve) and some nature conservation (Shark Bay World Heritage Area).

The Carnarvon Basin, stretching between Exmouth Gulf and Shark Bay and occupying the land west of the Kennedy Range, includes most of the catchments of the Lyndon and Minilya Rivers and the mature reaches of the floodplains of the Gascoyne and the Wooramel. It includes both Dirk Hartog and Faure Islands.

Although potable and stock water supplies were difficult to obtain, recourse having to be made on the coast to artesian supplies at great depth, the area was opened up in the 1870's and by 1900 there were 500 000 sheep in the area. Not surprisingly, large tracts

of the accessible alluvial land of the extensive floodplains were subjected to very heavy grazing and now exhibit quite serious degradation problems.

Payne et al (1987) show that 44 per cent of the very high quality pastoral land and 26 per cent of the high quality pastoral land is now in poor range condition. The most marked changes have been in the floodplains and tributary drainage plains. Productivity has suffered, habitat has been lost, rainfall infiltration has been lowered and there is scant prospect of the situation being reversed. Invasions of buffel grass on the sandy banks of some of the floodplains have restored some of the productivity but have, at the same time, permanently altered the floristic composition of these lands, the native grasses and shrubs being largely suppressed by the fiercely competitive exotic grasses.

The coastal dunes throughout the Carnarvon Basin area are fragile and subject to erosional forces. Their continued uncritical use for pastoral purposes should be questioned, along with the unsupervised use resulting from tourist pressure. Significant blowouts on the coastal dunes are of concern as their containment will be difficult. They are particularly numerous on the south west of the island and already exhibit a tendency to migrate across the island.

Gascoyne

This bioregion is characterised by low rugged sedimentary and granite ranges and broad flat valleys. The bioregion experiences very hot summers and warm winters. Rainfall is erratic and unreliable. It is dominated by acacia shrublands and acacia forests and woodlands. Other shrublands and acacia open woodlands, salt lakes and chenopod and samphire shrublands occur in the west. The major land uses are cattle and sheep grazing with smaller areas of minimal use (vacant crown land, other reserved crown land, reserved crown land - Aboriginal reserves), traditional Indigenous uses and nature conservation.

A large percentage of the area consists of rocky uplands and spinifex pastures, which are inherently resistant to erosion and degradation. In common with many other surveyed areas degradation is widespread on the more accessible tracts. These are mainly the alluvial plains, but an extremely fragile stony upland in the west was also found to be severely degraded.

Several of the rocky upland landforms contain inclusions of better watered and fertile units. The soils are inherently susceptible to erosion once the cover of the perennial plants is removed. Under the heavy grazing pressure these units received, the perennial components of the vegetation were almost immediately removed. In consequence, the units today may be wind-scalded or sheeted, rilled and guttered and lack any perennial cover capable of conferring stability and creating habitat for wildlife.

Little Sandy Desert

This bioregion consists of dunefields and ranges with an arid climate and summer rainfall. It is dominated by hummock grasslands and acacia forests and woodlands with very small areas of acacia shrublands, chenopod and samphire shrublands, eucalypt woodlands and heath. The major land uses are minimal use (vacant crown land, some other reserved crown land, reserved crown land - Aboriginal reserves) with some nature conservation.

This region has not been subject to prolonged grazing pressure. In general terms it is in fair range condition, exhibiting few of the scars of erosion and neglect found in the remaining pastoral areas. The effects of fire regimes has led to some changes in perennial and annual species.

Gibson Desert

The bioregion is characterised by vast undulating sand plains, dune fields, low rocky ridges and uplands with an arid climate and mainly summer rainfall. It is dominated by hummock grasslands with some acacia shrublands, acacia forests and woodlands and other grasslands group in the southern part. The major land uses are minimal use (vacant crown land, reserved crown land - Aboriginal reserves), traditional Indigenous uses and nature conservation.

This region has not been subject to prolonged grazing pressure. In general terms it is in fair range condition, exhibiting few of the scars of erosion and neglect found in the remaining pastoral areas. The effects of fire regimes has led to some changes in perennial and annual species.

APPENDIX 2 IBRA Sub-regions of Western Australia's rangelands, their area and landscape stress rating

(from National Land and Water Resources Audit, Landscape Health in Australia Database 2001)

Sub-Region	Bioregion	Area (ha)	Landscape Stress rating
	Carnarvon		
CAR1	Cape Range*	2 352 970	3
CAR2	Wooramel*	6 023 915	3
	Central Kimberley		
CK1	Pentecost	4 397285	5
CK2	Hart	2 324 678	5
CK3	Mt Eliza	953 656	6
	Coolgardie		
COO1	Mardabilla	1 843 082	5
COO2	Southern Cross	6 010 675	4
COO3	Eastern Goldfield	5 058 123	5
	Central Ranges		
CR1	Mann-Musgrave Block (WA/SA)	9 178 178	6
	Dampierland		
DL1	Fitzroy Trough	3 429 588	4
DL2	Pindanland	4 941 545	6
	Gascoyne		
GAS1	Ashburton*	3 686 853	3
GAS2	Carnegie	4 718 577	5
GAS3	Augustus	9 669 376	4
	Gibson Desert		
GD1	Lateritic Plain	12 714 687	6
GD2	Dune Field	2 914 090	6
	Geraldton Sand Plains		
GS1	Edel* (borders intensive land use zone)	183 710	3
	Great Sandy Desert		
GSD1	McLarty	12 316 702	5
GSD2	McKay (WA/NT)	26 737 944	5
	Great Victoria Desert		
GVD1	Shield	4 741 619	6
GVD2	Central	12 590 678	5
GVD3	Maralinga (WA/SA)	11 431 690	6
GVD4	Kintore	4 944 136	5
	Hampton		
HAM	Hampton	1 087 185	6
	Little Sandy Desert		
LSD1	Rudall	991 275	6
LSD2	Trainor	10 098 549	6
	Murchison		
MUR1	Eastern Murchison*	21 134 564	3

MUR2	Western Murchison	6 985 342	3
	Northern Kimberley		
NK1	Mitchell	5 942 702	6
NK2	Berkeley	2 446 279	6
	Nullarbor		
NUL1	Carlisle (WA/SA)	5 788 573	6
NUL2	Nullarbor Plain (WA/SA)	12 782 569	6
	Ord Victoria Plain		
OVP1	Ord (WA/NT)	3 236 695	6
OVP2	South Kimberley Interzone (WA/NT)	7 729 584	4
	Pilbara		
PIL1	Chichester	8 375 074	4
PIL2	Fortescue	1 875 468	4
PIL3	Hamersley	5 710 564	6
PIL4	Roebourne*	1 891 818	3
	Tanami		
TAN1	Tanami P1 (WA/NT)	20 772 903	5
	Victoria Bonaparte		
VB1	Victoria Bonaparte P1 (WA/NT)	6 407 405	4
	Yalgoo		
YAL	Yalgoo	4 895 256	4

Note:

1. Bioregions and sub-regions that straddle State borders are noted. Only those Bioregions and sub-regions that are partly or wholly within Western Australia are included.

2. *These sub-regions demonstrate the highest levels of landscape stress. A landscape stress rating of 1 indicates highest stress, and a rating of 6 indicates lowest stress.

3. For comparison purposes, a rating of 1 was attributed to cleared and cropped areas of the intensive use zone such as the wheatbelt, and a 2 or 3 rating was attributed to the Swan Coastal Plain. The most stressed areas of the extensive land use zone, with a rating of 3, are the coastal bioregion of the Geraldton Sand Plains, which borders on the intensive use zone, coastal Carnarvon and Pilbara and inland Gascoyne and Murchison bioregions.