FIRST RELEASE

WANPARA

Western Australian Environmental Review 1986

(On behalf of)

R G Chittleborough • F M Keating

September 1987

NOTES ON THIS UNAUTHORISED PUBLICATION

The following review was originally written for the Department of Conservation and Environment, in December 1986. It was, however, never published for general public consumption - due in part perhaps to the sensitivity of some of the observations made. This situation played a substantial part in the subsequent resignation from the department of the principal author, Dr Grahame Chittleborough.

The review has great value in providing an understanding of the current West Australian natural environment, and the nature and magnitude of the problems facing it. The review should be public property.

Consequently, a group of concerned citizens has decided to reproduce the report, on behalf of the authors, as a public service. **The authors have played no part in this action and must bear no responsibility.**

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WESTERN AUSTRALIAN ENVIRONMENTAL REVIEW 1986

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December 1986

PREFACE

A pre-requisite to shaping a State Conservation Strategy which sets out pathways that might be taken through future decades, is to assess where we are now; ie., to review the present state of our environment in each of its many facets.

Taking up the formidable task assigned to us, the authors have sifted through a wide range of publications and reports and sought the help of a large number of specialists experienced with various facets of the State's environment and natural resources.

Draft sections have been passed to a widely representative Consultative Committee for comment. Although this process of consultation often elicited further relevant data, it also underlined the differing viewpoints of the varied user groups.

While acknowledging input from many individuals, the authors take full responsibility for the integration of the material into this overview of the environment of Western Australia as a whole.

R G Chittleborough

ACKNOWLEDGEMENTS

Comments and criticisms of draft material were made by the widely representative Consultative Committee for the State Conservation Strategy. Particular mention should be made of the detailed responses contributed by representatives of the following: Department of Agriculture, Chamber of Mines of WA, Conservation Council of WA, Department of Mines, The Tree Society Inc., WA Naturalists' Club.

In addition to those individuals listed in the References, detailed information or draft material was readily given by Dr J M Arnold, J D Blyth, R J Guyton, R A Harvey, K J McNamara, Dr G A Robertson, B S Sadler, Dr K L Tinley, and D G Wilcox.

Coralie McDavitt of the Conservation Strategy core group helped to keep up the flow of material during this process of assembling an environmental review.

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EXECUTIVE SUMMARY

Western Australia's relatively small population lives in a varied environment of limited carrying capacity. The climate is Mediterranean in the Southwest, with wet winters and hot dry summers; in the North it is tropical with mild winters and cyclonic summers. Over most of the State arid and semi-arid conditions prevail, with erratic rainfall and drought. Western Australia's lands are largely salt prone and of very low fertility. Nevertheless, the State is richly endowed with plants and animals well adapted to these conditions. Many species are endemic, particularly within the Southwest region. While of high diversity and appeal, some natural ecosystems in Western Australia are very fragile.

Major land uses such as grazing, agriculture, urbanisation and industrial development are diminishing species diversity throughout the State; in some localities essential ecological processes continue to be disrupted. In the wheatbelt approximately 60 percent of the species of medium sized mammals have disappeared since European settlement. From more than 7,000 native vascular plant species recorded in Western Australia, 1,024 species are listed as rare or threatened, 83 percent of these being from the Southwest.

Wildlife conservation is achieved essentially through the protection and maintenance of habitat. National Parks and Nature Reserves established throughout the State make an important contribution toward this objective. More recently steps have been taken to designate marine parks and reserves along the coast. Considerable progress has been made for wildlife conservation in Western Australia, although further effort is required to protect and manage a full range of ecosystems and wildlife. The value of natural vegetation and fauna outside formally dedicated parks and reserves also need further recognition.

Introduced species of fauna compete with native animals for food, habitat or breeding sites, while exotic plants compete with native flora across much of the State. Increased availability of water has enabled a rise in the population of some species of both introduced and native fauna. In some areas of Western Australia this is of environmental concern.

The forests of Western Australia have a rich assemblage of flora and fauna but are generally identified by the two principal commercial species, karri and jarrah. Management of the karri forest is moving toward sustained yield; the situation with jarrah is less clear. The issues of clear-felling and the export of woodchips require further attention. Hardwood timber resources in the State's forest are insufficient to meet local demand so that Western Australia is a net importer of timber. There is growing pressure for both hard and soft wood plantations to be located on under-utilised agricultural land to relieve demands on native forests.

Jarrah dieback (*Phytophthora cinnamomi*) has affected some 13 percent of jarrah forest. Within State Forest, hygiene and other management procedures are considered effective in substantially reducing the spread and impact of the disease. However, activities within State Forest, National Parks and other areas in the Southwest, which have been shown to spread dieback continue to be of major concern due to the potential of the disease to destroy entire populations of endemic species.

Farming practices such as the introduction of legumes and the addition of trace elements have greatly increased productivity of some agricultural lands. However, modern farming is dependent on a high energy subsidy to our food production. Moreover, only 30 percent of land cleared for agriculture can be regarded as stable. Despite improved awareness and success in specific cases, such as stablisation of wind erosion in the Northeast wheatbelt, soil degradation is a continuing problem for much of Western Australia.

Approximately 23 percent of pastoral lands in Western Australia are in bad condition. Loss of vegetation and soil erosion in these areas has been caused by the grazing pressure of stock, as

well as feral and native fauna to varying degrees. Sound rangeland management involves controlling stocking rates and the populations of feral animals, along with regeneration programmes.

Availability of water resources has been and will continue to be a major determinant in the geographic pattern of settlement in Western Australia. In the Perth-Mandurah region the community's needs for water are met by a combination of surface storage (approximately 40 percent) and groundwater sources (60 percent). Currently one half of the region's water resources are allocated. Natural aquifers have provided the main source of water in the North, while people living in more arid areas rely on small localised groundwater occurrences. Groundwater resources are often linked to valuable wetlands. The community has to recognise the need for managing these limited resources on a sustainable basis.

Widespread salinisation of streams in the Southwest due to clearing of native vegetation in catchments has caused ecological damage and led to a loss of 36 percent of the estimated original fresh water resources. Progress is being made in stabilising selected catchments, but no significant advances have been made in rehabilitating seriously degraded catchments. Silting of streams is frequently associated with loss of vegetation in catchment areas.

Leaching and run-off of fertilizers from agricultural land on the coastal plain is an increasing problem leading to pollution of estuaries and wetlands in the Southwest. Nutrient enrichment affects many water bodies in this region including Wilson Inlet, Oyster Harbour and particularly the Peel Inlet. Remedial measures will be problematic and expensive.

Western Australia's coastal waters, though generally low in nutrients and hence productivity, support valuable commercial fisheries. Most of the commercial fish resources are already fully utilised, with the major fisheries being over-capitalised. Measures to control the level of fishing intensity include limiting fishing licences, gear restrictions, minimum sizes, quotas and the proclamation of fishing seasons and zones. While these measures have had some success, there is still a need to reduce the number of units fishing.

Beaches along the Western Australian coastline are used extensively by the community. The coastal zone in many places is fragile and easily damaged by human use. Consequently, access to and development of these natural systems must be carefully managed to avoid serious environmental damage. The long term prospects of rising sea level warrants attention in future planning of coastal use.

Mining occurs throughout Western Australia, impacting to varying degrees on a range of natural environments. These impacts are now being lessened by the increasing application of environmental management principles and controls.

Generally, air quality in Western Australia is excellent although localised problems occur due to burning of fossil fuels containing sulphur and from smelting and roasting operations. Dust problems also arise locally from degraded land and particular industrial activities. An occasional widespread air quality problem is that of smoke from fires, including deliberate burning off.

Perth, presently containing more that 70 percent of the State's population, has successfully retained many attractive features. However, strategies effective so far in guiding rapid growth and urban spread may warrant modification as the city matures. For example, proposed developments affecting the small remaining proportion of biologically productive wetland systems should be reconsidered.

While a range of density options are available, each with their own benefits and demands, most metropolitan people continue to occupy "quarter-acre" blocks. This places heavy demands on limited water supplies (with some 80,000 private bores), adjacent cultivated lands, residual wetlands and other natural areas. It also results in high costs for transport and other services, and places a heavy reliance on private cars. Alternatives include areas of urban consolidation with nodes of well planned medium-density living connected by efficient transport systems.

Effective urban planning affording a range of housing densities could provide varied lifestyles and more efficient resource use.

Although smaller than Perth, regional urban centres also affect the local environment. New towns recreating suburban forms have been built as part of resource developments in the Northwest to satisfy community expectations. This places pressure on limited resources.

Overall, Western Australia has accumulated an environmental debt which will have to be met by the community if we are to restore sustainability. Those involved in using or managing the environment, whether public or private, are generally aware of the causes of the problems. However, until community awareness recognises the need for further remedial action only the symptoms can be addressed

There is much scope for increased involvement of the community in planning a sustainable future, and for strengthening an environmental ethic by which individuals recognise their responsibility for stewardship of our environment; an ethic which sees conservation and development as mutually dependent activities within the system of which we are a part.

1. INTRODUCTION

The production and adoption of a conservation strategy for Western Australia is a logical progression from the widely ranging World Conservation Strategy [1] to the National Conservation Strategy for Australia (NCSA), [2] and then to a State Conservation Strategy pertinent to our local requirements.

A pre-requisite to the forward planning involved in a State Conservation Strategy for Western Australia is to review the present condition of our environment and natural resources, including an assessment of the effectiveness of our management efforts to date. Society's attitudes and pressures must also be seen as an inextricable part of a State Conservation Strategy since the values and lifestyles of a particular society largely determine the quality of the environment in which it lives.

The Terms of Reference for the preparation of a WA State Conservation Strategy require:

> "From the review already prepared (DCE Report No 12) [3] and other material, to summarise the present condition of each facet of our environment within this State."

Some of these facets have been reviewed adequately in recent years to enable highlights to be summarised; for other aspects there was little up to date information readily available in a form directly pertinent to local problems and needs. In order to widen the baseline of local data upon which to draw, a number of people were approached and invited to prepare review papers on selected topics (DCE Bulletins 207 [4] and 251 [5]).

A State of the Environment Report is an integral part of the development and implementation of a State Conservation Strategy. Learning from past impacts and better understanding the capabilities of the systems upon which the community depends will enable more soundly-based future planning.

This report examines available information on the state of the Western Australian environment, and establishes considerations for the development of a definitive State Conservation Strategy. However, this review should be seen as part of an on-going process. Regular reviews of the state of the environment are necessary for monitoring trends in environmental quality, and to provide an assessment of the effectiveness of resource management in meeting defined objectives.

2. LIFE SUPPORT SYSTEMS

2.1 SOILS

Much of Western Australia has sandy soils which have a low water-holding capacity. (3) Although the soils are generally poor in nutrients, the productive capacity in farming areas has been raised by fertilizers and the use of legume-based pastures. (3) However, it is now apparent, that "some soils have been cleared which are not capable of sustaining agricultural production under present systems". (Ref 3 p 83). Moreover the clearing of some areas has resulted in unacceptable degradation off-site.

Soil degradation including problems of wind erosion, water erosion, structural deterioration, compaction, acidity, water-logging, flooding and salinisation are now occurring throughout the State in varying degrees.

Wind erosion occurs widely and is regarded as the most severe erosion problem in the State.(3) Serious problems of wind erosion affected the eastern and northern wheatbelt area and the southern coastal plain (3) particularly in the late 1970s and early 1980s. However, land users are now more aware of the wind erosion hazard, and management systems have evolved to reduce or avoid the problem. Of particular note in this regard has been the development and adoption since 1980 of the lupin/cereal stubble systems on the northern sandplain. It has virtually eliminated wind erosion as a problem in that area.

Water erosion problems are most acute in the summer rainfall region of the State (3), but widespread water erosion has also occurred in the winter rainfall areas with a frequency of once every seven years since 1945. Trials have shown that the loss of only 4 mm of top soil results in a decreased wheat yield of ten to 20 per cent. In the winter rainfall region, it is likely that the risk of water erosion has increased in the inner agricultural areas due to increased cultivation in the high rainfall areas, but decreased in the outer agricultural areas due to the low incidence of fallowing, the widespread adoption of minimum tillage and reduced stock numbers.

Adoption of structural works designed to decrease water erosion has been slow in Western Australia. However, adoption of cost effective management practices such as minimum tillage has been remarkable in recent years. The development of Soil Conservation Districts should provide a facility to more quickly develop and implement solutions to soil degradation problems.

Many Western Australian soils are becoming more difficult to cultivate and significant productivity losses are occurring due to a decline of soil structure (6) in heavy soils, and widespread traffic-induced compaction in light soils. Loss of soil structure is probably the least obvious form of soil degradation, but may become the most important in terms of extent and severity across soil types and climatic zones within the State. Research has been intensified in these areas recently, and systems are being developed to minimise and repair damage.

In addition, the nitrogen status of Western Australia's agricultural soils is declining. (3) The use of nitrogen fertilizers and legume nitrogen fixation may result in a gradual increase in soil acidity. Further research needs to be carried out on the rate of acidification of Western Australian agricultural soils and on methods of overcoming it.(3)

Seepage-salting resulting from rising water tables within naturally saline and sodic soils as a result of the removal of deep-rooted plants in recharge zones, is a most urgent problem in the Southwest of Western Australia. (3) This affects, almost exclusively, the better class arable land.

Since agricultural development commenced, two percent (300,000ha) of once-arable land has become non-productive due to secondary salinity and the area affected by salinity is continuing to increase. Soil salinity has been estimated to have cost this State $120 million in terms of lost resources, and an annual cost of more than $50 million.(3) In addition to the direct effects, salinity has greatly diminished potential potable water supplies. Most of the Southwest rivers have become salinised such that the water is no longer suitable for domestic, industrial or irrigation uses, (7) and natural ecosystems have been adversely affected.

"In Western Australia wind erosion, water erosion, soil structure decline, salinity, waterlogging, non wetting and vegetation decline are all significant. Preliminary estimates suggest that farmers in the low and medium rainfall

areas are losing annually $38 million to wind erosion, $19 million to water erosion and waterlogging, $11 million to soil structural decline and $26 million to salinity. Off-site costs associated with many of these problems would be significant." (8)

"Only about 30 percent of the 17 million hectares of land cleared for agriculture in Western Australia's farming areas can be regarded as 'stable' (Ref 7 p 27). The remainder are affected to varying degrees by forms of soil degradation caused by land clearing, (7) and require special care and improved or new land management practices." (6)

Overgrazing of pastoral lands has resulted in vegetation degradation and soil erosion. Salt scalds in arid and semi-arid regions of the State presently extend over 335,000ha, particularly in the pastoral areas of the Murchison, Ashburton, Gascoyne, and the river flats of the Kimberley and Pilbara regions.(9) Overall, more that 20 percent of pastoral lands are in need of special management (see Section 3.4), including vegetative rehabilitation. In some localities, colonisation by non-indigenous pasture species has stabilised the soil, if changing the ecosystem.

Degradation of vacant Crown land due to uncontrolled recreation and mineral exploration activities has been barely monitored. Damage is not thought to be widespread, but in some cases it is known to be extensive.

Land degradation is recognised as a major and growing problem is Western Australia. Although generally considered to apply to agricultural and pastoral lands, the problem is in fact very broad and affects to some extent all land being used for productive and recreational purposes.(8) Despite effective efforts in specific localities, much more needs to be done to arrest continuing deterioration and to restore soils presently degraded. Many of the difficulties are economic rather than technical. While some of the more obvious types of degradation could now be avoided, better understanding of the subtle processes (eg compaction and increasing acidity) and their economic effects is required.

The serious condition of our soils across Australia has been stated clearly in the final report of the Interim Consultative Committee for the National Conservation Strategy for Australia. (10) "Land degradation in Australia is a national problem of major proportions and immediate urgency, which threatens severe economic, social, ecological, and in time political, consequences. In NCSA terms, it is unquestionably the foremost example of insufficient attention to ecological principles leading to resource use and development that cannot be sustained." (Ref 10, p 51).

2.2 WATER

A major portion of Western Australia is arid or semi-arid, subject to erratic rainfall and drought. Plant and animal communities were adapted to these conditions, as were tribal Aborigines. All were stressed from time to time through lack of water and associated pressures.

With the advent of European settlement a new set of stresses were superimposed on those already operating. The overall demand for water increased. In a few instances, actions to increase the availability of surface water were to the advantage of native fauna (see Section 3.8), but in general the additional pressures overloaded the already stressed native communities.

For the new settlers, water deficiencies have been a major determinant in the geographic pattern of development. Immediate demands for water have been met, though at a cost to the environment. With the current distribution of human population and water demands, no region of the State is considered to be near a threshold of critical supply problems at present. (11) However, while overall there may be sufficient consumable water for each region, a number of areas within regions may become or are short of usable water, and specific localities can experience difficulties in obtaining good quality water at reasonable cost. These problems may widen as Western Australia's population continues to grow, particularly in the Southwest.

The total annual consumption of water by the present population of Western Australia is 836 million cubic metres. (11) This is utilised for urban and industrial uses (53 percent), for irrigation (40 percent) and other rural use (7 percent). In the Perth-Mandurah region the community's needs for water are met by a combination of surface storage (approximately 40 percent) and groundwater sources (60 percent). (11) Projected growth in demand for water over the next 30 years can be met, though at increasing costs (both economic and environmental). There will be increasing problems of allocation, in resolving competing interests, and in conserving future

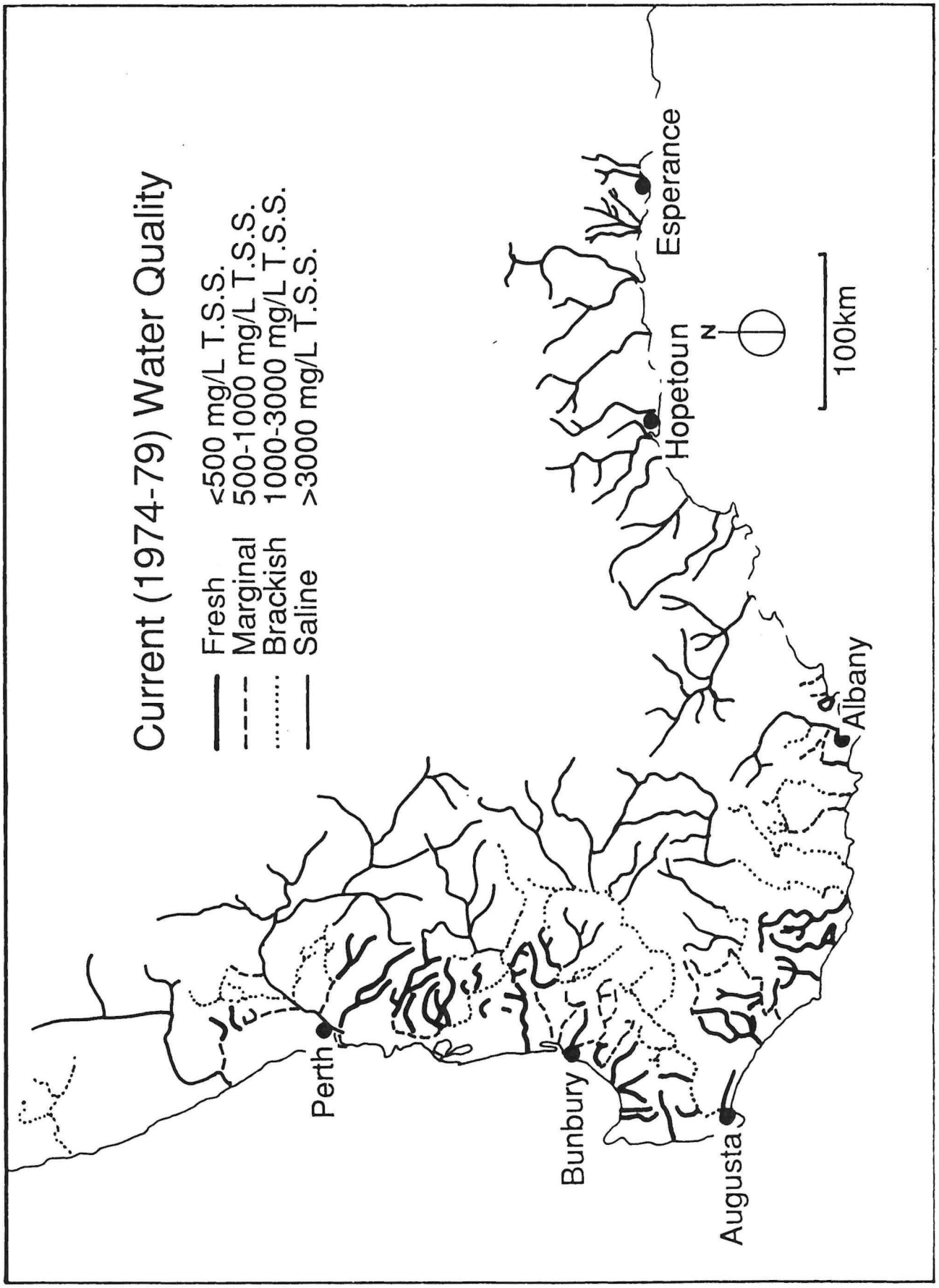

Figure 1. Salination of Streams in the Southwest Region.

options. Measures will be required to improve the efficiency of water use and to arrest the degradation of the water resources available.

Before European settlement all streams in the Southwest were probably fresh during the winter flows, with occasional brackish spates. However, after clearing the natural vegetation for agriculture, both the runoff and the salt yields have increased to such an extent that the flows in some major rivers are now saline throughout their length, while others are brackish (Figure 1).

Dryland salinity is now the most serious problem affecting water resources in Western Australia. Increasing salinity of streams in the Southwest of the State has "effectively resulted in a loss of 1000 million cubic metres per annum of potable fresh and marginal) divertible water or 36 percent of the estimated original total. Though it occurs elsewhere in Australia and in other countries, dryland salinity constitutes a greater water resource problem here in Western Australia than anywhere else in the world as far as is known". (Ref 3 pp 60-61).

Control strategies are now in place for the catchments of streams still within the potable limit (less than 1000 mgL^{-1}). These measures are based on the following principles: (12)

- protection of dedicated State Forest;
- prohibition on the release of Crown Land over a major portion of land in the Southwest;
- clearing controls for both freehold and Crown Land within proclaimed catchments; and
- limitations on bauxite mining until proven safe by research in potentially saline areas.

If these strategies can be maintained they are expected to contain further degradation of water quality of those streams still usable for water supply. They do not address the problems of dryland salinity in the catchments of rivers already brackish or saline (ie exceeding 1000 mgL^{-1}). Further action directed towards more fundamental salinity control is still needed, particularly those measures which can be beneficial to landholders in contributing areas. Salinity control and management will persist as one of the primary problems in future environmental management of water resources within Western Australia.

Water used for irrigated agriculture is estimated as 325 million cubic metres per annum. Most of the water is used in the Southwest division (70 percent), comprising some 22,000 hectares of irrigated land. The issue of major concern in the public irrigation districts of the southwest is rising groundwater levels and associated problems of salinity, particularly in the Collie district.(13) Investigations have commenced into means, costs and benefits of controlling groundwater levels.

Groundwater resources on the Swan coastal plain have also come under increasing environmental pressure over the last decade. (11) The pressures have resulted from rapid development in private usage and from land use in recharge areas. In certain portions of the metropolitan area of Perth the overall rate of abstraction of groundwater (public plus private bores) may be close to the sustainable yield. (13) Groundwater pollution caused by industrial discharges and sewage effluent is apparent in parts of the Perth coastal plain, particularly in the section of the unconfined aquifer in the coastal strip from Kwinana to Cockburn. Linked with the groundwater system are a (diminishing) number of shallow lakes important as wildlife refuges, (14) and as recreational resources.

Extraction of groundwater is regulated to some extent in certain areas of Western Australia, with other districts to be declared as and when needed. Such regulation and rationalisation is necessary to prevent damaging overdraw by competing users, to maintain remaining wetlands, to avoid saltwater intrusion, to protect recharge areas and to control incipient problems of groundwater pollution.

Non point-source pollution is becoming a problem in estuaries and coastal waters, the leaching of nutrients (especially phosphorus) from agricultural land being a major factor causing eutrophication (3) in the Southwest of the State. Western Australia also has localised problems of pollution in coastal waters as a result of discharges of industrial and urban wastes (3) (see Section 3.11). Legislation has not been adequate to manage these problems, but is being revised.

Western Australia is insulated from most forms of interstate and international problems affecting water resources such as external demands or acid rain. One exception is long-term man-induced climate changes resulting from increasing atmospheric carbon dioxide. (4) There is a need for long-term planning to accommodate these changes and also for the State to maintain a watch on studies into this phenomenon.

The WA Water Resources Council has been formed as a statutory council to give direct advice to the Minister for Water Resources and to directly influence the breadth of outlook taken by the Water Authority in management of the State's terrestrial water resources. The Council has a set of management objectives to guide the development of water resource management policies in Western Australia. (15)

The newly formed Water Authority of Western Australia has been given comprehensive objectives and charter for achieving integrated management of the State's water resources. This is being developed towards comprehensive planning and management for all beneficial uses of water. Sustainability and environmental objectives will be given high priority, together with community demands, in all water resource use decisions.

Several immediate actions are planned or taking place which are relevant to an environmental strategy for water conservation. Notable among these is the initiation through the Western Australian Water Resources Council of a State water planning activity. (16) This planning activity is being developed as a comprehensive and publicly visible process setting guiding strategies on priority issues decided within a wider State context.

Although environmental and recreational values of waterways and wetlands are now gaining increasing attention in tactical planning and management of water resources there is a need for greater integration of these uses with traditional water supply interests in strategic planning. Some initiatives of this kind include the Western Australian Water Resources Council's recent review of recreation on reservoirs and catchments. (17) One weakness has been the lack of clearly defined criteria by which to determine acceptable levels of environmental protection of wetlands. This is being rectified. Greater progress on establishing criteria may be feasible as strategic planning of beneficial use allocation proceeds for the State's water resources.

Further harnessing of water resources for consumptive uses will involve high financial and environmental costs, and will interfere with other uses, including the maintenance of aquatic ecosystems. Because of the competing claims for water and the environmental effects of large scale water supply augmentation projects, future water resource management should give increasing attention to demand management, in preference to developing 'new' sources of supply (see Section 4.2). Measures to reduce wastage and more efficiently utilise water could be adopted by all sectors of the community including domestic, irrigation and industrial users.

Flood plain management is a problem which is growing in magnitude with increasing land development. The populated Southwest region has the potential for rare but catastrophic floods. Clearing of land and urbanisation within the catchment accelerates the rate of runoff and leads to higher flood peaks for a given rainfall. (3) Conditions conducive to flooding also exist in the northern region of Western Australia.

While future water management will closely consider public attitudes, the need for informing the community of the full consequences of conflicting demands on our resources is recognised. Education should generate in the community an appreciation of multiple uses of water, ensuring that the quality of life is maintained.

2.3 AIR

> "Generally, air quality in Western Australia is excellent, mainly because of the low level and localised nature of industrial development, and the small population. Nevertheless, in spite of the great natural advantages of isolation and weather patterns, air pollution does occur in Western Australia." (Ref 3 p 67).

One of the more widespread air quality problems which arises from time to time is that of smoke from fires (including deliberate burning off). Particular problems emerge when plastics are burnt with domestic wastes.

Motor vehicle emission controls introduced in recent years have decreased emission of pollutants per vehicle. The phasing-in of unleaded petrol will afford further improvement in vehicle emissions, though the rate of increase in traffic necessitates further monitoring of air quality within Perth.

Localised air pollution occurs as a result of burning of fossil fuels containing sulphur and from smelting and roasting operations.(3) Dust problems also arise from degraded land and particular industrial activities.

Air pollution is controlled under the Clean Air act. Air quality management in Western Australia has traditionally focused upon industrial sources of pollution, with an emphasis on the protection of human health.(3) New legislation (in preparation) should provide the opportunity for effective control from non-industrial sources. There

should also be an increased emphasis on the protection of flora and fauna from air pollutants and on the maintenance of an aesthetically pleasing atmosphere.

The Department of Conservation and Environment has recently assumed responsibility for air quality management in Western Australia. Planned activities include the formulation of emission and ambient air quality standards. In addition to regular inspection of licensed premises, DCE will monitor ambient levels of pollutants to determine whether control strategies are achieving their objectives and to provide information to the public on ambient pollution levels.

The DCE has also recently assumed responsibility for administration of the Noise Abatement Act. The Noise Abatement Regulations ensure standards for control of environmental noise. Action on noise has so far been concerned mainly with the work place, but there has been a recent commitment to move on traffic noise.

One aspect of changes to our life support systems requiring consideration in long-term environmental strategies, is the effects of global increase in atmospheric carbon dioxide, largely due to the rapid increase in combustion of fossil fuels since the middle of last century. Although this is essentially a global problem requiring international action, Western Australia could address the issue by reducing fossil fuel consumption and through revegetation programmes. In addition, local adaptive planning to meet the anticipated climatic changes can be effective. [4]

3 NATURAL RESOURCES AND THEIR USAGE

3.1 ABORIGINAL LANDS

The cultural heritage of the State and human use of the resources did not begin only 150 years ago but extends back 40,000 years or more. (18) During this period Aboriginal people refined and adapted their culture to the local environment, (19) achieving a oneness with the land that was largely sustainable and a quality of life that caused Captain Cook to remark that "in reality they are far happier than are Europeans". (20)

Protection and preservation of Western Australia's Aboriginal heritage are in part an appreciation of the special view of the natural environment held by Aborigines. In Aboriginal terms it is difficult, if not impossible to make a clear distinction between the natural environment and cultural aspects. Aboriginal use of the environment is surrounded by rules, prohibitions and observances which are culturally transmitted from one generation to the next. The environmental features which we characterise as Aboriginal "sites" represent the broad spectrum of these views of and interactions with nature. (18)

Aboriginal people have occupied all parts of the State, leaving evidence in the forms of a variety of sites. The natural environment contains physical evidence of Aboriginal utilisation of the land and its resources. Throughout the State there is archaeological testimony to Aboriginal use of a variety of habitats in the form of campsites, middens, quarries, fish traps and other material evidence. Natural features including hills, watercourses, trees, boulders or other physical features may have mythological or religious significance to Aboriginal people. Both mythological and archaeological sites form an important aspect of the cultural heritage of Western Australia and of human use of its resources. (18) Many of these sites continue to be important to Aboriginal people for religious or sociological reasons.

The principal legislation designed to extend protection to Aboriginal sites in Western Australia is the Aboriginal Heritage Act 1972-80, which defines Aboriginal sites in a broad sense. All Aboriginal sites are protected by its provisions. Federal legislation which also applies to Aboriginal sites in Western Australia include the Australian Heritage Commission Act 1975 and the Aboriginal and Torres Strait Islander Heritage (Interim Protection) Act 1984.

The Department of Aboriginal Sites at the WA Museum is presently responsible for the administration of the Aboriginal Heritage Act. Over the past decade the Department has been under increasing pressure to examine the potential impact of development proposals such as mining and exploration, road building and townsite development on Aboriginal sites. (18) A number of specific site conservation projects have been initiated, but resource constraints have prevented the development of a long-term conservation strategy.

It is timely to consider a review of Aboriginal heritage protection in consultation with Aboriginal communities in Western Australia. The Aboriginal Heritage Act is in need of amendment to meet present requirements, while heritage and living resource conservation could benefit from a clear association at the level of policy making and field action. (18)

There is evidence to suggest that, during their 40,000 years of occupation, Aboriginal people modified the environment to some extent and it is apparent that their activities brought changes to the vegetation and landscape. (20) However, the impact of Aboriginal use of the land is not considered to have been large.

It is unfortunate that Aboriginal views on management of the land, which had been developed over many thousands of years and which constituted a large body of first-hand knowledge, have been largely ignored by Europeans since their settlement. (21) A bilateral exchange of information between Aborigines and Europeans regarding land management techniques could benefit the management of all natural lands. The Department of Conservation and Land Management and Aboriginal communities are working together on this matter.

Many Aboriginal people still live on or near their traditional land, and retain a great deal of their traditional knowledge about the natural environment. For example, Aboriginal people continue to hand down through the generations an immense body of knowledge relating to plant uses. (22) However, this knowledge is increasingly being lost to time. Today, Aboriginal communities no longer practice in any complete sense traditional land use, as elements of European technology have been adopted. (19)

Most of the land which Aborigines currently use and occupy in Western Australia is vested in or controlled by the Aboriginal Lands Trust (ALT), a statutory body which is serviced by the Aboriginal Affairs Planning Authority.(21) Land currently administered by the ALT totals approximately 20,612,000 hectares. The major type of holding is reserve land located largely in arid areas adjacent to the Northern Territory and South Australian borders. Other major reserves are located in the Kimberley, Pilbara and Eastern Goldfields, with a large number of small reserves situated within towns and agricultural regions. In addition, the ALT is responsible for 18 freehold properties (3,640 hectares), six leasehold properties (57,512 hectares) and seven pastoral leases (1,564,700 hectares).

Most of the reserves, pastoral leases and freehold areas are leased to or occupied by Aboriginal communities although a smaller number, mainly in towns, are leased to individuals or family units. The land may be used for residential purposes, enterprise activities or a wide variety of social, cultural or recreational purposes. (21)

Generally, Aboriginal land in Western Australia is only marginally managed in any sense of conservation. (21) Following European settlement there was a breakdown of the social and cultural structures of Aboriginal society and consequently a reduction in long-established land management practices. Aboriginal community groups continue practices such as burning off in many areas, but large areas can no longer be managed in this way. Over the last decade there has been a marked increase in the outstation or homeland movement which has seen a movement of relatively small (5 to 50 members) family groups away from towns and larger artificial communities. With the establishment of this network of small, widely-spread groups, management of Aboriginal land is entering a new phase, and it may be possible to widen the area included in planned burning off. (21)

Very little education and training in land management techniques is available for Aboriginal communities, particularly those in remote areas. Although some knowledge of traditional management techniques survive in many areas, it is essential that education in modern land management techniques be available if the large area of land involved is to be preserved. (21) This is especially important in the arid areas of Western Australia because Aborigines returning to the land bring new technology.

As with all lands, the concept of sustainable development should be re-applied to Aboriginal lands to ensure sound environmental strategies are effected. Environmental problems may arise due to "increasing pressures to develop granted Aboriginal lands that often have relatively few options for sustained development" (Ref 2 Section 22). Aboriginal lands in the arid centre are particularly vulnerable to some forms of use such as grazing, especially when there are other pressures.

The rapidly increasing tourist industry is placing extra pressures on Aboriginal reserve land. The entry permit system should allow a measure of control over the activities of tourists, although it is estimated that at least half of the people travelling through the Central Reserves do not apply for permits. (21) Furthermore, some tourists indiscriminately light fires and move away from main access tracks in the reserves.

Aboriginal communities in Western Australia have limited access to the resources necessary for land management, and they are very reliant on government funding for a wide range of functions. (21) Little, if any, funding is available for conservation management.

If conservation strategies are to be relevant for Aboriginal society they must recognise Aboriginal perceptions of the natural world and its relationship with Aboriginal cultural systems. (18) In fact, the wider community in Western Australia could benefit from greater appreciation of the Aboriginal view of the environment. "The close identification with the environment, natural within Aboriginal culture and similar cultures, tended to have beneficial effects in terms of ecology and conservation considerations." (Ref 20 p 4)

3.2 VACANT CROWN LAND

Land held by the Crown which has not been sold, leased or reserved for a public purpose is classified as vacant Crown Land. Such land comprises almost half of Western Australia, covering a land area in excess of 1,080,000 square kilometres (Figure 2). (3) Most of the State's vacant Crown land is in the arid centre, with some large areas of uncommitted land also being located in the northern tropical region. Scattered, small parcels of vacant Crown Land constitute an important land resource in the more intensively settled areas of Western Australia. Vacant Crown Land throughout Western Australia has suffered degradation as a result of human activities, with pressures being most intense near urban centres.

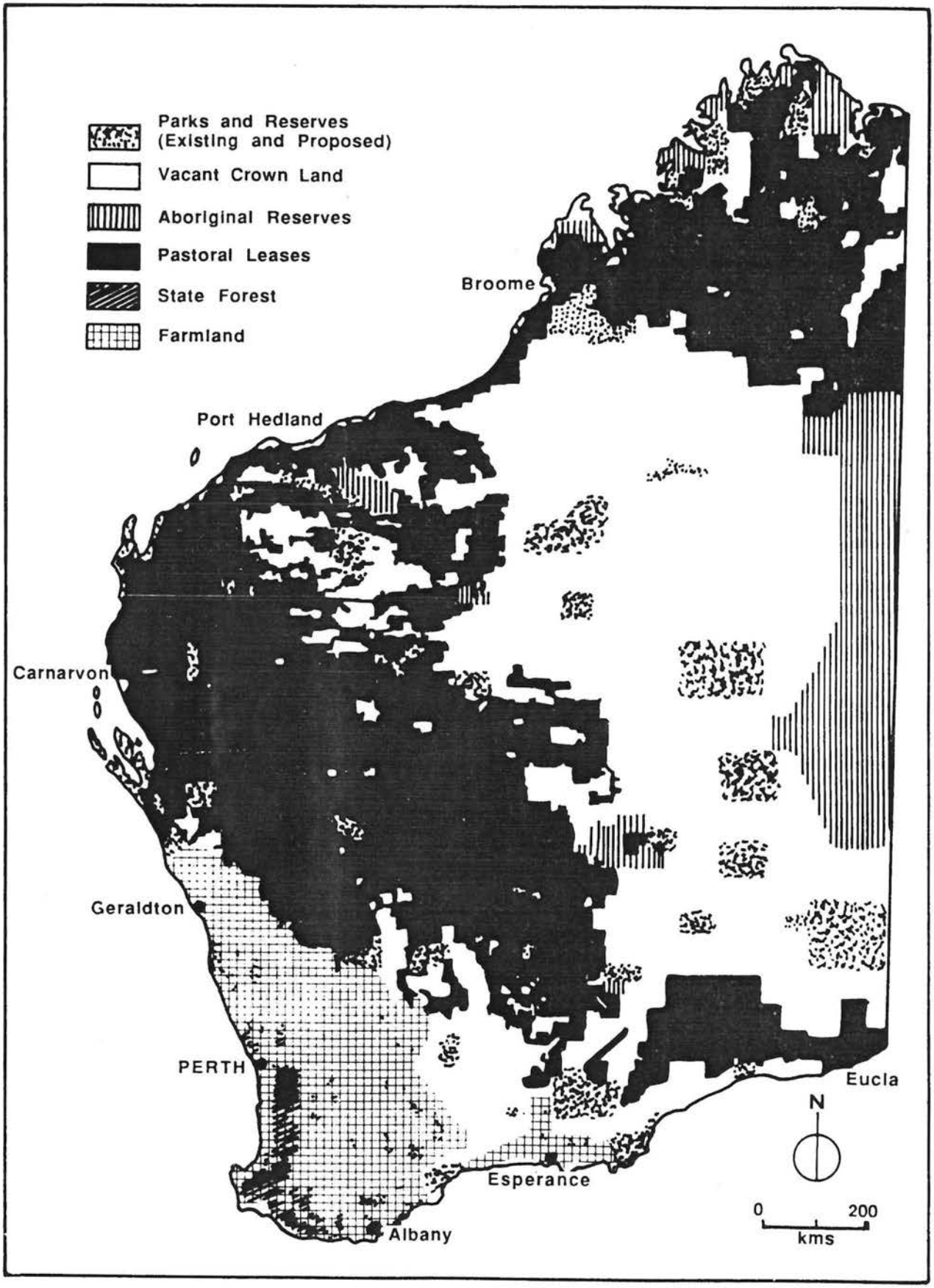

Figure 2. Land Tenure and Purpose in Western Australia. (3)

Administrative responsibility of the State's vacant Crown Land is held by the Department of Lands and Surveys, but manpower, financial and geographical constraints prevent effective management of un-allocated land. (3) "The Department of Lands and Surveys has only a custodial role for un-allocated land and little capacity for land management for production or protection, and even an inventory of land held in this way throughout the State is a formidable task." (Ref 23 p 5).

Vacant Crown Land is valuable for maintenance of genetic diversity but is subject to increasing use pressures and demands for further alienation. (23) Information describing living and other resources of vacant Crown Land in Western Australia is scant, but measures for the conservation of flora and fauna on this land require immediate consideration if native plant and animal communities are to be preserved. (3) Burbidge and McKenzie (pers comm) have assessed that within the non-pastoral arid zone, at least 22 percent of the mammalian fauna have declined substantially in area of distribution or disappeared altogether since European settlement. This trend is continuing.

Vacant Crown Land is often seen as a low-cost resource (3) that requires little management input. Though not designated for use, the land is subject to a variety of pressures. Vast tracts of the arid centre are subject to petroleum exploration by means of parallel series of clear graded seismic lines cutting across all vegetation types. Where these seismic lines cross dune crests, small blowouts may occur. If other pressures (eg fires or off-road vehicles) are not severe, active plant recolonisation may occur. However, in the arid centre some cleared seismic lines remain visible for decades even when not used further by vehicles.

Although some of the pressures on vacant Crown Land may not yet be intense, the effects are cumulative. Recovery of the fragile ecosystems of the arid centre is very slow, (3)(23)(24) particularly where un-managed fire devastates large tracts of land and there is increasing use of off-road vehicles, keeping the ground bare. Feral animals add to the pressures, as discussed separately (see Section 3.9). Vacant Crown Land throughout Western Australia requires protection and management to preserve natural resources and to safeguard its potential for any future use. (3)

3.3 PARKS AND RESERVES

Western Australia, stretching from the tropics in the north to the temperate south, comprises one third of Australia. As such it possesses a diversity of landscapes, flora and fauna, and marine ecosystems unsurpassed by any other Australian state. As discussed in the section on Wildlife (see Section 3.8), many species occur nowhere else in the world. It is important that representative and viable examples of these species and systems are protected. The justification for such protection is not only on ecological and aesthetic grounds, but also has an economic basis, in maintaining genetic diversity for potential utilisation by future generations.

Parks and reserves set aside to maintain representative assemblages of plant and animal communities can make a valuable contribution to minimising further losses of Western Australia's living resources. A well-planned and managed system of parks and reserves is important not only for ethical reasons, but also for the aesthetic appeal of being able to enjoy living things in their natural surroundings and because they may one day be required to play new roles in arid-land stabilisation, food production, medical research and disease prevention. (3)

Considerable progress has been made already toward this objective (Figure 2), although in some areas such as the wheatbelt and the Swan coastal plain, the opportunity to achieve a representative system of conservation reserves has been lost. The Environmental Protection Authority (EPA) appointed the Conservation Through Reserves Committee (CTRC) in 1972 to develop proposals for a set of reserves representing the major flora and fauna communities in Western Australia. The CTRC divided the State into 12 areas, with the boundaries relating to geography and human activities. Recommendations for these systems were developed by the EPA and later endorsed, in principle, by government. With regard to System 7, the Kimberley, the Government will use the EPA recommendations as the basis for the creation of future reserves in that region.

A substantial proportion of the EPA recommendations for parks and reserves endorsed by Government have been fully implemented, with others being delayed due to technical and administrative problems, lack of funds for the purchase of freehold land, or difficulty in resolving conflicts with competing uses. (3) The System 6 Report offers advice on how certain of these difficulties may be resolved. (25)

Many areas of conservation value throughout Western Australia have now been identified, and the State is progressively moving towards the establishment of additional parks and reserves. Nature Reserves and National Parks total approximately 5.6 percent of the area of Western Australia. [26] *This system of parks and reserves still does not fully represent the range of terrestrial ecosystems, however, nor is the security of tenure adequate for many reserves, especially those in the Southwest of the State where some 90 percent of the population resides and competing pressures are greatest. Some National Parks in the Southwest are too small to withstand pressures of increasing usage. Furthermore, current knowledge of how Western Australia's distinctive ecosystems function does not provide an adequate information base for management.* [3]

Nature Reserves, established primarily for the preservation of nature, total close to 10 million hectares throughout the State. [27] The most extensive reserves are located in the Kimberley and the Central Deserts, with small, scattered reserves in the farming areas of the Southwest. [23] Particularly important are the many coastal island Nature Reserves which preserve species and habitats largely isolated from environmental changes on the mainland. Management plans have been developed for some Nature Reserves, but the plans generally have not been based on specific research and consequently lack detail. [23]

In Western Australia, National Parks cover an area of approximately 4.5 million hectares, some one million of which is in the Southwest land division. [28] The primary purposes of WA National Parks has been defined as "to preserve for all time scenic beauty, wilderness, native wildlife, indigenous plant life and areas of scientific importance, while also providing for the appreciation and enjoyment of these things by the public in such ways and by such means as will leave them for future generations as little impaired as possible". (National Parks Authority - Management Policies).

The national Council of Nature Conservation Ministers defined National Parks as follows:-

> "A National Park is a relatively large area set aside for its features of predominantly unspoiled natural landscape, flora and fauna, permanently dedicated for public enjoyment, education and inspiration, and protected from all interference other that essential management practices, so that its natural attributes are preserved."

Western Australia, as a member of the International Union for the Conservation of Nature and Natural Resources is also required to uphold a similar international definition, namely:-

> "A National Park is a relatively large area:
>
> 1. Where one or more ecosystems are not materially altered by human exploitation and occupation, where plant and animal species, geomorphological sites and habitats are of special scientific, educative and recreative interest or which contains a natural landscape of great beauty; and
>
> 2. where the highest competent authority of the country has taken steps to prevent or to eliminate as soon as possible exploitation or occupation in the whole area and to enforce effectively the respect of ecological, geomorphological or aesthetic features which have led to its establishment; and
>
> 3. where visitors are allowed to enter, under special conditions, for inspirational, educative, cultural and recreative purposes."

The largest National Parks are in the north of the State. Urban National Parks such as Yanchep, do not meet the criteria for National Parks. These parks fit more appropriately into a provincial or regional category.

The Western Australian parks and reserves system does not have a category for small areas which do not meet the criteria for National Park but may be used for public recreation purposes as well as nature conservation. In the Southwest some nature reserves are being used, improperly, for this purpose.

Some areas of Western Australia (particularly in the semi-arid, arid and tropical zones) are either of wilderness quality or could become of wilderness quality with relatively little effort. There is only one gazetted wilderness area in Western Australia, the Nuyts Wilderness Area (5,500 hectares) within the Walpole-Nornalup National Park (18,835 hectares) on the south coast. However, a number of other National Parks and Nature Reserves in the State are managed as wilderness areas.

National Parks and Nature Reserves in this State vary in respect of their security of tenure and purposes according to their designation as Class A, B or C. Present classifications of parks and reserves in Western Australia, however, "do not necessarily reflect the present-day value of the land as a park or nature reserve, nor do they

clearly indicate the desirable balance between conservation of natural areas and public access and enjoyment of them". (Ref 3 p 77). *In fact, the present system of classification of parks and reserves is considered to be quite inadequate and should be revised as a matter of urgency.* [23]

While the number of terrestrial parks and reserves in Western Australia has been progressively increasing, little attention has been paid to aquatic reserves. There is statutory provision in the CALM Act for Marine Nature Reserves or Marine Parks but so far none has been formally declared and few have been recommended. Biological surveys of the various marine habitats around the coast have been restricted in location and content. [3] There is a need for integration of effort and promotion of wider coverage of marine ecosystems in Western Australia. [3] Wetlands too, have generally been inadequately reserved, protected and managed (see Section 3.10).

Although considerable progress has been made towards the setting aside of lands for a representative system of parks and reserves, inadequate resources (staff and funds) have severely restricted planning and management. Very few management plans have been completed, [23] and many parks continue to be unmanned. [28] Feral animals and exotic weeds which threaten the natural resources of parks remain unchecked in many areas of the State where staff shortages prevent effective control. [28]

National Parks are used for a range of activities including scientific, educational and recreational purposes. Within the community there is some debate as to which activities are appropriate for these reserved areas. This issue was considered in a recent survey of Western Australian residents as discussed in a report to the Conservation Council of WA. [29] Activities which respondents considered appropriate for at least some National Parks included walking (98.37% of respondents in agreement), scientific study (94.57%), orienteering (86.44%), non-motor boating (83.51%) and camping (80.04%). *Activities which respondents felt should not be allowed in any of Western Australia's National Parks included a number of which could have a high impact on natural ecosystems, notably hunting (89.04%) and wildflower picking (81.34%); exploration for minerals (83.18%) and mining (87.85%); logging (83.18%); trail bike riding (80.91%); off-road vehicles (67.02%) and motor boating (70.71%).*

Planning and management problems throughout Western Australia's network of National Parks are of particular concern given the increasing number of people visiting the parks. [28] Inadequate management endangers the reserves themselves, and already in Western Australia "existing parks and reserves are in danger of deterioration because the managing agencies have insufficient resources for their management and protection". (Ref 3 p 76).

In a conscious step towards rectifying this situation, the recently formed Department of Conservation and Land Management (CALM) has integrated management responsibility for National Parks, Nature Reserves, State Forest and other Crown land in Western Australia. The amalgamation of staff and other resources of the Forests Department, National Parks Authority and the Wildlife section of the Department of Fisheries and Wildlife, together with additional staff appointments to CALM are aimed to assist in alleviating many problems associated with Western Australia's parks and reserves system.

It is also recognised that conservation of flora and fauna is not achieved solely by a representative system of dedicated parks and reserves. Maintenance of natural areas on private land, vacant Crown Land and other vested lands such as road verges is also important, particularly in affording corridors facilitating gene flow between reserves (as discussed in other sections). Local Government Authorities also have responsibilities for some reserves with conservation value. However, few Local Government Authorities have management plans for such reserves or trained conservation reserve managers.

3.4 PASTORAL LANDS

The occupied pastoral lands of Western Australia cover about 951,000 square kilometres or 38 percent of the State's area. Located predominantly in the semi-arid and arid regions containing the State's most fragile ecosystems, [30] the pastoral zone also extends into the northern tropical region of Western Australia (Figure 2). The area is largely designated for single type land use, principally the grazing of sheep and cattle on native vegetation on land held under lease from the Crown. [3]

Both the WA Land Act 1933-1982 and the Soil and Land Conservation Act 1945-1982 assign responsibilities for the conservation and management of lands used for pastoralism. Under the lease conditions each pastoralist has a legal obligation to maintain the leased land in good condition. [23] A five-year development plan for each lease is required to be submitted to the Pastoral Board for approval. The Board has the right to specify stocking rates and conditions. If these are not met, the lease is liable to forfeiture.

A comprehensive picture of rangeland condition throughout the State is emerging from a series of regional resource surveys being carried out jointly by the Department of Agriculture and the Department of Lands and Surveys. Rangeland surveys of the Gascoyne River catchment, the West Kimberley region, the Nullarbor Plain, the Ashburton River catchment and the Carnarvon Basin have been completed, with the remaining surveys expected to be completed in the 1990s. (3) Existing surveys indicate that approximately 23 percent of pastoral land is in bad condition, ie seriously degraded (Table 1). About half of this area is marked by soil erosion. Considered solely on economic criteria, 52 percent of pastoral leases within the Kimberley and 47 percent of those south of the Kimberley have been assessed as non-viable. (31) (30)

Table 1. Range Conditions for five surveyed pastoral areas in Western Australia*

Region Surveyed	Total Area (sq km)	Range Condition Classes (Percent of observations) Good	Fair	Bad
Gascoyne (1970)	63 400	32%	53%	15%
West Kimberley (1972)	89 600	20%	50%	30%
Nullarbor (1974)	47 400	50%	10%	40%
Ashburton (1976-78)	61 200	64%	27%	9%
Carnarvon Basin (1980-82)	74 000 (approx)	45%	32%	23%
Average of All Areas	**335 600**	**40%**	**37%**	**23%**

*Updated from DCE Report 12. (3)

Today, 58 percent of pastoral lands are in need of some form of range management, while a further 33 percent require stock reduction as well as range management (Table 2). (3) At least one third of Western Australia's pastoral land requires a reduction of stock numbers to restore range condition and productivity. (32) However, much of the pastoral industry is under severe economic pressure,(23) and station owners "may not be able to afford to reduce their income-earning capacity in the short term to protect their land in the long term". (Ref 32 p 51). The pastoral industry in the Kimberley has, in general, relied on open range herd management and has been reluctant to outlay the capital expenditure necessary for proper management of rangelands or efficient levels of animal production.

Rates of land degradation were probably highest in the early years after pastoral settlement, and during major drought periods. On some sections of land, the ecosystem was entirely unsuitable for pastoralism; (3) (30) some of the remainder have now been so badly degraded that sustainable use of these systems is no longer possible. On a number of stations, re-appraisal of land condition each time a station is sold indicates a continuing decline in carrying capacity.

Table 2. Areas of Western Australian pastoral land needing treatment (revised). (3)

Treatments	Areas km²	Areas %
No special treatment	86 000	9
Range management only	547 500	58
Range management and stock reduction	127 500	13
Range management and stock reduction and works	190 000	20
	951 000	100

On many pastoral leases, ecosystems have been altered greatly by changes in plant composition, competing weeds, feral animals such as goats, donkeys, brumbies and camels, and increased numbers of predators such as dingoes. Once overgrazing has occurred, resting by the removal of stock may be inadequate where elevated populations of kangaroos retard the recovery of perennials. (33) Government agencies and landholders are making commendable efforts to control competing animals, but they continue to add to the management problems on pastoral lands. (34)

Uncontrolled wildfires pose another threat within pastoral environments of Western Australia. (31) Prescriptive fire management for all shrublands and grasslands is now being recognised, albeit late, as an essential part of vegetation management. In some communities fires are essential to conserve broad-scale heterogeneity. However, not all semi-arid or arid vegetation types are predisposed to burning, even on very long time scales. (35)

The basic cause of the deterioration of Western Australia's pastoral land has been the combined grazing pressure of stock, feral animals and kangaroos, each elevated by increasing the number of permanent watering points. Until recently, management of pastoral lands has been ineffective. (3) (30) (31) The Task Force on Land Resource Management in Western Australia which reported in January 1984 found that management had not been effective in the regulation of stocking rates, nor in arresting the loss of vegetation on pastoral lands. (23) *Forfeiture of a pastoral lease on grounds of environmental mis-management has rarely, if ever, been imposed. Even if applied in an extreme case, this action should not be left until the rangeland has been degraded irreparably.*

The Kimberley Pastoral Industry Inquiry advocated that the Pastoral Board should be given the resources to address both the environmental and economic factors influencing effective utilisation of pastoral lease land. (31)

Much information exists on the measures available to improve rangeland condition through appropriate and responsive management, or, in certain instances, cultivation and seeding. Major regeneration programmes have been undertaken on the Ord and Fitzroy rivers. (36) A good deal of regeneration has been by introduced pasture species. Where this has been highly successful, little of the original plant diversity remains.

Resource surveys and on-going monitoring of rangeland condition are essential to increase knowledge, and hence understanding, of the pastoral environment. (3) Monitoring programmes have been initiated on approximately one hundred pastoral properties, and these are expected to extend to other stations in the future. (7)

Newly formed Soil Conservation Districts are facilitating local participation in finding solutions to problems of rangeland degradation. This trend, together with a growing awareness by pastoralists of the needs of the land and its declining carrying capacity, provides some optimism that degraded range condition can be improved. In times of adversity, however, peer pressure may not be brought to bear on those having economic problems.

Some claim that increased security of tenure would provide a financial or psychological incentive for the outlay of such expenditure, (31) but this is debatable, especially under present economic pressures. The Pastoral Tenure Study Group has recommended that the land tenure adopted should provide sufficient equity, security and incentive to enable the pastoralist to manage and maintain the rangeland as a valued resource. (37)

Numerous activities now compete for use of land traditionally designated for pastoralism in Western Australia. (3) These include new towns and increasing populations, mining activities, recreation and tourism, nature reserves and Aboriginal interests. Alternative land uses have been tolerated to some extent, but broader interest groups presently lack representation on agencies responsible for the administration of pastoral land in Western Australia.(23)

The Pastoral Tenure Study Group considers that it is preferable to have a land tenure system which could accomodate conservation, tourism, community, Aboriginal, mining or other interests. Compensation should be provided to the lessee whenever the Government wishes to resume and reallocate the land to another use. (37)

Pastoral activities have contributed to the declining diversity and distribution of native flora and fauna in rangeland areas. Grazing by domestic and feral stock is regarded as a major factor in plant extinctions in Australia. While less is known of the fauna, Burbidge and McKenzie (pers comm) have assessed that within the pastoral arid zone, at least 20 percent of the mammalian fauna have declined substantially in area of distribution or disappeared altogether since settlement. This trend is continuing. Some habitats and communities located in the rangeland areas of Western Australia are not yet adequately represented within parks and reserves, although there remain significant conservation opportunities.

It is thus apparent that pastoralism in Western Australia has not been operating on an economic or ecologically sustainable basis. Sections of land committed to pastoralism were unsuitable for grazing from initial settlement, with increasingly widespread rangeland areas now severely degraded such that they will no longer sustain pastoral production. However, attitudes towards pastoralism are changing markedly, with recognition of the environmental legacy that inappropriate management has left. A fresh approach to the use and management of rangelands in Western Australia should place an emphasis on long-term ecosystem stability rather than short term production.

As part of such a fresh approach, more serious consideration might be given to other options for making better use of the natural ecosystems on our arid and semi-arid lands. Rather that introducing non-indigenous pasture plants more suited to the introduced grazing animals, ranching of native animals already well adapted to the natural systems might be more sustainable. Established examples elsewhere are the domestication of llamas and alpacas well adapted to the arid sierras of South America, (38) and the ranching of eland and oryx which make best use of natural pastures in Africa. (39) In Pilbara habitats, the euro has been shown to be far more successful than sheep. (40) As pointed out by Sirolli, (41) quality productions from kangaroos and emus may afford economic as well as environmental advantages.

3.5 AGRICULTURAL LANDS

Land allocated for agriculture in Western Australia covers an area of more than 19 million hectares which is concentrated in the transitional winter rainfall zone of the Southwest. (42) This comprises a little less than eight percent of the State, and includes 17 million hectares of presently cleared farmland. (7) Although the agricultural industry has developed within a number of environmental constraints, it has been economically successful and has emerged as one of the State's most important forms of primary production. (3) Agriculture in Western Australia is dominated by broadacre industries producing grains, wool and red meats primarily for export, with other small industries such as dairying and poultry oriented toward supplying domestic markets.

By comparison with most world agriculture, Western Australian farmers operate in a environment which is relatively dry and in which soils are of exceptionally low fertility. Nevertheless efficiency is high when measured per unit of limiting inputs (rainfall, capital and labour).

With 10 percent of Australia's farmers and graziers, Western Australia accounts for around 15 percent of the nation's gross value of rural production. At present, Western Australia produces about 33 percent of the nation's wheat and carries about 22 percent of the nation's sheep.

This reflects the high degree of expertise of Western Australian farmers, especially with regard to:

- development and use of legumes
- economic dryland farming systems and
- fertilizer treatment for mineral nutrient deficiencies..

Collectively, Western Australia's agricultural land is its most productive capital asset. Ley farming technology has greatly improved the fertility and productive capacity of the soil but on the negative side soil erosion and salt encroachment are increasing under current farming systems. (43) *"Only 35% of the cleared farmland is thought to be stable; about 40% requires soil conservation measures including fencing, contouring and other management practices to control both water and wind erosion and a further 25% needs special attention to prevent wind erosion." (Ref 42 p 7).*

Furthermore, since agricultural development commenced, two percent once-arable land has become non-productive due to secondary salinity, and the area affected by salinity is continuing to increase. (3)

Within the agricultural lands a range of farming systems are practised. These systems vary from intensive irrigated horticulture and pastures, mainly in the coastal areas near and south of Perth through predominantly grazing enterprises in the above-600mm rainfall area, mixed grazing and cropping between 400mm and 600mm to predominantly cropping in the areas of less than 400mm rainfall.

There are approximately 16,000 commercial farming businesses in Western Australia. In the agricultural areas average farm size has doubled over the past 30 years and is now the largest in Australia. The output per man employed in grain farming is higher for Western Australia than anywhere else in the world.

Western Australia's gross value of rural production in 1984/85 wa estimated at $2,674 million. Of this total, an estimated $1,724 million came from crops, $364 million from livestock slaughterings and $586 million from livestock products ($502 million from wool). Wheat ($1,190 million) and sheep ($647 million) are clearly the two largest income earners, together accounting for 68 percent of gross value of rural production in 1984/85.

Western Australia exports around 70 percent of its rural production, including about 98 percent of its wool, 95 percent of its wheat and 50 percent of all meat produced. In 1981-82, the value of these agricultural exports amounted to 47 percent of the State's total overseas exports (see Section 4.2).

Most agricultural products are not processed before export. For example, in 1983/84, processed products accounted for 21 percent ($318 million) of the total value of agricultural exports ($1,510 million). Agricultural product processing currently accounts for around 15 percent of the total value of manufacturing activity in the State.

While the productivity of agricultural lands has been elevated considerably over the decades, this has been achieved by great increases in total energy expended (as represented by direct fuel, fertilizers, pesticides, machinery, etc). In fact, energy inputs to farming in the USA over the past 60 years have increased faster than the increase in food energy produced. When farm output is plotted as a function of energy input, the rise in farm output was most rapid in the 1950s, flattening by the 1970s. This indicates that we may be nearing the end of an era, so that further energy inputs will produce smaller increments in production. (44)
On the data available, the energy subsidy plotted against time shows no sign of abating.

Another aspect of this energy subsidy is that the main thrust of crop breeding (at a world level) in recent years has been to produce plants which can respond to more abundant supplies of fertilizer and water. (45) *To improve yields without greater energy inputs requires a different approach to plant breeding.*

Western Australia's agricultural sector is supported by a major infrastructure, both government and private, to supply the inputs and to transport and market the products. These include road, rail, air and port facilities; grain storage and handling; fertilizer distribution arrangements; saleyards and abbatoirs; wool handling and storage; a network of agencies dealing with machinery, fuel, chemicals and other imports; and health, education and local government services.

Although agriculture makes a large contribution to the Western Australian economy, the rural sector share in recent decades has been declining in relative terms because other sectors (mining and services) have been growing at a faster rate. Agriculture now accounts for about 9 percent of Western Australia's gross domestic product (17 percent twenty years ago), 30 percent of the State's overseas exports (68 percent twenty years ago), and 7 percent of Western Australia's employment (13 percent twenty years ago). Nevertheless, agriculture continues to grow in

absolute terms (rising volume of production and exports) and this growth, plus the increasing dependence on off-farm inputs, have boosted industries allied to agriculture.

Through its close links with allied industries involved with supplying inputs and transporting and processing its products (industries such as: transport, machinery, chemicals and fertilizers, merchandising, processing and the service sector), agriculture has a major influence on the economy as a whole. In the past 15 to 20 years, weather cycles, commodity price movements and technological advances have led to substantial changes in Western Australia's agricultural land use, total rural output and composition and in farm incomes.

Over the past 30 years, cleared farmland has been used with increasing intensity. Cropped area plus sown pasture area as a proportion of total cleared area rose from 49 percent in 1955/56 to 85 percent in 1983/84. Before 1970/71 the increase was mainly due to increases in the area of sown pasture, but since then the expansion has been principally in area cropped.

Cropping has become increasingly mechanised and geared towards a minimum tillage system involving the use of herbicides. Relatively buoyant grain prices from 1973 to the early 1980s led to continual increases in the total cropped area in the State due mainly to a higher proportion of individual farm areas being cropped. There has also been a large increase in the area sown to grain lupins in recent years reflecting the important place of a legume crop in rotations, in contributing nitrogen to the system and breaking the disease cycle inherent in intensive cereal cropping.

More recently grain prices have declined and the outlook for a recovery is not encouraging. This is causing farmers to reappraise the balance between cropping and livestock enterprises, and the recent swing to cropping may have peaked with the possibility of a swing back towards livestock, particularly sheep.

Inevitably, agricultural development has affected the natural environment. The removal of native vegetation over the agricultural areas has undoubtedly been the major environmental impact of post 1829 settlement and development. Plant communities of very high diversity and endemism have been cleared extensively (see Section 3.8).

In many cases clearing has been excessive, and often inappropriate soil types and land systems have been alienated, usually in ignorance. Land degradation and stream salinisation are of concern to Western Australia's rural sector (see Sections 2.1, 2.2). Soil salinity is spreading and it is clear that lack of knowledge of the nature and behaviour of the soils used has caused loss of structure, compaction, hard setting and erosion. The costs of land degradation have been estimated to be considerable in some areas of the State (see Section 2.1).

It is well recognised that wind erosion and salt encroachment are only symptoms of the problems that exist in the farming systems currently in use. "In particular, they indicate the instability and inappropriateness of the system of farming currently in use". (46) The solution lies in developing a more
appropriate farming system; one more attuned to the environmental conditions of the region, a system that will be stable in the long-term. (46)
The various problems of land degradation are currently the focus of considerable research. (7) Recently formed Soil Conservation Districts have been successful in encouraging local participation in assessing agricultural land degradation problems, and developing solutions. In addition they provide an important means of implementing new farming practices.

In an attempt to minimise environmental hazards caused by removal of native vegetation, an Initial Development Plan has been required for newly released agricultural land for several years. (42) Concern over clearing of freehold agricultural land has led to the recent proclamation of regulations under the Soil and Land Conservation Act which requires farmers to notify their intention to clear land. If this is likely to cause land degradation a Soil Conservation Notice could be issued to regulate the clearing.

Continued pressure exists for further alienation of land for farming in marginal areas of the Southeast and south coastal areas. (23) A major reason for this pressure is the attractive conditions of payment provided for by the Land Act in the purchase of vacant Crown Land. (42) However, an economist (G Oliver) considers that if the farmer had to bear the real costs, demand would disappear. (47) He also states that a thorough benefit-cost analysis would show that further large-scale release of land to agriculture would result in net costs to the State. Halting land release could result in economic benefits to the State, as well as retaining options for the future. In many marginal areas, land use decisions should be deferred until better information is available. (3)

Assessment of new land areas for agriculture has previously given consideration to factors of climate, soils and water supplies as well as identifying potential hazards including salinity, soil erosion and flooding. (3) In some

instances, however, "the lack of detailed data has led to impact assessment that has been more subjective than desirable". (Ref 42 p19). Land Use and Environmental Impact Assessment procedures have been introduced recently to replace a moratorium on land release since 1983. The aim is to overcome the deficiencies of previous agricultural land assessment, and to ensure that vacant Crown Land is designated for purposes which are in the best long-term interests of the community. (42)

Comprehensive climatic data provide the basic foundation upon which land is assessed for agricultural development. (42) *Of particular concern in Western Australia is the spread of agriculture into areas for which long-term rainfall records do not exist.* (3) *Understanding long-term climatic changes is crucial for determining viable land use options for marginal areas, so that the collection of weather data is of prime importance for future land assessment. Furthermore, changing climate may require that some present land uses be altered greatly.* (4) *For instance, the Southwest sector of the State may have gradually less winter rainfall, so that alternative uses may need to be found for the wheatbelt.*

Habitat clearing for agricultural development has severely affected Western Australia's indigenous flora and fauna. More than 800 plant species in the agricultural and adjacent areas are rare or endangered, and a large number of the 136 species of plants declared to be rare in Western Australia are confined to the agricultural zone (see Section 3.8). Approximately 60 percent of the species of medium-size mammals (40g-4kg) have disappeared from the wheatbelt since European settlement. (48) *Small parks and reserves in the agricultural areas afford some habitat protection, but 68 percent of the rare and threatened plants are not in existing reserves. Uncleared land on farms could make a valuable contribution to nature conservation.* (3) *The Conservation and Land Management Act enables the Department of Conservation and Land Management to enter into agreements with farmers to achieve conservation objectives on their land, but this is dependent upon voluntary action by landowners. Protection of flora and fauna in agricultural areas is also hindered by an unfilled need to advise the farming community on the management of natural landscapes.* (23)

Farm production is adversely affected by weeds and feral animals (rabbits, pigs and foxes), although the impact of these pests on the State's agricultural industry has not been assessed. (3) Control operations to reduce the spread of weeds and vermin in agricultural areas have had varied success (see Section 3.9).

Modern agriculture relies on the use of chemicals for the nutrition and protection of cultivated plants and livestock. The use of agricultural chemicals in Western Australia has increased significantly in recent years and they are now an important component of the industry. (49) (50) Pesticides, including herbicides and insecticides, increase production and enable the continued export of grains. (49) Minimum tillage practices associated with herbicide use assist in conservation of soil quality. (3)

Regulations exist to ensure that pesticides are used in a proper manner, (49) but there is need for continuing education programmes informing the public about the possible dangers of agrochemicals. Some of the chemicals are toxic and the effects of their misuse on natural ecosystems, as well as on operators, third parties, and consumers is of concern. A research programme is investigating some of the long-term impacts of chemical use on human health in agricultural areas. There is also a need for much more widespread monitoring of pesticides and their residues through both target and adjacent ecosystems. (50)

The leaching of nutrients (especially phosphorus) from agricultural land is a major factor in the eutrophication of wetlands and estuaries in the Southwest of the State. (14) The flow of nutrients from fertilizers applied on the coastal plain could also cause pollution of groundwater resources in the Southwest. (51)

Rural landholders are increasingly (some acutely) aware of their needs and problems in environmental care. As in other states, (52) on-farm programmes of rehabilitation are being developed by individuals. However, for several decades the agricultural sector has experienced a severe cost-price squeeze. Costs have been rising more rapidly than product prices received by farmers with a consequent long-term decline in their terms of trade, shown by the ratio of indexes of prices received to prices paid. For example, Western Australian farmers' terms of trade have declined 17 percent in the past four years and a massive 46 percent since 1973-74.

Through productivity gains, farmers have been only partially able to offset the cost-price squeeze with resultant increasing pressures on farm incomes. As a consequence, farm debt has been rising and the capacity to service debts from farm incomes has been diminishing. Most farmers are in debt, so that while they may well appreciate the need for rehabilitation of the land, they are in no position to make a major input toward that goal. In fact, the responsibility is much wider than resting with the farmer today. The degraded condition of much of our farmland has accrued over 150 years. The whole community has benefitted from this farming history, so now should share the environmental debt which has accumulated. (52)

An overview of the condition of agricultural lands in this State leads to the conclusion that the long-term objective of sustainable utilisation is not being achieved. Extensive restoration of degraded lands together with modified agricultural practices to ensure a sustainable environment in the future, is essential. This is an accumulated environmental debt which is inescapable and must be met by the community.

3.6 OTHER LANDS

Included here is private land (urban and rural) not being used for agriculture, lands held by industry and Local Government (including road verges), and land designated for special purposes such as water catchment, rail reserves and airport surrounds.

Significant opportunities for preservation of natural landscapes exist on areas of land owned publicly and privately throughout Western Australia. This is particularly important in areas where little opportunity remains for reservation of natural areas due to a shortage of un-allocated Crown Land. (3) Maintaining such areas makes an important contribution to flora and fauna conservation, in affording corridors facilitating gene flow between reserves, for control of salination and erosion, as well as for aesthetic values. Man-made landscapes, including parkland and rural properties, also have recreational and aesthetic value for local residents and tourists.

Many valuable natural environments have been destroyed or altered through the expansion of urban land-use activities. Urban growth has reduced native flora and fauna populations, and increased the presence of introduced species in built-up areas. Active protection and management of native habitat sites remaining in cities and towns is important for maintaining species diversity, as well as providing some direct contact between the urban community and their natural environment.

Considerable scope exists for improving the appearance of urban landscapes in Western Australia. Tree planting schemes offer great potential for enhancing the visual environment of cities and town, especially if native species are used. Open space between urban corridors provide valuable landscape land provide opportunities for parkland development. Areas of important landscape amenity on the periphery of the Perth metropolitan region, including forests and farmland, have conservation, recreational and aesthetic value and thus deserve a high level of protection and management.

Local Government Authorities are an important means of encouraging native vegetation retention, particularly through town planning schemes and planning powers which can be used for resource conservation measures. Management of lands vested in local authorities for various purposes should also be guided by broad environmental principles, although shire councils generally have to rely on government agencies for expert advice on conservation issues.

Open space of regional significance, which can include land in private ownership, may be managed for the retention of natural vegetation, or developed as "green belts" or as parks for recreation. (25) At present, planning legislation in Western Australia allows for land to be set aside as regional open space within the Perth metropolitan region. There is some statutory machinery for regional planning for open space in the remainder of the State, but this has not been widely used to date.

Procedures by which the Metropolitan Region Planning Authority (MRPA) reserved land as open space involved constraints on development and an obligation on the Authority to pay compensation, or alternatively to acquire the land where it could not be sold privately, or its sale value was affected by the reservation, or where development had to be refused because of the future use of the land for open space. These procedures involved costly expenditure and finance, and relevant expertise required to manage the land were not always available. (25) Current obligations on the State Planning Commission to control development and pay compensation could be eased if the State had both powers and resources to make agreements with owners which ensured conservation (and even recreational access) as an alternative to acquisition.

Among the possible measures are changes to the Town Planning and Development Act, the Local Government Act and the Valuation of Land Act. The amendments would allow for agreements between the relevant Minister and the landowner in relation to the development, preservation, conservation or other specified use of land; the provision of incentives and assistance; prohibition of subdivision or development; change of valuation etc. Other proposals are to introduce new zoning definitions, such as "Landscape Protection Zone"; the redefinition of "development" to include destruction of trees or vegetation and the incorporation of vegetation conservation as a

matter which may be provided for under a town planning scheme. All of these amendments would assist the process of conservation of our living resources.

A concept recently introduced to Western Australia by the EPA is that of regional parks, aimed at protecting the conservation and recreation values of largely natural areas having a mixture of land ownership and purposes. (53) A regional park will cater for a greater variety and intensity of recreational pursuits than are permitted in a National Park. Many areas having potential as regional parks, including marine, urban and countrywide locations, were identified in the System 6 Report. (25) However, regional parks are still essentially in a conceptual stage in Western Australia, as to date no such parks have been formally gazetted.

The Conservation and Land Management Act enables the Department of Conservation and Land Management (CALM) to enter into agreements with owners to achieve conservation objectives on their land. However, CALM has to have the financial resources, the owner must be willing, and the local authority must have the right to make a submission.

Localised pollution due to particular industrial activities on private land has caused social problems in areas of Western Australia. The Environmental Protection Act aims to control and prevent any emission which may cause pollution. Measures to minimise exposure to contaminants should continue to be an integral part of land-use planning. It is appropriate to continue to give consideration to the possible adverse effects of industrial activities on the natural environment (see Section 4.4).

The consumption of increasing quantities of resources creates waste management problems, particularly in cities and towns. In addition to being unsightly and a source of obnoxious odours, the disposal of domestic and industrial waste may have adverse environmental effects. Of particular concern has been the loss of wetlands due to their use as rubbish dumps in the past, (54) and the "throw-away" mentality prevalent today.

Remnant vegetation along road verges enhances the visual amenity of cleared landscapes, particularly in the wheatbelt. Road and rail reserves in Western Australia contain a valuable reservoir of plants and wildlife. Remnant plant communities in these reserves, however, are declining through factors such as construction and maintenance activities, grazing and fire protection. Land designated for public utilities (ie water, power and communication services) also requires the removal of significant areas of native vegetation to reduce fire hazard and avoid overhead wires.

Careful management of the State's coastal lands is needed if further resource degradation is to be avoided, and coastal developments are to be protected. Numerous management problems around the Western Australian coast have resulted from inappropriate planning in the past, including buildings unwisely located on frontal dunes and poorly designed and located roads. (55) Indiscriminate use of off-road vehicles is an increasing land management problem in Western Australia. The costs incurred to Local Government Authorities, private landowners and community organisations as a result of these actions have been considerable. To avoid further unnecessary expenditure, land capability assessment and consideration of coastal processes should always precede land-use planning in the coastal zone. Management plans identifying particular site requirements have been prepared for some areas along the Western Australian coast, although there remain many areas in urgent need of assessment.

Procedures for the retention of natural areas on private land require community acceptance of planning objectives which aim for conservation outside reserves. (25) (23) Convincing landholders of the value of retaining natural vegetation is far better than coercion. This approach will be aided by an extension service to advise landowners on vegetation clearance and resource management. Further incentives (including compensation) for landholders should be considered where the maintenance of native flora and fauna will involve the occupier in expenditure. (3)

3.7 FORESTS

Western Australian forests are generally identified by the two principal commercial species, karri (*Eucalyptus diversicolor*) and jarrah (*E. marginata*), both endemic and of world-wide repute. Other forest species include marri (*E. calophylla*), wandoo (*E. wandoo*), tuart (*E. gomphocephala*) and brown mallet (*E. astringens*). Associated with the forests is a rich assemblage of understorey and fauna.

Clearing of the forests and woodlands has been extensive since European colonisation. Clearing for agriculture, timber harvesting, the provision of public utilities, mining activities and forest disease continue to encroach on

the remaining forest vegetation. Depending on how the original forest margin is defined, 30 to 50 percent of our jarrah-marri-karri forest area has now been lost.

Today, a total of just over 2.5 million hectares of native forests remain (Figure 2), constituting about one percent of the State. Almost two million hectares are in State Forest and Timber Reserves under the control of the Department of Conservation and Land Management, while 520,000 hectares of native forests are on privately owned land, mainly farms. (3) Timber resources are insufficient to meet local demand, so that Western Australia is a net importer of timber.

Forest Management Priority Areas dedicated to conservation of flora, fauna and landscape or to public recreation in natural surroundings have been established in the forest estate. Being part of State Forest, MPAs dedicated to conservation have security of tenure equivalent to that of 'A' class National Parks, and could thus make an important contribution to the conservation of representative forest ecotypes.

Also important, both ecologically and aesthetically, are stream and road reserves, which retain forest communities for essential physical stability, for natural retreats and corridors, as well as for attractive features sought by tourists. Recent actions, however, raise doubts as to the security of these reserves.

The State Forest constitutes the largest remaining area of natural vegetation in the intensively settled Southwest, (23) though community structure has been considerably altered in some areas. It is therefore of conservation, recreation and aesthetic value, as well as being the source of timber, important to the social and economic well-being of the Southwest. The forests of Western Australia have many intrinsic conservation values and distinctive landscape attributes. An increasing number of visitors pursue a wide range of leisure-time activities in areas set aside for recreation within the forest estate. (56) Maintaining public access to natural areas in the State Forest is important for ensuring wide recreational opportunities for local residents and tourists.

The majority (1,447,000 ha) of the State Forest is dominated by jarrah, other species occurring with it being marri (*E. calophylla*) and to a lesser extent blackbutt (*E. patens*). Jarrah forest is logged on a variable selection system, aiming to use the timber industry as a tool to restructure the forest to achieve higher productivity in the future. During 1983/84, a total of 21,537 hectares was cut over, (57) somewhat less than in earlier years. (3) Cutover forest is regenerated using natural regrowth.

The jarrah forest is affected by the soil-borne root fungus, *Phytophthora cinnamomi*, which causes dieback disease. This has affected 200,000 hectares of State Forest. (3) Dieback can dramatically change the floristic composition of forests, many plants within that community being susceptible to the disease. Any land use activities that involve soil or gravel movements such as roadworks, logging and mining in the forest may contribute to the spread of jarrah dieback. (58)

Quarantine measures were imposed in 1974 over large areas of State Forest in order to monitor the natural spread of disease. Stringent forest hygiene procedures have been introduced to control all earthmoving operations within and outside quarantine areas as measures to control dieback. Researchers are investigating alternative techniques (including ecological approaches) as more permanent means of containing the fungus. (59)

Open-cut mining operations located within State Forest involve the direct removal of vegetation and thus visually degrade the immediate forest landscape. Areas mined for bauxite have been rehabilitated for many land uses including timber production, water protection and recreation. (60) Water management to prevent stream pollution by silt discharged from mine pits is being controlled through use of mechanical and vegetative filters. Dieback spread from mine pit to surrounding forest is minimised through careful haul-road design and use of transported soil.

Early efforts at rehabilitation of bauxite mining areas were less effective, but recent rehabilitation programmes have resulted in more vigorous and diverse plant communities which encourage fauna to return. (61) Revegetated minesites are planted with at least 50 percent Western Australian species. Although jarrah is not planted because of its prolonged lignotuberous phase and susceptibility to dieback, it is seeded into rehabilitated pits. Assessment of successful rehabilitation needs also to consider whether functional ecological relationships have been restored.(56) Rehabilitation of coal, tin and mineral sands mining sites affect smaller areas of forest but remain a source of concern to some members of the public. (3)

Bauxite mining is recognised as a potential cause of dieback spread in the jarrah forest. "No formal measurement of expansion of disease during mining and rehabilitation has been attempted, but observation shows that both spread and intensification of disease occurs." (Ref 61 p 36). Without precise monitoring of the effect of bauxite mining on the spread of jarrah dieback, it is difficult to determine the effectiveness of hygiene procedures

undertaken in mining areas. (56) This criticism is applicable to other earthmoving operations conducted within the Disease Risk Area of State Forest. A total of 148,000 ha of forest dominated by karri remain in State Forest. Over a large part of this area, karri occurs in mixture with marri. Forest management favours the regeneration of karri rather than marri and establishes a broad range of age classes of karri from which a maximum sustained yield can be achieved. It is hoped that this will be reached by about 2080. (62) However, this sustained yield will be less than that which could have been achieved from the original extent of the karri forest before clearing for agriculture.

The area of karri-type forest for wood production is managed as a clear felling system with all cutover areas regenerated either by natural seedfall from seed trees, by sowing seed or by hand planting of nursery raised seedlings when insufficient seed is available. During 1983/84, a total of 1,487 ha were clear felled. However, in the winter of 1983, a total of 2,294 ha of karri were regenerated; 600 ha by natural seed fall, 256 ha by sown seed and 1,448 ha by planted seedlings. (57)

The concept of sustainability should not be confined solely to timber yield but should be applied to sustainable forest ecosystems. For example, a vigorously growing stand of young karri may represent high production of timber, but will present very few refuges for hole-nesting birds and mammals. A mosaic of stands of widely differing ages is recognised as providing a sound ecological basis for management.

Sawmilling recovery is generally in the order of 30 to 40 percent of log volume. The State, together with industry, could do more to improve timber extraction, conversion and utilisation.

In 1975 a woodchip industry commenced operations in the Manjimup area (under the Wood Chipping Industry Act Amendment Act 1973), using hardwood forest residues that were formerly burned as waste. There are now plans for a new woodchip industry in the area between Albany and Walpole along the south coast. The principal justification of the woodchip industry (according to ALP State Platform, 1984 p 37) (63) is that when practiced in conjunction with sawmilling, it permits the use of silvicultural techniques which enable the regeneration of the forest. *Woodchipping properly applied as a management tool utilises poor quality timber and improves the timber producing efficiency of regenerating forests. However, irrespective of the philosophical justification of woodchipping, the scale and effectiveness of this management technique in practice requires close consideration.*

Dedicated State Forest continues to be given up to localised demands for agricultural land. In most instances the parcels of land being released do not carry commercially useful timber. However, the natural vegetation on these sections of dedicated State Forest may include habitats or functions of greater long-term value than either agriculture or timber production.

Further pressures on native forests arise from 'experimental' logging on stream and road reserves, and from clearing for public and other utilities. Forest areas are traversed by numerous road and rail links, powerlines, pipelines and various service corridors, with over 100,000 ha having been cleared for public utilities in the last 20 years. (3) In addition to the permanent loss of forest resources, the establishment and maintenance of utilities increases the risk of infecting larger areas with forest disease.

The multi-purpose value of State Forests is well recognised by management, (3) though the task of rationalising conflicting demands continues to present challenges. Management plans for the State Forest are determined after extensive consultation with government agencies and industry, with broader community interests also being considered. (3) This wide contribution to policy formation is vital but so far has been largely informal.

Apart from State Forest, some 20 percent of the residual native forest is in private ownership, mostly on farms.(3) The retention of remnant vegetation on farming properties has high conservation values although there are few incentives for maintaining natural landscapes on freehold land (see Section 3.6). Available advice concerning tree planting and management of natural areas on rural properties is limited, (23) and there has been little research on forest management at the farm scale. (3) The recent proposal for a woodchipping operation between Walpole and Albany would rely heavily on cropping remnant forest on freehold land.

Within both State Forest and forested private land, the retention of cover is also recognised as vital for safeguarding potable water resources (see Section 2.2), and for this reason clearing controls have been placed on forest land in a number of catchment areas. (3) Clearing of the natural vegetation in the Southwest of the State has resulted in most streams becoming too saline for water supply (see Figure 1). In addition to agricultural clearing, open-cut mining and rehabilitation, (61) and dieback (59) also have the potential to affect water resources in salt-prone areas of the Southwest.

Plantations of exotic softwoods are being established in the forest estate as a supplementary source of timber for Western Australia. The planting of 2,207 hectares of pines during 1983 brought the total area of pine forests on State land to 57,050 ha. (57) A further 12,000 ha of pines are on private land. (3) On present long-term plans, the total amount of pine forest is likely to stabilise at about 100,000 ha, representing five percent of the total area of State Forest. Pine forests allow time for natural hardwoods to regrow, and permit areas of native forest to be taken out of production. (64) However, softwood plantations introduce major new environmental problems (eg fire, drainage, and soil acidity), and restrict habitats for native wildlife.

In summary: having such a paucity of natural forests (less than one percent of the State), which are in close proximity to the major population centres with their various demands (water catchments, timber, food growing, recreation needs, etc), and which also straddle valuable mineral resources (bauxite, tin, gold, coal), our forests are under severe and conflicting demands. Usage to date has certainly exceeded sustainable rates, while demands and pressures continue to increase.

Recognising that a very limited (and shrinking) resource is under such diverse (and increasing) pressures, we must face the fact that it is no longer possible to satisfy every demand being made on our forest ecosystems. More emphasis should be given to managing demand (ie less wasteful use of our timber resources). Greater reliance will also have to be placed on imports of timber, though this only transfers environmental problems elsewhere.

Clear and publicly understood and accepted policies for Western Australia's forests must be implemented. Representative examples of forest systems need to be preserved as part of the National Estate (in a National Park and Nature Reserves system) to accommodate the more passive functions. The remainder of the State Forest must be managed efficiently to meet multiple use demands, on a sustainable basis. Remaining natural forests standing on private land have conservation value, while the re-establishment of further forests on cleared land would reduce pressures on natural forest ecosystems.

3.8 WILDLIFE

Western Australia has a rich heritage of plants and animals in terms of number and diversity of species. Many occur nowhere else in the world, and in some cases the State is the last refuge for species which once occurred widely across Australia. The State's wildlife has suffered considerably as a result of human actions, and many species and natural communities are in need of active conservation measures if they are to survive.

The modern indigenous vertebrate fauna of Western Australia has been given as 167 species of mammals (including 68 marsupials), 475 birds (including 376 species which breed in the State), 387 reptiles, 68 amphibians and approximately 1,600 fish. (27) (65) The invertebrate fauna is large but poorly known.

The currently recognized flora of Western Australia includes 7,125 species of indigenous vascular plants. For the nonflowering flora of the State, comprehensive checklists have been published only for the larger fungi and lichens, (66) while an earlier checklist of mosses records some 50 species. There are no State lists for algae and mosses. (66)

In recent years there have been considerable advances in the knowledge of species occurring in Western Australia, resulting largely from biological surveys and taxonomic work by the W.A. Museum, Herbarium and the Wildlife Research Centre of the Department of Conservation and Land Management (formerly part of the Department of Fisheries and Wildlife). Western Australian species of flora remain undescribed (Hopper pers comm) along with many species of fauna (particularly invertebrates).

Many species occur only in Western Australia, although the degree of endemism varies widely between groups. For example, 23 out of 24 amphibian species recorded in the Southwest are endemic, as are 50 percent of the State's freshwater fishes but only 21 of its 130 land mammals. (65) Many species of flowering plants (2,472) are endemic to the Southwest of Western Australia. (67) Heathland and woodland areas marginal to the higher rainfall forested region of the Southwest are centres of floral richness. (68) It is in this transitional rainfall zone (average 800-300mm per year) that plant species are at greatest risk (Figure 3). (69)

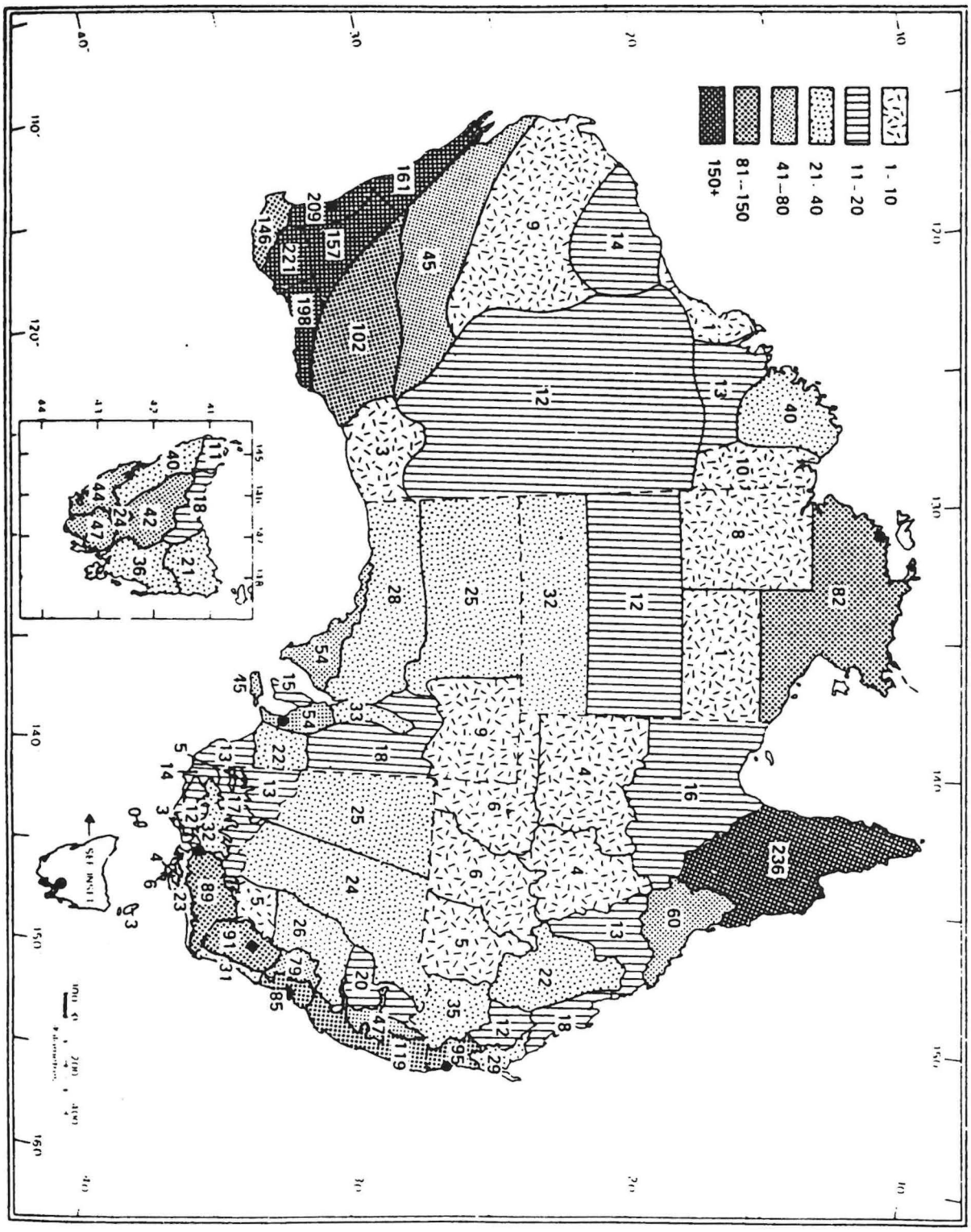

Figure 3. Total numbers of rare or threatened plant species for each region in Australia [69]

The broad distribution patterns of most terrestrial animals can generally be related to major climatic zones. These give rise to three major faunal divisions: a northern tropical fauna adapted to conditions of reliable monsoonal summer rain and dry winters characteristic of the Kimberley: a temperate fauna adapted to Mediterranean-type conditions with reliable winter rainfall and dry summers characteristic of the Southwest; and, between them, a fauna adapted to arid conditions with irregular and variable rainfall that prevail over the remainder of the State. The characteristics of inland waters and coastal waters vary according to factors such as regional climate, geomorphology and physical environment, and their faunas vary accordingly.

Aboriginal use of the land and its resources in Western Australia affected the wildlife, but the flora and fauna can be considered as having been in relative balance with Aboriginal use at the time of European settlement. However, European man has brought about substantial changes affecting many indigenous plant and animal communities. These changes continue to operate today and in many cases are increasing.

Some areas have been burnt more severely than they were by Aboriginals. Changes in fire regime threaten the survival of certain plant species and communities, and there may be a consequent reduction in habitat for animals which require dense or climax vegetation. In the deserts, extensive hot fires have replaced Aboriginal burning patterns which resulted in a tight mosaic of small burns of various ages providing both food and shelter for many animals and preventing the development of large summer wildfires. (70) The effects of these changes have been most evident in the decline of medium-size mammalian fauna.

The impacts of changes imposed by European man have varied widely. Some species appear not to have suffered significantly, and a few may have benefitted (eg red kangaroos and galahs in pastoral country where water has been provided). However, for most species the effect of European man has been to cause reductions in range and population size, to the point where many are endangered and some are extinct. While extinction is a natural consequence of evolutionary processes, the rate of extinction has been increased markedly by human actions.

In the wheatbelt, approximately 60 percent of the species of medium size mammals have disappeared since European settlement. (48) On the arid pastoral lands, at least 20 percent of the mammalian species have disappeared or declined substantially in area of distribution (Burbidge and McKenzie, pers comm). On the vacant Crown Land of the central sandy deserts 22 percent of the mammals have disappeared or declined drastically in distribution.

Already 126 vertebrates are listed under the Wildlife Conservation Act as rare or otherwise in need of special protection, and 11 of these are presumed extinct in the State. Similarly, thorough field studies have led to the declaration under the same Act of 133 plants as rare. Additions to both lists will occur, with a high proportion of the undescribed flora also likely to be rare and/or restricted.

Several factors have led to the extinction or decline of vertebrates in Western Australia. In particular, the clearing of land for agriculture and the draining of wetlands has resulted in the destruction of native habitat, so that very few indigenous species remain in farming areas. Introduced predators (particularly cats and foxes) have had a dramatic effect on native fauna, while competition for food and degradation of habitat by stock and feral animals (eg rabbits), and changed fire regimes appear to be major factors in the decline of indigenous mammals.

For Australia as a whole, 2,206 species of plants are listed as rare or threatened. (69) Of these, 1,024 species or 46.4 percent are from Western Australia. Most (83 percent) of the latter are from the Southwest. From a total of 52 plant species now classified as extinct in this State, 42 (81 percent) were from the Southwest. These figures may be conservative as surveys in the more arid regions are very limited. (69) Only 32 percent of Western Australia's rare and threatened plants are represented in existing reserves. (69) More Nature Reserves may be required, along with a more responsible attitude toward flora outside reserves.

Factors possibly endangering plant species include land clearing, grazing and trampling of native vegetation, recurrent fire and invasion of weeds, diseases, production forestry, commercial exploitation, altered water tables and salinity and altered soil nutrient status. (68) The semi-arid centres of species richness and endemism occupy soils of highly leached nutrient-deficient sands and lateritic gravels; the relatively recent expansion of agricultural development into these heathland areas, following the relatively recent advent of superphosphate and trace element soil enrichment, may constitute a major threat to many rare wildflowers. (68) Another major threat is the dieback fungus *Phytophthora cinnamomi* which is increasingly widespread in the Southwest forests and south coast National Parks and Nature Reserves, with dire consequences particularly for the Proteaceous flora.

Flora and fauna which proliferate and interfere with agricultural and pastoral production, or adversely affect the natural environment, are generally considered to be pests. Various approaches are available to control these pest

populations, including commercial exploitation. In the interests of maintaining an industry, those harvesting pest species work toward a sustainable yield rather than even local eradication. Hence commercialisation of pest species is not an effective means of eliminating introduced pests. On the other hand, it is equally true that commercial operations on a native species that has reached pest proportions are unlikely to lead to its extinction. In all instances, killing should be conducted in a humane manner.

Many introduced species are "declared" under the Agriculture and Related Resources Protection Act 1976 (see Section 3.9), but control work has generally focused where a species is threatening agriculture or pastoralism, with inadequate attention being paid to other situations where native wildlife is being killed or displaced by introduced pests.

Some native species (eg larger kangaroos and various parrots) are also declared under the above Act and so are subject to open seasons and/or to damage licences under the Wildlife Conservation Act 1950, because of perceived damage to primary production. Undoubtedly the heaviest such exploitation is directed at three species of kangaroo: the western grey, the red kangaroo and the euro. In 1985 permits were issued for the killing of 220,000 kangaroos in Western Australia. The three species can generally be taken anywhere within their range, irrespective of the extent of damage being caused locally to agricultural production. However, there is little published quantitative evidence on the extent of the impact of high densities of kangaroos on various forms of agricultural enterprise in the different regions of Western Australia.

Other forms of direct utilisation of wildlife are the commercial growing of many species of Western Australian plants, the commercial trapping of finches and recreational hunting (ducks), while Aboriginals continue to use native plants and animals as food sources. Illegal shooting, trapping and trading of fauna (particularly birds and reptiles) continues to make inroads into native fauna populations and to destroy breeding sites. There is also some accidental netting of aquatic animals during fishing operations.

While the commercial utilisation of native plants and animals can be properly planned and managed on a sustainable-yield basis, some sections of the community believe strongly that the commercial exploitation of wildlife (particularly kangaroos) is morally wrong. All would agree that cruelty towards animals (whether native or introduced) is unacceptable, but that should be seen clearly as a separate issue.

Some might question the importance of the loss of native plants and animals which are not seen to have any direct and immediate economic value to man. A rationale for respect [71] includes:

(a) Ethical: part of our responsibility for stewardship (see Section 4.6).

(b) Ecological: each is important as part of the economy of nature; working units within the ecosystem (of which man is an integral part), necessary for stability and viability.

(c) Unrealised future potential: maintaining a gene pool which may be drawn upon later (eg Pimelea sp extracts now being tested for anti-leukaemia activity).

The Department of Conservation and Land Management is the government agency responsible for the conservation of wildlife throughout the State. The Department aims to achieve this through a combination of wildlife protection legislation; the setting aside and management of wildlife habitat in National Parks and Nature Reserves; responsible management of other public lands and private lands; biological survey and scientific research to improve knowledge of the State's wildlife and ecological processes; and public education and information programmes to generate the vital community awareness of and support for nature conservation.

Wildlife conservation is achieved essentially through the protection and maintenance of habitat. Consequently a major focus of wildlife conservation is the establishment of a system of permanently protected parks and reserves. Although considerable progress has been made in the development of a parks and reserve system for Western Australia, it is still not fully representative of the State's ecosystems, nor is it adequate to guarantee the survival of the State's ecosystems and human users is also essential to ensure the continuing success of wildlife conservation.

Nature conservation should not be regarded as something to be confined to parks and reserves. Much can be achieved for wildlife conservation through safeguarding and enhancing the conservation values of lands outside formally dedicated parks and reserves. State legislation, principally the Wildlife Conservation Act, is aimed at conserving as wide a range of flora and fauna as possible throughout the State. The practical benefits of conservation are becoming increasingly apparent to land managers, particularly in agricultural and pastoral areas where retention of native vegetation is important for soil conservation. However, landholders require financial and technical assistance to maintain the conservation value of naturally vegetated lands in private ownership.

Western Australia has more than 3,000 islands which are of crucial importance for nature conservation. Many islands provide refuges for a number of terrestrial animals that have recently disappeared from the mainland or have contracting distributions. Islands are also important for the degree of endemism in their faunas, and as breeding sites for seabirds, turtles and seals.

Finally, there are national and international perspectives to wildlife conservation. Liaison and co-operation are achieved through avenues such as Western Australian membership of the Council of Nature Conservation Ministers and the Australian Committee for IUCN. Australia participates in the World Heritage Convention and in UNESCO's Man and the Biosphere programme, though there has so far been little Western Australian activity on these. Australia is also involved in a number of international conservation agreements including:

- The Convention in International Trade in Endangered Species
- Australia - Japan Migratory Bird Agreement,
- RAMSAR Convention on the Protection of Wetlands of International Importance.

3.9 INTRODUCED SPECIES

Most of our pastoral, agricultural and horticultural industries are based on introduced species (eg sheep, cattle, wheat, fruit trees and vegetables). However, many introduced plants and animals perform no useful function but have multiplied to become pests. These are widespread throughout Western Australia, occupying agricultural lands, pastoral areas, parks and reserves, coastal lands, urban areas, road and rail reserves. Non-indigenous species can significantly alter native communities, for example, introduced grasses replacing native heath communities. They can also cause serious economic losses to primary industries through loss of production. In Western Australia, the impact of introduced plants and animals is clearly evident on the landscape. Generally species are classed as pests because they threaten primary production rather than for their impact upon indigenous ecosystems.

So far, 18 species of introduced mammals have established breeding populations in the wild of Western Australia [65] as well as 11 species of birds [65] and 838 plants. [66] The total cost to the community has not been assessed. In 1984-85, the Agriculture Protection Board of Western Australia spent $5.8 million on the control of existing pest infestations, and a further $1.6 million was expended from other sources. [72] However, no estimate is available for losses in productivity or less-direct environmental costs.

Pastoral areas have been invaded by many introduced plants including Noogoora burr which is a major threat to the sheep industry, and the prickly Parkinsonia bush which prevents grazing and access to water points. [72] Large infestations of mesquite occur on pastoral stations in the Pilbara. Introduced plants which have become established in agricultural areas include soursob, Cape tulip, blackberry and arum lily. [72] Forest lands in the Southwest have also been invaded by introduced weeds, including blackberry and arum lily, which compete with native plants and may change the environment to the detriment of native fauna. [72] [73]

Feral donkeys, goats, horses, cattle and camels are all well established in Western Australia, particularly in the rangeland areas where they have caused significant environmental degradation and adversely affected the pastoral industry. [73] Damage to crops in agricultural areas has been caused by rabbits and feral pigs. [72] Foxes and feral cats are predators of livestock and poultry, while these introduced animals together with feral pigs also have the potential to spread exotic diseases to domestic animals. [73] Urban and agricultural areas of Western Australia have been invaded by introduced pigeons, rats and mice which are generally considered to be pests. [74]

The greatest emphasis on pest species has been given to their effects upon food production. Insufficient attention has been given to their wider impacts upon indigenous ecosystems. The majority of introduced species compete with native animals for food, habitat or breeding sites, while feral cats and foxes are direct predators upon native species. Veldt grass and wild oats have had a dramatic effect on native heathlands, while Watsonia has adversely affected wetland environments.

Introductions of freshwater snails, weeds and fish have very serious potential as disease vectors, for choking waterways and causing loss of native species.

State government agencies, Local Government Authorities and landholders have had varied success in attempts to reduce the presence of introduced pests in agricultural and pastoral areas, and in the State's system of National Parks and Nature Reserves. Measures to control introduced plants on road and rail reserves and other disturbed sites on public lands have also been implemented. (72) Total eradication of all introduced pests present in Western Australia, although desirable, is an unrealistic objective. (73) It may be more realistic and of less cost to contain a population at a low level rather than to attempt eradication. Investigations of more effective control methods remain an important area of research.

Herbicides are being used to contain introduced weeds, along with burning, slashing and biological control methods. (73) Many modern herbicides are selective in their effects, but the long-term impacts of chemicals used for weed control on humans and other non-target species is largely unknown. (3)

Shooting, trapping and poisoning are the main techniques employed for controlling introduced animals. (73) Commercial use of feral species (eg goats and donkeys) has little impact as a control measure.

Although many introduced species have become pests for which control methods are actively sought, there are some which benefit sections of the community. For example, brown and rainbow trout and English perch introduced into streams of the Southwest provide sport for many fishing people, (3) though aquatic ecosystems are then modified extensively as native crustacea, insect larvae and fish are consumed.

Considerable effort is made to prevent the introduction of new pest plant and animal species to Western Australia.(72) Of particular concern are potential introduced pests such as the starling, which have been recorded but are not established species in Western Australia. A checkpoint is maintained for interstate traffic entering the State via Norseman and animals and goods arriving by air or sea are subject to inspection. (73) However, there remains a constant danger of new plants and animals entering regions of Western Australia where there are no checkpoints.

In summary, environmental problems caused by introduced plants and animals are widespread in Western Australia, but the total cost to our community has not been assessed. An active policy on the control of pest species is generally aimed at the containment of existing infestations and the prevention of further introductions of species have potential to establish as pests. Success rates differ widely; existing or fresh techniques are proving effective against certain species while others are widening their ranges. Continued applied research and field control operations are necessary.

3.10 RIVERS AND WETLANDS

Western Australia is a dry State in the world's driest inhabited continent. In this circumstance, it might be expected that rivers and wetlands would be an insignificant feature of the Western Australian landscape. Such is not the case, especially in the Southwest. The major population centres have within them, or nearby, a range of wetlands of great biological and social significance. Aquatic systems such as the Swan and Canning rivers and the chains of urban lakes are among the most important amenities that Perth has to offer, and are not equalled in other Australian cities.

> However, "Of all the resources of the coastal plain, the rivers, estuaries, lakes and swamps have been most affected by European occupation. They are also the most biologically productive areas on the plain and directly or indirectly support most of its wildlife. More than half a million acres of wetland have been drained for agriculture on the coastal plain and reclamation has claimed 1,501 acres of wetland along the shores of the Swan and Canning estuaries alone. This area was once a valuable waterfowl habitat, and its destruction has drastically reduced waterfowl use". (Ref 75 p 226).

Important and interesting wetlands are not restricted to the Southwest. Because of Western Australia's vast size and range of climatic, geographic and physiographic conditions, it supports a wonderful diversity of streams and wetlands, each major type supporting its own characteristic fauna and flora.

In the past, freshwater wetlands have largely been valued for the rich soil available once they are drained, and rivers for their water for direct consumption. However, their values as aquatic systems are much wider, as discussed below.

The unusual conditions of geological history, climate and isolation have created a diversity of typically Australian streams and wetlands. The animals that occur in, and depend upon, these natural habitats are in many cases as distinct, and as scientifically important, as the better known mammals and birds of terrestrial habitats. Many species of fish and invertebrates of great evolutionary and zoogeographical significance, occur only in Western Australia. Aquatic systems of the Southwest appear to have acted as refuges for some very ancient groups.

Much of the amenity for human use stems from biological processes. Rivers and wetlands are important habitats (especially as nursery areas) for a large number of crustaceans, fish and birds of commercial and recreational value. Unsatisfactory water quality may cause biological reactions, such as the loss of useful species or the creation of algal blooms, which adversely affect recreational and commercial use.

Western Australian rivers and wetlands, including some salt lakes, are important habitats for transcontinental migratory birds, giving Australia a responsibility towards them under the UNESCO Convention on Wetlands of International Importance (1971), to which Australia is a signatory, and also the Australia - Japan Migratory Bird Agreement, ratified by Australia in 1981 (see Section 3.8). However no wetlands in this State are yet on the International List. (76) A network of stopover points along migration routes is required, each with an adequate buffer zone to protect the area from outside influences.

Rivers, wetlands and groundwater are all integrally connected. Wetlands may be surface expressions of the groundwater, or, in their role as natural drainage basins, act as recharge and filter areas for surface water entering the groundwater. They are also important in moderating extreme events, such as floods and droughts, affecting river discharges.

It is important to recognise that streams and wetlands are to a large extent expressions of what occurs in their catchments. Flow regimes, water quality and biological processes, including the input of nutrients, are dependent upon soil type, vegetation and land use in catchment areas.

An increasingly important function of rivers and wetlands, especially in urbanised areas, is that of recreation. Rivers and wetlands provide a pleasant backdrop for a range of activities including sightseeing, bird watching, picnicking, swimming, boating, fishing and water skiing. While some passive, low-impact recreational activities are compatible with maintenance of conservation values of rivers and wetlands, other more active forms may (directly or indirectly) affect the natural environment adversely. The natural and biological features of wetlands will continue to be of immense value for education and research.

Despite the values listed above, at least 75 percent of the wetlands of the Swan coastal plain have been lost by clearing and draining. (77) A similar proportion throughout the Southwest region has been lost, or highly modified by the clearing of catchments and consequent salination.

Furthermore, relatively few land reserves front rivers in agricultural areas. Most of the significant wetlands on the Swan coastal plain are reserved for parks and recreation, and were recommended for conservation and incorporation into regional parks in the System 6 Report. (25)

Many human activities continue to degrade and modify rivers and wetlands. In Western Australia those activities with the greatest potential to damage remaining wetlands are:

- clearing of catchments and resulting salination;
- depletion of groundwater;
- continued draining for agriculture;
- nutrient enrichment from agricultural and urban areas;
- urban development;
- mining/dredging for bed material such as peat, diatomaceous sand etc;
- sedimentation resulting from clearing or disturbance of forested headwaters in the Southwest, and from over-grazing in the north;
- damage by stock of banks and foreshores and of waterholes, soaks and springs;
- pest control measures;
- damming of freshwater rivers and streams;
- pollution resulting from industrial development; and
- fire.

Most of the above potential threats to rivers and wetlands are concentrated in, but not restricted to, the Southwest. The Perth metropolitan region relies heavily on groundwater resources to meet present water demands. The recent substantial increase in groundwater extraction has serious implications for the remaining Swan coastal plain wetlands. Agriculture, urbanisation, industrial development and their resulting pressures on surface and groundwater are expanding in the north and Northwest.

An issue rarely considered in wetlands management is damage and depletion by stock to waterholes, springs and soaks throughout the arid and semi-arid pastoral areas. Many of these small freshwater bodies have been vital resources to Aboriginal populations, and with the contemporary moves to decentralisation may resume some of this importance. They also possess great scientific value, and are crucial to the survival of native wildlife. Natural processes of erosion in the north and Northwest have also been greatly accelerated due to overgrazing by domestic and feral animals.

Dam construction has inundated river valleys thus altering flow regimes, while clearing native vegetation for agriculture in the Southwest has increased the runoff and salt yields of many rivers. Consequently the remaining river and stream segments that are relatively undisturbed are even more valuable for recreation, nature conservation and scientific study.

Several State agencies have direct responsibilities in relation to the management of rivers and wetlands throughout Western Australia. The Water Authority of Western Australia is responsible for the planning and management for all beneficial uses of water, particularly that of human consumption. The Department of Conservation and Land Management (CALM) is the manager of State Forests, National Parks and Nature Reserves, many of which contain important rivers and wetlands. It is also responsible for the protection of flora and fauna, especially the maintenance of species and genetic diversity, throughout the State (including freehold land). The Department of Fisheries manages inland fisheries including marron and trout. Due to the extent of agricultural activity over most catchments, the management responsibilities of the Department of Agriculture (particularly the Commissioner for Soil Conservation) also have an important bearing on the future of rivers and wetlands. The Department of Conservation and Environment appraises new developments which could affect rivers and wetlands, while its recently formed division of pollution control is to assume responsibility for water pollution. The newly formed State Planning Commission has statutory responsibility for land-use planning in the State, including rivers and wetlands.

It would appear that as planning and management bodies widen their outlook from previous single-purpose approaches to multi-purpose use of resources, boundaries as previously defined disappear. Unless there is a clearer re-defining of responsibilities, care of rivers and wetlands may suffer from fragmentation, where many claim responsibility but there is little co-ordination.

3.11 COASTAL WATERS AND FISHERIES

Australia has declared control over the sea around its coast for up to 200 nautical miles. The Australian government controls also the environment of the territorial seas form the 3-mile limit to the 12-mile limit, while the waters up to the 3-mile territorial sea are regarded as the State's own internal waters. Western Australia has the longest coastline of any Australian State, stretching a distance of 12,500 km and encompassing a wide range of marine biogeographic zones.

The marine coastal waters of Western Australia have many beneficial uses, one being a valuable commercial fishing industry. [3] The total gross value of all fisheries rose in 1983/84 to $160 million. [78] The progressive increase has been due to rising product values rather than an overall increase in catches. Major fisheries include the western rock lobster, prawning and the pearl culture industry. A fishery which Western Australia shares nationally and internationally is that on the southern bluefin tuna.

Management of commercial fisheries has improved with the development of a broad data base encompassing fisheries statistics as well as biological and ecological information. [3] Each of the major fish populations which constitute the fisheries of Western Australia is now experiencing heavy fishing pressure, so that the application of measures to control the level of fishing intensity has become increasingly important. These measures include limiting fishing licences, gear restrictions, minimum sizes, quotas and the proclamation of fishing seasons and zones.

However, despite sound management well directed toward sustainable yields, the fishing industry in Western Australia (like others around Australia [79] and throughout the world) is confronted with a serious problem of

adjusting to advances in technology. In the major fisheries of this State, improvements in the fishing power of each unit has reached a point where the combined effect imposes a rate of exploitation which is endangering the breeding stocks upon which future recruitment depend. (80) The simplistic response is to reduce the number of units fishing. But with very limited alternative fisheries, there is nowhere within the fishing industry for the surplus fishing units to move. In short, there are more fishermen than the resources can continue to support. This is not the only primary industry faced with such a problem.

In addition to monitoring direct exploitation of fish stocks, it is equally important to look after the marine environment in order to protect fisheries. For example, intensive trawling operations have the potential to significantly alter habitats on extensive areas of the sea floor. Fishermen observe that species composition of catches change with time as grounds are worked intensively. The impact can be likened to the effects of trampling and grazing on over-used pastoral lands.

Marine coastal waters are part of the fragile coastal zone, which also encompasses areas of land in close proximity to the coastline or estuaries. The use and management of these adjacent lands directly affect the quality of coastal and estuarine waters. Understanding the interaction between the marine and terrestrial environments is crucial for sound management of marine coastal waters.

In protected inshore waters, localised problems due to effluent discharges (eg Cockburn Sound, Princess Royal Harbour) and less direct enrichment-causing eutrophication (eg Peel-Harvey Estuary) are occurring (3) and can be expected to spread. These changes have potential to reduce fish productivity, to contaminate edible species, as well as to diminish the recreational amenity of coastal sites. Considerable research has focused on identification of the cause of these problems with a view to implementing appropriate management strategies, which can be expensive. (81)

Marine and estuarine environments have also been physically disturbed by reclamation, clearing and dredging. In addition, with the development of an offshore oil industry there exists the possibility of accidental oil contamination from exploration and production activities.

With expanded usage as multi-purpose resource, marine coastal waters are under growing environmental pressures. Estuaries and inlets close to Perth are being used increasingly for many forms of recreation including water skiing, boating, amateur fishing, crabbing and prawning, some of which compete with professional fishing activities. (3) Even on the more distant Northwest coast, recent industrial developments, rapid population growth and an expansion of tourist activities have significantly increased pressures on marine ecosystems. Conservation of marine resources is becoming a matter of concern in remote areas where it is difficult to monitor use pressures.

Marine Parks and Nature Reserves provide opportunities for effective protection of the natural environment, including fish breeding and nursery grounds, as well as for compatible recreational use. (55) While Marine Nature Reserves are set aside strictly for conservation purposes, the reservation of a Marine Park may be for conservation and compatible uses (including public recreation). The establishment of a representative system of marine and estuarine protected areas in Western Australia is only in the initial stages, however, with limited biological surveys of marine ecosystems and few areas recommended for parks and reserves. (3)

Protection of estuaries and embayments from adverse human activities is particularly important given their vital role as nursery habitats for many species which may be fished elsewhere. (3) The conservation of mangroves and shallow inshore waters, which provide the only suitable nursery areas for juveniles of a large number of coastal species, should also be given high priority. (53)

The problems outlined above highlight the need to carefully manage human pressures on marine coastal waters, particularly those sheltered areas which are of immense conservation value and which have so many benefits for the community. Management of coastal waters and estuaries in Western Australia, with the exception of fisheries, is largely fragmented with responsibilities being distributed among several agencies. (55) Furthermore, legislation has not been adequate to manage problems of pollution in coastal waters as a result of industry and urban wastes. (3) Planning and management for the coastal zone must also ensure that land use activities are compatible with the adjoining marine environment.

3.12 MINING AND EXTRACTIVE INDUSTRIES

Considered here is the relationship between the development of mineral resources, fossil fuels and industrial minerals (extractive industries), the conservation of living resources and community goals.

Western Australia has rich reserves of iron ore, alumina, nickel, gold, heavy mineral sand, diamond and tantalum which are being developed largely for income form export markets. (82) Extractive minerals including sands, limestone, limesand, clays and shales, hard rock and gravel are used for local building and roadworks. As well as filling domestic demand, supplies of natural gas are to be exported from the North West Shelf later this decade. Production from local oil fields meets part of the needs of Western Australia, but in 1983 51 percent of the State's energy needs were met by imported oil. (82)

Mining activities occur throughout Western Australia, impacting on a range of natural environments, and interacting with a variety of land-use activities including pastoralism, agriculture, forestry, conservation, recreation and tourism. Exploration and mining operations have left obvious scars in some remote areas particularly as a result of the cutting of roads, tracks and seismic lines, and also the illegal use of earth-moving equipment by some gold prospectors. (3)

Open cut mining and quarrying are used to extract a wide range of mineral deposits throughout the State. The concurrent extraction of ores which are widely dispersed can have significant impacts on whole regions. (3) A specific example is the extraction of bauxite in the area of State Forest.

In addition to the actual mining operation, other aspects of mining projects which have environmental consequences include the establishment of townsites, water supplies, power supplies, mine industrial services, ports, conveyors, access roads, railways and refineries. (3) Further processing of minerals may also have a wide range of potential environmental impacts. Poorly managed tailings disposal, for example, can result in land disturbance, dust generation and water pollution. (3) Many of these aspects of mining projects are now subject to environmental controls.

Many mining operations adopt high standards of conservation and rehabilitation, but there are others (particularly some of the gold mining industry) that continue environmentally undesirable practices which will present management problems in the future. The Mining Act is generally adequate to control most environmental aspects of mineral exploitation and mining operations. However, due to insufficient resources the Department of Mines "has not set appropriate environmental conditions on many mining and exploration operations, and it has been unable to adequately enforce relevant provisions of the Act". (Ref 83 p 1) Recommendations made by the Playford Work Party (83) should change this when they are implemented.

The environmental consequences of larger new development projects with total mining in excess of 1,000,000 tonnes are referred to the Department of Conservation and Environment or the Environmental Protection Authority, which recommends conditions for environmental protection and rehabilitation. However, it is not only the tonnage to be mined but also the environment in which mining is to occur, and the area of land to be disturbed that must be considered in deciding on this referral.

Illegal mining operations are of environmental concern as there is frequently no attempt to rehabilitate the ground stripped of vegetation, (83) and those responsible are often difficult to apprehend.

Landscapes degraded by mining activities can be rehabilitated to a pre-determined land form or to accommodate a particular land use. Difficulties do exist, however, in re-establishing the often diverse range of natural habitats disturbed during mining and in stabilising degraded landscapes. In Western Australia, significant problems of rehabilitation affect a number of mining operations located in forested areas of the Southwest. (3)

For rehabilitation to be successful it must be an integral part of the initial mine planning. "Many of the environmental problems we face today have resulted from a failure to adequately consider and plan rehabilitation when mining was first proposed." (Ref 83 p 32). Conflicting planning issues frequently need to be resolved prior to nomination of the post-mining land use. In Western Australia, such land use decisions should benefit from the preparation of regional plans which are a statutory function of the newly formed State Planning Commission. Detailed land-use decisions should also take account of locally relevant knowledge and up-to-date circumstances.

The Department of Mines compiles and maintains an inventory of known mineral and fossil fuel resources of Western Australia, and geologically assesses the resource potential of areas. (3) In many localities, however,

insufficient ecological data are available for an adequate environmental assessment of mining proposals. Comprehensive ecological data are not only necessary for good land-use planning, but also to assist the successful rehabilitation of areas disturbed by mining activities. This is being partly offset by biological surveys undertaken prior to the start of large development projects. (3)

Conditions applied to minerals exploration and mining on reserved land throughout Western Australia vary widely depending upon the management objectives of the vested authority. (3) Furthermore, procedures for establishing exploration and mining rights in National Parks and Nature Reserves are based on a classification system that does not necessarily reflect the conservation value of a given reserve. (3)

A large number of extractive industries producing basic raw materials for local building and roadwork construction operate in the Perth metropolitan region. (84) Similar but smaller-scale operations (mainly for local use) are scattered throughout Western Australia. These industries can cause localised and unsightly visual scars on the landscape.

It is now standard practice for planning authorities to place conditions on extractive industries development requiring the rehabilitation of excavation sites. (84) Generally, the primary requirement for restoration and rehabilitation is the covering of all excavated areas with topsoil, although other conditions may be written into local authority planning approvals. The State Planning Commission will soon implement its planning policy for basic raw materials in the Perth metropolitan region. An Extractive Industries Committee will oversee the preparation of extractive industry plans by local authorities to ensure that the removal of materials takes place within acceptable environmental and amenity standards. (85)

Onshore petroleum exploration activities have been criticised in the past for the bulldozing of seismic and grid lines which have sometimes been unnecessary. Offshore petroleum exploration and production are a potential cause of environmental damage because of the risk of oil spills. (3) Regularly updated contingency plans, preventive procedures and a system of environmental reporting based on the proximity of projects to sensitive localities are currently used to successfully manage offshore petroleum activities. (3)

Various sectors of the mining industry are actively attempting to protect and rehabilitate the environment during their operations. However, much more could be done to protect areas of high conservation value, and to restore areas degraded as a result of all exploration and exploitation throughout Western Australia.

In our nationwide commitment to the twin objectives of sustainable development and conservation, there is a need to recognise that mining is not automatically the best or most appropriate land use for an area. In all land-use planning it must be demonstrated that mining is the most desirable land use option environmentally and socially, as well as economically, before being allowed to proceed.

4. SOCIETY'S ROLE: ITS NEEDS AND IMPACTS

4.1 QUALITY OF LIFE

While the centrepiece of both the National and the State Conservation Strategies is sustainability, the most important social requirement is to optimise the quality of life. This is one of the major goals (25a) set out in the National Conservation Strategy for Australia. (2) In fact, this concept is built into the definition of development as given by both the World and National Strategies, in that development is "... the modification of the biosphere and the application of human, financial, living and non-living resources to satisfy human needs and *improve the quality of human life*" (italics added) (Ref 1 Section 1.3)

Increasing affluence in the availability of goods and continued increase in consumption of resources do not in themselves guarantee further enhancement of the quality of life (irrespective of the other vital question of whether such increases are sustainable). It is important here to distinguish between quality of life and the standard of living. The latter can be measured in terms of the total consumption of resources. Clearly, within impoverished communities, there is a very real need to raise the standard of living to meet basic necessities of food, shelter and health. But once these essentials are available, it is questionable whether there is a correlation between affluence and quality of life.(86) The progression of society from concern solely with survival, to a focus on quality of life is well summarised by Tyler Miller (87) in Table 3.

Table 3. The stages of cultural and ecological evolution in human society. (87)

Characteristic	*Primitive*	*Frontier or Industrial*	*Spaceship*	*Earthmanship*
Relationship to nature	Man in nature but controlled by nature	Man vs. nature: increased control	Man vs. nature: attempt at complete control	Man and nature: Selective control
Goals	Survival	Survival, high standard of living	Survival, high standard of living	Survival, high quality of life
Method	Try to secure enough food, clothes & shelter to stay alive	Produce, use, acquire as much as possible in one's lifetime	Complete technological and social control of nature and man to avoid exceeding the limits of the earth	Selective control based on ecological understanding, diversity, harmonious collaboration, and to avoid exceeding limits of the earth
Social units	Individual, tribe	Family, community, corporation, nation	Family, community, earth	Family, community, earth
Reward	Staying alive	Profit, efficiency, power	Survival, comfort, power	Survival, joy, a purpose to life.
Population	Reproduction to survive	Reproduction determined by economic & social	Reproduction controlled by the state factors	Reproduction controlled by a balance of voluntary action and mutual coercion through laws
Environmental quality	Not always a meaningful idea	A free good to be used and abused at will	A basic concept of critical value	A basic concept of critical value

There are inextricable links between the natural environment and social and economic behaviours. Recognition is dawning that the values and lifestyles of a particular society will largely determine the quality of the environment in which it lives.(88) *With a range of social changes to be faced within Western Australia (and in Australia as a whole), there is scope to stimulate community awareness about the set of values that will carry us into the 21st century. In this respect, it would be worthwhile to identify, assess and rank the factors considered to contribute to a high quality of life.*

Such an exercise was commenced by the US EPA in 1973.(89) It was quickly evident at this symposium that Quality of Life is a personal expression of one's sense of well-being. It was also quite clear that much more than economic welfare is involved. In a very real sense, it expresses that set of factors which, when taken in aggregate, makes the individual happy.

While the US EPA symposium focused initially on drawing from the concept of a set of indicators which might be applied by decision makers with some reliability, the exercise quickly demonstrated a more immediate value. Participants found themselves faced, for the first time, with questions of their personal values and priorities. They needed more time to sort out their own motivations and objectives.

During the symposium, the difficulties in agreeing on the selection of a comprehensive, yet precise and manageable list of factors, precluded any quantification of Quality of Life. Further, it was questioned, not only whether the concept **can** be quantified, but also whether that **should** be attempted.

Nevertheless, the symposium agreed on the value of a set of Quality of Life indicators as an educational device to stimulate community awareness rather than as an immediate input to the planning process. A list of 47 factors was developed, grouped into three areas; economic, political/social and environment. The exercises in ranking of factors, carried out during the symposium, indicated that for those participants, economic factors were well to the fore in the top ten, with environmental factors tending to be ranked lower. That may reflect the stronger promotion of a consumer ethic than an environmental ethic within that community. It would be interesting to know whether rankings changed later as participants had more time to reflect on them.

During the process of examining perceived values and exploring their implications, it is quite possible that factors initially thought important to one's quality of life might be relegated in favour of others. Furthermore, if asked to rank these factors again at another time, an individual would probably assign somewhat different priorities. Individuals or groups within a localised community are also likely to differ in their perception of factors important in contributing to quality of life.

This is not to suggest that it is hopeless to attempt to describe the concept of Quality of Life in a manner that has some meaning for decision makers in the long-term planning of societal development. Rather, it indicates that considerable effort is required to disentangle the concept to the point where it has decision-making relevance.

If the process of identifying factors important for Quality of Life could be encouraged and guided towards a sharpening of the indicators to be applied, a community might shape its own requirements for the future and thus pass clearer signals to decision makers.

Clearly, the process could be developed further in Western Australia, so as to identify quality of life values which are important to our community. With a greater range of options now available, the challenge today is to select wisely from the opportunities presented by rapidly advancing technology, to move towards activities and lifestyles that are both sustainable and also maintain (or restore) a high quality of life. This could be summed up as moving from a consumer to a conserver society.(90) *This represents a change in direction rather than stagnation. It calls for social, ecological and environmental factors to be included with economic aspects in achieving and maintaining a high quality of life.*

Recognising that quality of life values and priorities of a community may well shift with time, long-term strategies need to have regular review processes to be adapted accordingly.

4.2 RESOURCE CONSUMPTION

The Western Australian community generally enjoys a high standard of living, with resource consumption having increased steadily since initial European settlement. However, the National Conservation Strategy recognises that continuous growth in per capita demand is inconsistent with the maintenance of essential ecological processes and life support systems. Even if reactive responses such as pollution control and environmental rehabilitation are

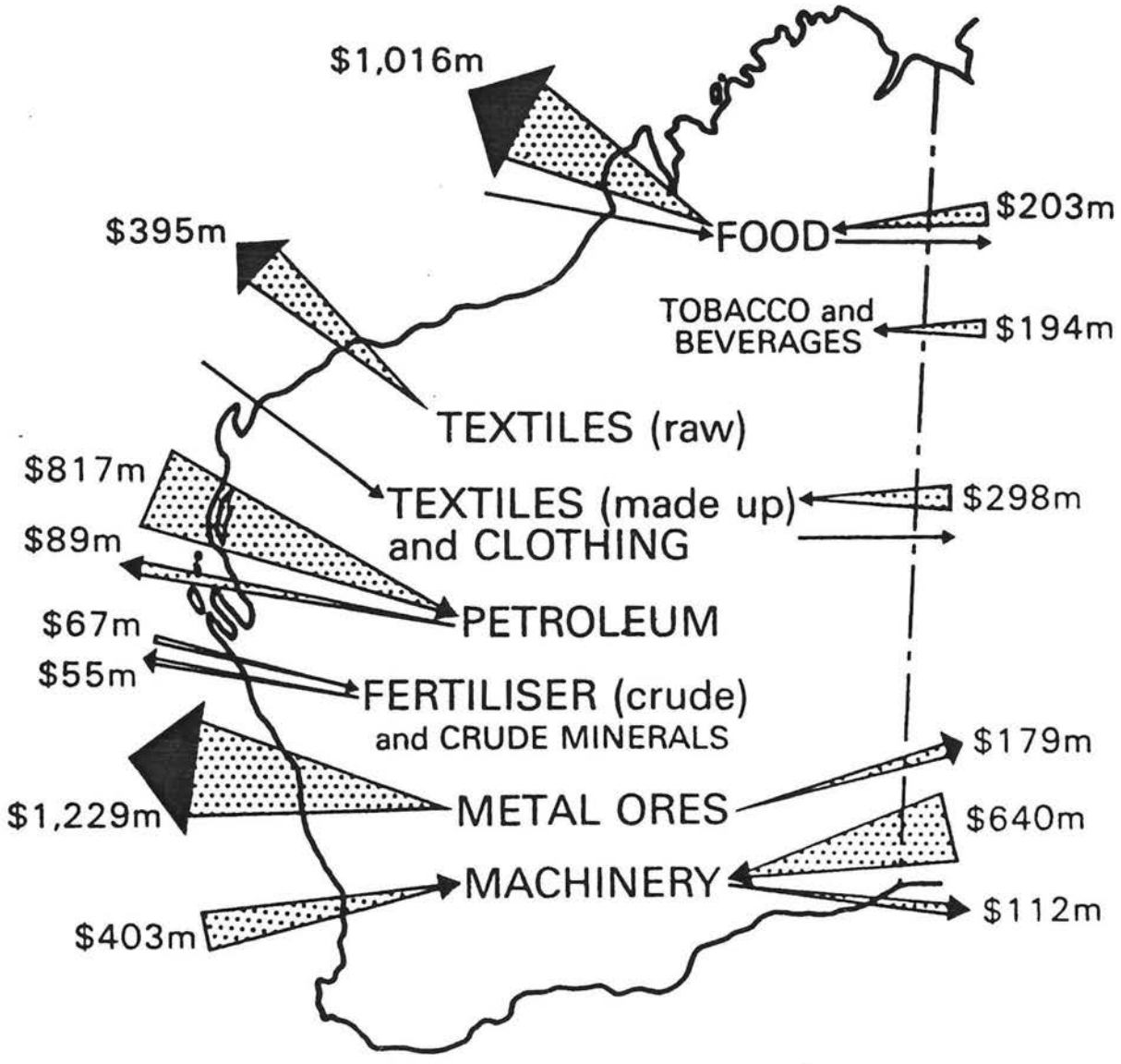

Figure 4. Western Australian trade 1981-82 (from W.A. Yearbook, 21, 1983)

effective in the short-term, a phase must be reached where rising consumption of resources exceeds the capacity of our environment and ecosystems.

In keeping with the directive of the National Conservation Strategy to focus on causes as well as symptoms, a long-term strategy should be designed to move towards stabilising resource demand. This might be approached by reducing per capita consumption, by stabilising population, or by a blend of both.

Western Australia's small resident population is not a real measure of total people-pressure on our environment. Included should be all those people overseas who consume our wheat and meat, and use our timber, wool, iron, bauxite, nickel and other resources. Conversely, it should be recognised that primary production in Western Australia is very heavily dependent on imported fuel, chemicals and machinery (Figure 4).

Domestic water consumption in Perth affords an example of how a community might conserve a resource by voluntarily reducing per capita consumption without diminishing the quality of life. In 1977, pressed by low levels in reservoirs due to drought, Perth residents responded to a call for a reduction in demand by dropping per capita consumption of water (Figure 5). This economy was subsequently offset by an increase in private bores so that the overall per capita domestic water consumption is now higher than ever. However, in a recent survey of domestic water use in Perth, the Water Authority of Western Australia found that most householders believe they could reduce their level of water use but few are actively seeking to do so. (91)

Restraint in water use is particularly important given the limited supply available to support a growing population. Conserving water may be achieved by persuasion (eg convincing people to replace lawns and north-temperate gardens with drought resistant native plants and not to over-water), by coercion (eg, metering and charging for water used by private bores), and/or by revising urban planning, as proposed by Kenworthy (92) and Newman. (93)

In the field of energy consumption, opportunities exist in Western Australia for conserving energy and for diverting to renewable energy sources in a number of sectors. Energy savings are possible in the transport (through urban planning; efficient public transport systems), (90) (92) (94) domestic (through the design and construction of house; in the operation of house and appliances used in it), (90) (95) commercial and industrial sectors of the community. Pausacker and Andrews (90) estimate that Australia could reduce energy consumption by over a third while maintaining the present standard of living.

The City of Fremantle provides a good example of compact housing and diverse urban functions whilst maintaining a high quality of life for local residents. Initiatives seen within Fremantle relate to housing densities and urban consolidation, the mixing of work places in with housing, and the promotion of alternative forms of transport. Fremantle demonstrates the opportunities available to local government and other planning authorities to actively pursue more resource efficient urban forms. (93) (94) The entire Perth metropolitan region could become more resource efficient through a process of urban consolidation based on appropriate land-use planning and an efficient transport system.

Perth is one of the most car-oriented cities in the world and is therefore bound to a large supply of oil (or some substitute fuel) at a reasonable price. (92) The continued growth of the Perth metropolitan region along the urban fringe is responsible for increasing the travel distance of all trips. Furthermore, the dominant transport policy in Perth is a continual process of attempting to eliminate all restrictions in traffic flow with the result that more cars use the road, energy consumption increases and public transport becomes less and less effective. (92)

Despite adequate supplies of energy to meet existing demands in Western Australia, it would make good sense to continue moving away from dependence on non-renewable energy sources (especially imported fuel) which in the long term must become scarcer and more expensive. New Zealand has already decided to move away from imported oil as the major energy source. (96)

A wide range of alternative energy sources are available, although further research is required to determine their use potential. The Western Australian government has supported and encouraged renewable energy programmes, with a particular focus on solar energy. This support was to be broadened to encompass energy research in its widest sense, thereby also encouraging energy conservation and selective fuel usage. (97) Amongst alternative energy options, solar energy for heating water is already used by many Perth households. Western Australia is also rated as having excellent wind power potential, particularly along the 350km of coast from Cape Naturaliste to Albany.(90)

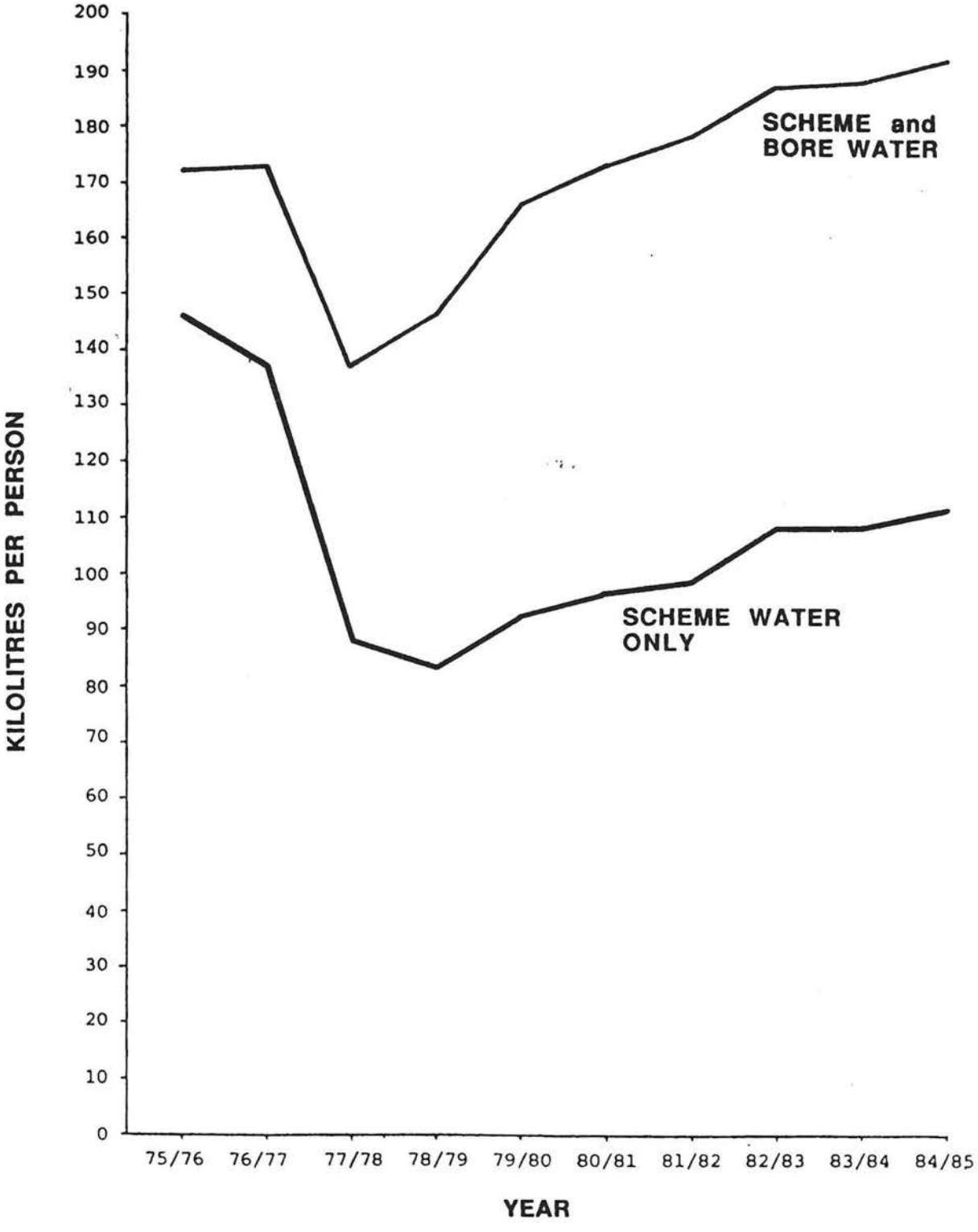

Figure 5. Estimated Per Capita Consumption of Water by Perth Residents each Year.

Conserving other non-renewable resources (eg minerals) is also sound practice in a strategy framed towards long-term sustainability. Not only will this ensure that supplies of non-renewable resources last longer, but will also reduce further environmental impacts of extraction and processing.

In the field of primary production there are also conserver options, and opportunities for adding value to our raw materials by doing more processing. For example, in the case of the timber industry, cured timber for cabinet making is of twice the value of green sawn timber used for building. (98) Many of our exported raw materials could have their values increased through further processing before they leave the State. (41) In addition, diversifying the range of primary products produced locally, focusing attention to more efficient use, and seeking alternative resources, may enable us to lessen our increasing reliance upon imported primary products (eg, timber, finfish).

The consumption of increasing quantities of resources demands efficient waste management and pollution control measures. Waste disposal is becoming an increasing problem in Perth, with a decreasing number of sites being available for waste disposal, particularly in the more populated municipalities. (99)

Recycling is gaining recognition as an alternative to waste disposal. The greatest potential for recycling lies with the category of domestic and commercial waste, of which 350,000 tonnes per annum are generated in Perth. (99) Community awareness about recycling is increasing with campaigns encouraging the use of 'bottle banks' and deposit points for aluminium cans.

Composting of organic wastes may benefit home gardens, parks and agricultural lands. Studies initiated recently by the Perth City Council confirmed the viability of a single composting plant handling domestic wastes from several municipalities in the metropolitan area. Composting would have long-term environmental benefits by increasing the organic content of infertile soils, increasing the capacity of soils to retain moisture and nutrients, and lessening eutrophication of adjoining lakes, rivers and estuaries. Even heavier soils benefit from compost by improved soil structure.

An industrial waste exchange system organised by the Health Department and the Keep Australia Beautiful Council (Western Australia) is having considerable success in recycling materials.

In Western Australia there is considerable scope for restraining resource demands and applying a more prudent approach to resource use without sacrificing high quality of life. In particular, opportunities are available for conserving water, energy and other natural resources; placing an emphasis on more durable goods; and for recycling materials.

4.3 POPULATION

In simple numerical terms, Western Australia has a low population density, with a resident population (in 1983) of 1.374 million in an area of 2,525,000 km^2 giving an overall mean density of 0.54 persons per km^2. Even at the projected growth of the State's population to 2.184 million by the year 2011 (100) the average density would reach only 0.86 persons per km^2. However, because most of the State is very arid, such statistics have little ecological significance.

In effect, Western Australia already supports a higher population than the present 1.374 million residents, through impressive exports of primary products. However, this could not be achieved without continued imports of fuel, the ingredients for fertilizers and pesticides, machinery, etc.

The net impact of people on their environment is not determined only by numbers, but involves a combination of population size and distribution, the standard of living (per capita resource demand) and lifestyles, and the capabilities of the land systems.

As we have made a commitment to achieve sustainability in an environment of limited carrying capacity, choices have to be made eventually between a modest population with a high per capita resource consumption, and a high population with a lower standard of living.

By a concerted and determined programme of rehabilitation of soils and water, together with improved land management and diversification of primary production, further growth in population might be sustainable even at present rates of consumption. However, bearing in mind the long lead time in effecting change, should not a

policy on population be forged now? To delay may mean that the greater population, concentrated in favoured locations, will have to accept a lower quality of life.

In shaping population policies for Western Australia, we should examine carefully the actual need for more people, rather than persisting with the subconscious attitude of accepting whatever growth that may occur. With a rapidly advancing technology which requires fewer and fewer people to produce more than enough consumer goods [101], and with increasing acceptance of a significant proportion of the population unemployed, there is little case to support a necessity for continuing population growth - apart from the repetitious cycle of increasing consumers to produce a demand (if employed) for the excess goods - a direction which is not sustainable in the long term.

If we base our predictions for future population growth on an extrapolation of past and present data [100], planners will then be obliged to accommodate such expected growth. This tends to become a self-fulfilling process, hardly affording a workable framework for a long-term strategy centred on sustainability, in an environment of limited carrying capacity.

We are at a point where a fresh direction is desirable. Instead of fostering population growth locked into a consumer-based economy, we should put more effort into promoting fresh and satisfying occupations for both the unemployed and the alienated employed, so as to diversify and enrich the quality of life throughout the community .[41]

Data collected for the 1981 census show that Western Australia as a whole has an annual growth in population of 2.30 percent, which is higher than in other Australian states. The rate of population growth in the Perth Statistical Division, however, is 2.63 percent, reflecting a widespread trend across Australia and elsewhere during recent decades for population to move from rural to major urban centres. [101] Perth now contains more than 70 percent of Western Australia's population.

In a move to provide an urban alternative to Perth, the government is pressing ahead with the "Bunbury 2000" plan. As discussed by Professor Appleyard, [102] the expected doubling of the population in that region within 15 years will clearly change the distribution and intensity of pressures on resources and the environment.

Although Perth is gaining in numbers from people leaving the wheatbelt and pastoral areas, there is now an exodus from Perth to smaller centres in the Southwest Statistical Division. Data grouped from eleven centres in the Southwest (Croft pers comm) show that from 1976 to 1984 the population grew at an annual average of 3.61 percent. Many people leaving the city are skilled tradesmen and professionals. Some had moved previously from the wheatbelt to Perth. One of the beneficial effects of this distribution of population is the diversification of small industries appearing within these smaller centres of the Southwest. Overall, employment in these centres increased during the past eight years by an average of 3.91 percent per annum, ie faster than the rate of growth of the population. This indicates a multiplier effect of diversification.

The recent movement of people from cities to more attractive rural areas is taking place across Australia. Scott Williams [103] estimates that 60,000 have already resettled, while at least 100,000 people are seeking to move. So far this natural movement has not been planned by government. There is scope for more positive responses to the aspirations of the community in fostering decentralisation and diversification where this is sustainable.

Tourism is a special feature of population growth, as it consists of short-term pulses of growth by the influx of visitors to a region, greatly increasing pressures within that area. The economic potential of tourism is clear.[104] Increasing available income and leisure is expected to allow more time on tourism. During 1983-84 there were 4,847,000 intra-state travel movements by the Western Australian population, at an estimated expenditure of $750,000,000.

The immediate target in developing tourism appears to be the fostering of economic investment in first-class hotels, airports, roads and other facilities to meet the basic requirements of mass tourism (comfort, relaxation, ease of access, etc). However, as pointed out by Pearce and Moscardo [105], various levels of motivation can be identified amongst tourists, ranging from basic escape and relaxation, through renewing relationships with the environment, to self-development and self-actualisation. Not only should the quite different needs of each level be considered, but also an effort made to lead individuals from one level to another. This should be part of a wider policy of promoting an environmental awareness and shaping an environmental ethic (see Section 4.6).

In planning tourist development, close attention must be given to the sensitivity of the environment and to guiding activities in a manner which will maintain the natural features attracting tourists. This is vital during the planning phase, but it is also vital that monitoring be continued after the development to ensure sustainability.

There is scope here for very worthwhile modelling of the factors contributing to the rising demands on our environmental resources attracting tourism. (102) Unless this is done, we shall be in danger of following the path of tourism in Kenya, where the very industry that supported the presence of parks and reserves brought on the destruction of the ecosystems they were set up to protect. (106)

As summarised by Pearce and Moscardo (105):

"The tourism justification for conservation interests can be a good one. It is popular, politically acceptable and even financially rewarding. Its use, however, should be backed up by a thorough research appraisal of the sensitivity of the environment and the psychological profile of potential visitors. Without such planning the tourist justification becomes an anti-conservation monster, devouring natural resources and selectively degrading Australia's best environments."

While the Western Australian Tourism Commission recognises this need for a fit between the environment and the visitor, the rapidity of some tourist developments carries the risk of giving precedence to economic considerations over social and environmental aspects.

As recognised by the National Conservation Strategy, continuous growth in population and per capita demand is inconsistent with the maintenance of essential ecological processes and life support systems. Western Australia's small population has already had widespread and significant environmental impacts. Future population planning for this State must therefore give consideration to the numbers and densities which are sustainable with a high quality of life, in land systems having a limited carrying capacity. "The time has come for man to manage his own population as well as the resources upon which he depends". (107)

4.4 COMMUNITY HEALTH

Although it is difficult to define the term health, available definitions indicate a changing perception of health, from an absence of disease to a more dynamic and complete state which is described as wellness. (108) The development of the concept of wellness has followed the shift in the importance in our society from infectious diseases, to those attributable to lifestyle. Dimensions of wellness include intellectual, emotional, physical, social, occupational and spiritual. Community health, in its broadest sense, encompasses living in harmony with the natural environment of which man is a part and upon which he is dependent.

This dependence is underlined by Iltis, (109) who points out that urban man is physically and genetically adapted to a warm, moist, well vegetated environment in which he only recently evolved. He has had little time to adapt culturally to urban living. His continuing dependence on nature is demonstrated not only by the commonplace negative association of ill health with crowded cities, but also from the well-documented therapeutic effects of the out-of-doors on the mentally ill.

Major factors affecting health are environment, behaviour or lifestyle, medical care and heredity (human biology), with the best results being achieved when there is a balance between these factors. Community health is thus seen in the holistic sense.

There has been a dramatic improvement in the physical health of Western Australians in the past 150 years. (108) Improvements in hygiene, nutrition and the general standard of living since the turn of the century are reflected in the dramatic decline in the infant mortality rate, and the improved life expectancy. Further containment of infectious diseases in Western Australia depends on the continuation of a favourable environment, high rates of immunisation and widespread availability of treatment.

In our northern region the monsoonal conditions during the summer months, and the formation of Lake Argyle and Lake Kununurra, are conducive to the build-up of mosquitoes and midges in the main Kimberley towns. Concern has been expressed about the potential for mosquito-borne diseases such as Arbovirus occurring in the region. (110) Control strategies are regularly implemented to help reduce the population levels of mosquitoes.

Western Australia is generally regarded as a healthy community. However, many people die prematurely from causes preventible by environmental or lifestyle changes. (108) The proportion of deaths due to infectious diseases, as compared to those related to lifestyle causation, has been reversed during this century. Major health problems in Western Australia today include cardiovascular disease, motor vehicle accidents, social and mental

problems and malignant diseases, all of which have lifestyle and the social environment as major components of their causation.

Land-use planning can also have an impact on human health, especially through the location of industrial activities which may pollute the environment. Providing parks and areas of green open space can make a positive contribution to the physical and mental well-being of a community.

Effective action must be taken to relieve psychological as well as economic pressures currently affecting many rural areas of Australia, including farming communities in Western Australia. These pressures have implications for the overall well-being of rural communities throughout the State.

Unemployment is presently a serious factor in contributing toward social disruption and impairment of community health, especially amongst youth. Clearly, strategies integrating conservation, development and employment will be reflected in better community health. (41)

Chemicals make an important contribution to modern society. (50) Fertilizers and pesticides have been the cornerstone of improved food production. The net sales of agricultural chemicals in Western Australia now exceeds $62 million per year. To this should be added the hidden long-term costs to the environment or to community health. The long-term effects of pesticides (Western Australia sales in 1982 exceeding $36 million) on local ecosystems and community health are not known, as monitoring of flora, fauna, soils,water and people has not been very extensive in this State. High levels of pesticide residues have been recorded in aquatic food chains of the Ord River (111) and to a lesser extent in the Preston River. (112)

Chemicals are also central to the operation of many modern industries, and provide many materials in wide use today. Many chemicals, however, have the potential to adversely affect human health and/or the environment, particularly if they are incorrectly used or accidentally spilled.

Throughout Australia, there has recently been a great deal of activity to rationalise and improve chemical controls so as to minimise harmful exposure to people and the environment. Of some concern in Western Australia is the use of industrial chemicals which is still largely unregulated. (50) Requirements for labelling, indicating methods of use, first-aid and clean-up procedures are most necessary.

Health hazards are also present in some working environments although more recently there has been increased emphasis on occupational health in Western Australia. (108) More stringent noise regulations should reduce work-induced deafness in the future. Additionally, the hazards of substances such as asbestos and the need for safe handling of many chemicals are now being recognised. However, contamination from chemicals used in everyday household functions is becoming of increasing concern to the community. (113)

In Western Australia, a number of health problems such as infectious diseases have largely been controlled so that by world standards we must be regarded as a healthy community. However, we are increasingly faced with health problems attributable to environmental and lifestyle causes. Many of these chronic diseases are preventible. Recognising the close link between health and the environment, we should seek lifestyles which maintain environmental quality, so promoting community health and the quality of life.

4.5 ENVIRONMENTAL PLANNING AND MANAGEMENT

At times the overlapping of these two processes has become blurred. Planning provides the direction; management provides the means by which those objectives will be implemented. During recent times there have been many advances in environmental management within Western Australia, largely by reacting to specific issues and projects. However, environmental planning in the broad sense has lagged. There is a growing awareness of the need for long-term environmental planning within which the more specific management activities may relate.

The careful allocation of land to appropriate uses is necessary in order to promote sustainable use of the environment and to minimise the costs of environmental management. To this end, land suitability analysis (the evaluation of specific or alternative locations for a particular use) should be an integral part of all land-use planning in Western Australia. This will mean that in some areas of the State it may be necessary to rethink (and perhaps reverse) previous decisions on land use-allocation, for example in certain agricultural and pastoral areas.(114)

A comprehensive data-base which includes resource, environmental, social and economic facets is essential for assessing proposed projects and activities. (115) Whole systems (and regions whose systems are governed by common processes) need to be considered rather than assessing each land use separately. Also, it is not possible to manage the economic portions of ecosystems on the tacit assumption that these can continue to function without the non-economic parts. (116)

Regional environmental planning is the key to integrating conservation within the planning process. (117) Such an approach in Western Australia might utilise the four broad ecological regions identified by Tinley (118) from a combination of climatic features, physiographic and vegetation formations and water catchments.

Regional land-use planning throughout Western Australia is to be undertaken by the Metropolitan Planning Council (appointed along the lines of the previous Metropolitan Region Planning Authority) and the Country Planning Council (covering eleven country planning regions) established as part of the newly formed State Planning Commission. The Department of Regional Development and the North West has established a number of Regional Development Advisory Committees, covering all rural areas of Western Australia, to advise and assist in the co-ordination of developments and overall long-term planning in each region.

Carefully considered guidelines on regional land use planning are needed to provide a framework of reference for Local Government Authorities as well as for departments managing lands dedicated for specific purposes. Local Government Authorities are an important instrument for facilitating environmental planning and management, particularly through their town planning schemes which can specify environmental objectives. In addition, by-laws (eg for extractive industries) may have explicit provisions for environmental management. (114)

Environmental management in Western Australia has often been reactive, which in part reflects environmental problems inherited from past decisions and practices. (114) Symptoms have been dealt with on a one-off basis, each considered in isolation from its source, in an attempt to find immediate solutions for day-to-day environmental problems. (118) This often results in the entrainment of further, unanticipated environmental problems.

There has also been a tendency in Western Australia for environmental management to focus on highly visible impact developments (eg open-cut mining), whereas great environmental damage may result from chronic but widespread activity (eg poorly managed pastoral lands). (114)

In the case of land-use management there has been a heartening trend away from the earlier style of single-purpose departments and authorities, towards a widening acceptance of responsibility for multi-purpose use of land and waters. The formation of the Department of Conservation and Land Management reflects this wider approach. Management policies on environmental matters are becoming increasingly broadened and integrated through such agencies as the WA Water Resources Council, the Research Co-ordinating Committee and the Coastal Management Co-ordinating Committee (114), though there is scope for further co-ordination.

The private sector has also taken initiatives to apply environmental principles in managing their operations. The Chamber of Mines of Western Australia has prepared an environmental policy for field personnel in the mining industry, while a number of resource companies have "inhouse" environmental awareness programmes aimed at ensuring that all employees and contractors understand what is required. (114)

At the project level, there is a sound framework for environmental management, particularly in the context of environmental impact assessment (EIA). The EPA undertakes this activity for environmentally significant projects to ensure that environmental considerations are afforded an appropriate place in decision-making. (114)

In Western Australia the preparation of Environmental Review and Management Programmes (ERMPs) places a strong emphasis on the environmental management component of project evaluation, and recognises the need for monitoring project effects. In its evaluation of proposals, the EPA takes a particular interest in proposed management strategies, and for major projects may require that the proponent submits monitoring reports on actual impacts and the performance of the management strategies. (114) The State has made few resources available to undertake independent checks (115), although an educated public could provide a valuable role in the monitoring phase of environmental impact assessment. (119) However, this should not be seen to replace the regulatory role of the relevant management body.

Environmental Review and Management Programmes prepared in Western Australia focus primarily on the potential impacts of development on the natural environment. The Commonwealth Environmental Protection (Impact of Proposals) Act 1974 requires that consideration also be given to the social impacts of development in

the preparation of an EIA, but these have not been assessed in any depth by the Western Australian EPA. This stems from the more limited definition of 'environment' in the original WA Environmental Protection Act. (120) The impacts of development on people may well be as important as the impacts on their environment (121) and should therefore be considered in Western Australia.

Public involvement is an important part of environmental planning and management. Provisions already exist for public involvement in some matters of environmental management (eg in EIA; in the preparation of management plans under the CALM Act; in soil conservation matters). However, this involvement could be extended further back into planning, and strategies developed to make it more effective. (114)

Dependence on foreign owned companies for major developments is of concern to some of the local community. While certain of these companies undertake appropriate environmental management, some of the local community feel impotent at the lack of involvement in the earlier planning process. This is reflected in pressures for legal recourse through third-party appeals. Some would cite overseas examples of this as blocking progress; others would view it as a refreshing re-examination of options.

A high priority should be given to providing the public with information about how the environment functions and the interrelationship of conservation and development. An informed public, made aware of their own responsibilities to the environment, is more likely to undertake conservation measures at the individual level.(114)

There is opportunity to plan for development which is socially enhancing and environmentally acceptable. Important in this regard is the concept of maximising unit product value rather than total throughput, as stressed by Sirolli. (41) For example, primary industries could be complemented by an array of small manufacturing businesses utilising local resources more fully.

Employment opportunities may also be generated in conservation and related industries such as National Park management, forest management, reafforestation, alternative energy industries, energy conservation activities and pollution control industries.

In summary, planning and management should be aimed at sustainable development, maintaining environmental quality, and affording widest possible opportunities for meaningful work. When all costs (including social and environmental costs) are assessed in the longer term, such an approach will yield the greatest net gain to the community as a whole.

4.6 ENVIRONMENTAL AWARENESS: SHAPING AN ENVIRONMENTAL ETHIC.

Throughout Australia there is widespread appreciation of nature and increasing community awareness of the need for living resource conservation. (2) Already the residents of Western Australia have indicated a very high level of concern for issues to do with conservation and environment (122), but the Australian community as a whole has still to accept responsibility for the care and conservation of our resources. (123)

Education (in its widest sense) is seen as the key to more enlightened community attitudes which may lead to the adoption of an environmental ethic, a framework of conduct by which people relate to, and care for, their environment. In order to cultivate an ecological consciousness and encourage the practice of wise stewardship, people should be encouraged to:

- appreciate the inherent values of the living and non-living aspects of the environment;
- understand the basic principles of ecology; and
- recognise the interdependence of conservation and sustained development.

Environmental education should also embody the informed participation of the public in decision making and environmental management.

There is a dawning recognition that the values and lifestyles of a particular society will largely determine the quality of the environment in which it lives. (88) *Long-range policy decisions need to be amenable to change in*

the light of shifting quality of life values and priorities. (88) *In Western Australia there is scope to stimulate community awareness about the factors considered important for quality of life, and the direction the community wishes to take. The interest is evident; it is a matter of motivating people toward a scale of acceptable values for which they are willing to work. People have a need "to feel that the plans, the values, the priorities which have been adopted are theirs".* (124)

Environmental education should seek to increase awareness and active involvement in conservation issues, and the adoption of individual lifestyles that are consistent with the concept of sustainability. Furthermore, education also has a role to promote an environmental ethic within the community. It is important that "all who own or use the environment, or who make decisions on its use, are informed about how the environment functions, the need for environmental management and their responsibilities and means of doing so". (114) *Some still regard land as property, entailing privileges but not obligations, ie, a strictly economic relationship.* (125)

The Education Department of Western Australia has a positive commitment to environmental education, with an environmental ethic permeating all curriculum documents. In addition there are several sites (provided in co-operation with other departments and organisations) as centres for environmental education. Theses centres provide accessible locations for hands-on experience in environmental education. (126)

Venues for environmental education at adult level include technical colleges and universities (126) which provide formal education courses as well as interest courses for the wider community. The provision of on-site interpretation facilities and programmes in National Parks and other popular sites (eg the coastal zone) are also valuable opportunities for informing the public about conservation matters.

Murdoch University conducted a survey of more than 1,500 residents in Western Australia to ascertain community attitudes to conservation and the environment. Despite the availability of environmental information and courses in Western Australia, most people surveyed felt that a much greater emphasis should be given to environmental education. (122)

Widespread community concern for the Western Australian environment was indicated by the Murdoch University survey with 57 percent of respondents feeling that we were presently doing irreparable damage to the land; 61 percent felt that the WA environment was deteriorating while only 13 percent saw it getting better. Ninety-six percent felt that for our grandchildren's sake we should be doing more to look after the environment. There would appear to be much scope for developing and fostering an environmental ethic within the WA community with 88 percent of respondents agreeing that a more conserving society will only be achieved by a change in community attitudes. Furthermore, 78 percent of respondents agreed that in order to protect our environment we would all need to change our lifestyles to some degree. Only 16 percent of surveyed residents believed that technology would solve the environmental problems of the future. (122)

Most would agree that we should not hand over to government all responsibility for land and ecosystem management; that we as individuals fail to perform through lack of an environmental ethic.

The Quality of Life concept (undefined as it is) is concerned with the betterment of the human condition, which in our society appears to be inextricably bound up with economic development. Development and the Quality of Life concept need to be brought together to promote the fulfillment of the whole person in relation to the environment in which she/he lives. Thus a broadening of our understanding of "development" is needed. It will be important to pursue this in a personal and communal framework. (88)

The paramount question when identifying a sound ethical basis is whether we view "nature" and "human society" as distinct realms with a dichotomy between them, or whether we see them as facets of the same system. The former view leads to "conservation" and "development" being seen as opposed, and is the view which appears to have dominated the earlier debate in Australia. The latter view sees "conservation" and "development" as mutually dependent activities, a view which is now beginning to be taken seriously. (88) *It forms one of the leading principles of both the World and National Conservation Strategies; and recognises that humanity and nature are inextricably bound together.*

The challenge is thus to plan for growth (giving consideration to the type, rate, direction and quality of such growth) to ensure that the integrity of the environment is maintained. The pivotal question for the community is not whether we should proceed with industry, but what type and quantity of industry and technology is appropriate and sustainable. (88) *Australia could lead the way in the application of appropriate technologies and a steady-state economy which could be both ecologically sound and financially profitable.* (127)

A conserver society, which could evolve from our present society, would develop its economy in harmony with, rather than in opposition to, our environment. Such a society would be based on the ethic of stewardship, a feeling of responsibility for conserving the natural resources as well as our life support systems. (90) *There would still be selective economic growth in a conserver society, along with conservative use of resources and minimal waste production. The cornerstone of an environmental ethic should be a commitment to sustainability.*

5. AN OVERVIEW OF THE WESTERN AUSTRALIAN ENVIRONMENT

5.1 REGIONAL ASSESSMENTS

Having considered separately a range of facets of our environment, these now need to be assembled into an overview as it is clear that within a given area the various facets interact as parts of a whole system called upon to meet a range of human needs. For a regional assessment, the four broad ecological regions described by Tinley [118] will be used (Figure 6).

5.1.1 Southwest Region

While this Region might be sub-divided into an inland farm area, central forests, coastal plains, and marine zones, these are inextricably linked by common processes and pressures. For example, through drainage patterns, changes well inland have effects through to the sea. Also, coastal urban centres exert pressures radiating outward. Hence this winter rainfall region is best considered as a single entity.

Containing the highest diversity of species (many of which are endemic), the majority of the State's population, and supporting the widest variety of uses, the Southwest Region has the greatest range of pressures upon the environment and the strongest competition for resource use.

Soil and stream salinisation is one of the most serious problems of the Southwest. The State's highly productive agricultural industry (see Section 3.5) is largely based on saline-prone soils where extensive land clearing and sometimes inappropriate farming systems (still in use today) have caused secondary salinisation. Rising surface salt is not only taking increasing areas of land out of production but is also increasing the salinity of streams and lakes to the detriment of wildlife and restricting human use. Attitudes and awareness amongst the rural community have been changing, with many farmers commencing revegetation projects. Integrated action through whole catchments should involve all land and water management bodies.

Another environmental problem of this Region occurs in the lower rainfall areas where extensive clearing for agriculture has led to severe wind erosion and loss of top soil. More appropriate land management systems have now evolved (see Section 2.1), but in 1984/85 wind erosion was still costing farmers some $38 million annually (see Section 3.5). Some of this land should not have been cleared for agriculture, yet pressures continue for the release of further uncleared vacant Crown Land to extend agriculture into even more marginal areas. The anticipated trend toward increasing severity of climatic conditions in successive decades adds weight to the existing evidence that much of this marginal land should be taken out of grain production and actively rehabilitated before it is degraded even further.

Throughout the greater part of the wheatbelt, where sustainable production could be maintained in the long-term, continuing input toward retaining soil quality is essential. Decline in soil structure, compaction and acidity, though less obvious at present, may become the most severe problem of these lands in the future.

The farming community working these lands has become increasingly aware of these various problems, with many farmers taking more appropriate action. Increasing economic pressures, however, have not only limited the extent of such efforts but have also pressured towards further clearing and higher cropping rates. Thus while environmental awareness and attitudes continue to sharpen, immediate economic realities take precedence. These circumstances somewhat dampen the optimism for a rapid overall improvement in the condition of agricultural lands in the short term.

Another important aspect of the extensive clearing throughout the Southwest Region is the high loss of plant and animal species. This major problem is often overlooked in a pre-occupation with land degradation problems. The lower rainfall woodlands and heathland (800-300 mm rainfall), a zone originally of very high diversity and endemism, has now been largely cleared. This is of concern, not only ethically and ecologically, but also in that it reduces our options through the removal of unrealised future potential uses, and severely restricts the genetic diversity of species surviving in uncleared islands. National Parks and Nature Reserves provide invaluable refuges for native flora and fauna, but many of our rare and endangered plants are not represented in existing reserves (see Section 3.8).

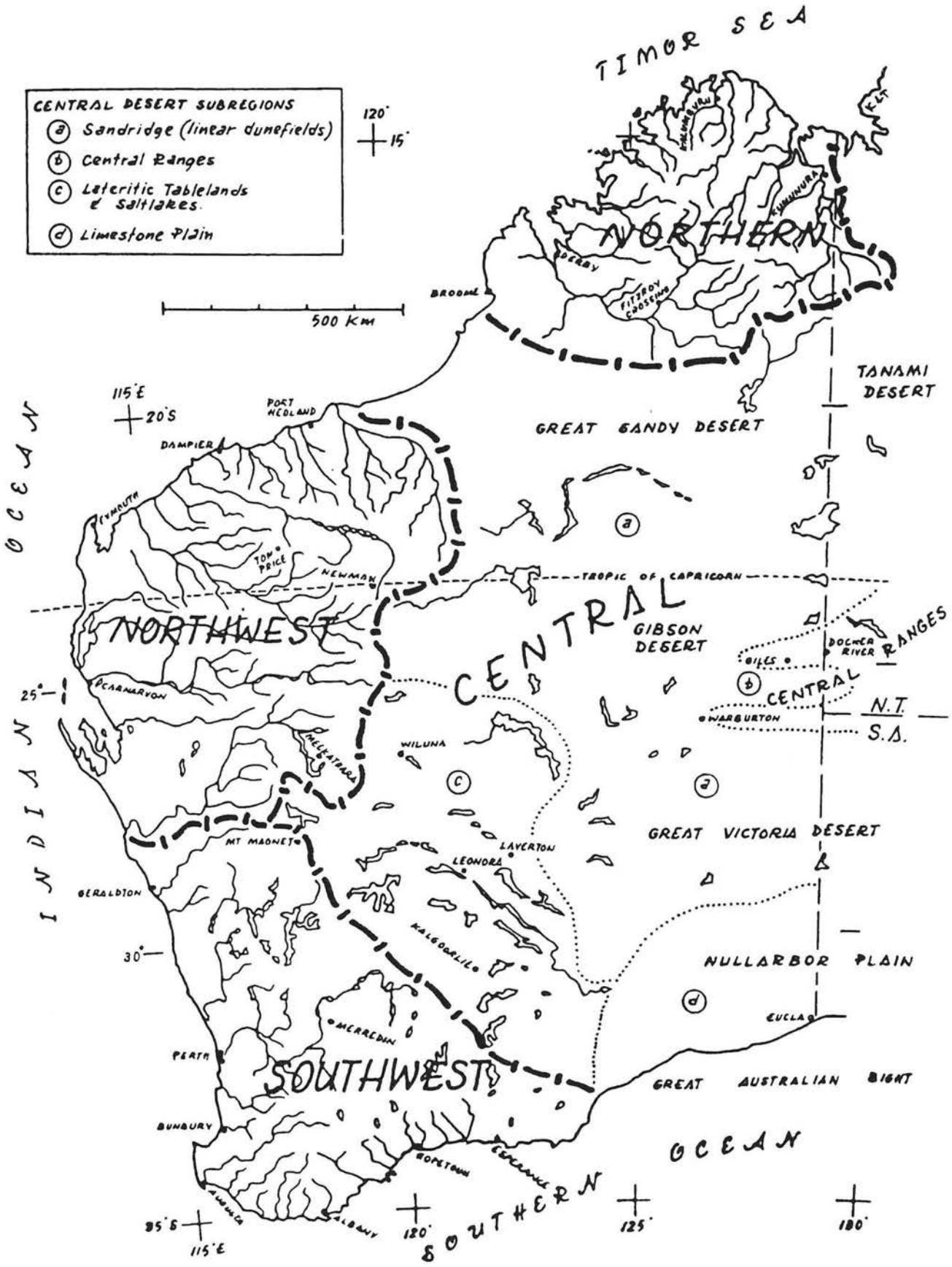

Figure 6. The Major Ecological Regions of Western Australia (118)
(As identified by the closest fit of climate, physiography and vegetation to hydrologic divides)

Further, some reserves are too small, while the security of tenure of many is inadequate. Hence, native flora and fauna remaining on uncleared freehold land and along transport corridors are of even greater importance in the Southwest Region, not only as stabilisers of sensitive portions of landscapes and for aesthetic reasons, but also for the survival of species, the maintenance of genetic diversity, and as corridors linking island reserves. As the loss of species and habitats is continuing, much more active management is required here.

Our forest systems, confined to a small but actively used part of the Southwest Region, are a very limited and shrinking resource which is under severe and competitive pressures and demands that are increasing. It has been evident for some time that it is not possible to satisfy every demand. Clear and well supported long-term management objectives are essential. There appears to be some confusion between the maximum sustainable yield of timber resources and the sustainable use of forest ecosystems; both are legitimate objectives, but they are not identical.

In addition to various land use pressures, 200,000 hectares of State Forest are affected by the soil borne root fungus, *Phytophthora cinnamomi*, which causes dieback disease. Research into the nature and advance of dieback, together with quarantine measures, aim to minimise further spread of the disease.

With most of our population living on the coast of the Southwest Region, urban and industrial pressures including waste disposal and localised pollution, are generally concentrated here. Some sections of the coast are under intense and competing uses including recreational and tourist activities, ports, protection of the coast from erosion, protection of fish nursery areas and professional fishing. The establishment of marine parks and reserves which would do much to assist effective management of coastal resources in the Southwest Region is only in the initial stages with Marmion Marine Park being the first of these reserves.

Because of the widespread salinisation of streams largely caused by agricultural clearing inland, increasing reliance is being placed on extraction of groundwater from the Swan Coastal Plain, exerting increasing pressures on wetlands already severely reduced by landfill. In some localities groundwater extraction has reached or exceeded sustainable yields, presenting increasing problems for management. Surface water, groundwater, estuaries and coastal embayments are increasingly affected by pollutants, both localised from specific discharges and also the more difficult non-point sources such as nutrients leached from agricultural fertilizers.

A wide range of chemicals are spread, discharged or dumped across the Southwest Region. Included in these are pesticides which play an increasingly important role in agricultural production. Quite apart from care in handling and application, there is a need for more widespread and systematic monitoring of pesticides and their residues through both target species and in adjacent ecosystems (including Southwest streams).

Open cut mining (for bauxite, tin, gold, mineral sands and coal) causes severe though generally localised impacts on the environment in the Southwest Region. In some instances a great deal of effort has been made at rehabilitation, the long-term effectiveness of which is still being monitored. However, viewed from the perspective of the Southwest Region as a whole, environmental impacts from mining are of far less significance in the long-term, compared with the widespread and severe degradation of soil and water resources, and loss of species diversity through agricultural practices.

5.1.2 Northwest Region

This Region extends from the Murchison through the Gascoyne to the Pilbara. Rainfall is low and erratic, though occasional tropical cyclonic storms can cause flooding. The major land use is pastoralism.

The most serious environmental problem of the Northwest Region is the widespread and severe destruction of natural vegetation due to previously un-managed overgrazing. This has resulted in extensive sheet and gully erosion during the infrequent storms, followed by wind erosion and subsequent scalds. Massive quantities of sediment have lodged in the lower drainage, widening the extent of overbank flooding. With loss of vegetation there has been a loss of native fauna, a considerable proportion of the medium sized mammal species having disappeared. Introduced pests such as goats have added to the problems caused by overstocking. Commercialisation of the goats has apparently ensured the maintenance of that population, rather than reduced it. Plant pests such as Parkinsonia bush and mesquite also have impact on pastoralism as well as displacing native vegetation.

There is now a growing recognition of the extent and severity of these problems and the needs for rehabilitation. Such policies should be pursued energetically: unsuitable and badly degraded areas should be taken out of pastoralism: stock should be reduced on much of the remainder (in addition to active rehabilitation): alternative

species should be assessed in grazing trials. There may be prospects in the long-term for some increase in rainfall within the northern section (Pilbara). [4] The potential benefits of this will be negated unless erosion is minimised through revegetating.

Despite severely limited water resources (one eighth of that available in the Southwest Region), parts of the Northwest Region have high potential for recreation and tourism, particularly the coastal zone and inland parks. More intensive management (including development of marine parks and reserves, such as Ningaloo Marine Park) is required to control the impact of people pressure on the fragile ecosystems of this Region.

Mining, hydrocarbons and salt production are important activities. Mining in National Parks and Nature Reserves continues to cause conflict, though government policy is clarifying.

Fish resources are valuable, though generally considered to be fully exploited. Impacts of trawling on marine habitats (Shark Bay, Exmouth Gulf and the Northwest Shelf) warrant attention.

5.1.3 Northern (Kimberley) Region

As in the Southwest, this Region ranges from seasonally very wet to semi-arid, but in this case the rainfall is monsoonal during summer. Large areas carry coarse arid grasslands with low nutrient value and hence low carrying capacity. The best natural pastures are on the bottomland sites and floodplains. Much of the lower part of this Region has long been committed to pastoralism; cattle leases have extended more recently into part of the higher rainfall areas. Northern and coastal sections are largely inaccessible; some of these are Aboriginal reserves.

Here again, much of the pastoral land is severely degraded by overgrazing leading to sheet erosion and scalding. Cattle staying around watering points have totally removed vegetation and compacted the soil, with consequent impact on native wildlife dependent on habitats around natural waterholes. Rehabilitation, which has been effective in selected areas, must be extended.

The current economic status of the Kimberley pastoral industry [31] with its attendant problems of range regeneration, TB eradication and/or general property/herd improvement possibilities demands a better understanding of the interaction of economic and environmental factors that influence the effective utilisation of pastoral lease land.

Tourist pressures are increasing on the scenic gorge country, the fragile Bungle Bungle ranges and the spectacular Kimberley coastline. Management of these activities is necessary to protect the environment and maintain the natural features attracting tourists.

Mineral, oil and gas exploration and production activity have also also added new pressures on the environment in recent years, with seismic grid lines which cross the landscape creating the potential for soil erosion.

Aboriginal communities and their outstation movement are spreading the small Kimberley population over wider areas creating the demand for better roads and potable water supplies.

The conduct of the Kimberley land-use study will be timely in helping to identify future land use by the systematic evaluation of the likely environmental and economic consequences of each land-use option.

Of particular interest will be the re-evaluation of existing pastoral leases to be used in an environmentally sustainable and economically viable manner as recommended by the Kimberley Pastoral Industry Inquiry.

Further environmental damage could come from the spread of noxious weeds such as Noogoora Burr, Parkinsonia and Calotropis, and the build up of vermin numbers such as donkeys and dingoes. The Agriculture Protection Board has instigated control, eradication and inspection programmes with the assistance of the Local Government Authorities and pastoralists.

Attempts are being made to develop a horticultural industry at Broome and Derby. However, future land release in these towns requires a full investigation of water demand/supply factors to ensure effective groundwater management.

The monsoonal conditions associated with the summer months and the formation of Lake Argyle and Lake Kununurra are conducive to the build-up of mosquitoes and midges in the main Kimberley towns. Concern has been expressed about the potential for mosquito-borne diseases such as Arbovirus occurring in the region. Malathion sprays are used periodically each summer to reduce the population levels of mosquitoes.

5.1.4 Central Region

Although the Central Region is arid and some areas are called deserts, much of it is clad in drought resistant savannah vegetation. There is a fair degree of species diversity, but these communities are highly sensitive to increased pressures due to critical water balance and long recovery time. Hence Nature Reserves in this Region need to be large in order to maintain viable communities. Little water is available (one sixteenth of the amount of usable water in the Southwest Region).

Much of the Central Region is vacant Crown Land within which little change might have been effected. However, mineral and petroleum exploration activity, and increasing recreational movements of four wheel drive vehicles have left their marks on these fragile systems. Occasional extensive hot fires replacing the Aboriginal practices of a tight mosaic of small burns of various ages, have also contributed to the decline of both plants and the medium sized mammals. However, impacts on these vacant Crown Lands are largely un-monitored. The management of Aboriginal lands within this fragile Central Region requires careful guidance.

In the lower portion of the Central Region two areas have been used for pastoralism; to the south, pastoral leases extend across the limestone soils of the Nullarbor; in the vicinity of the goldfields and the salt lakes to the west, pastoral leases extend across lateritic plains and red clays. Some of these marginal pastoral areas have been overgrazed.

In the goldfields area, stripping of vegetation by illegal mining operations presents local problems. In Kalgoorlie, sulphur dioxide emissions from roasting operations affect nearby air quality. Dust arising from mining activities also causes local problems.

While remote from most of the population of Western Australia, the arid Central Region does require monitoring and management to sustain environmental quality. Satellite imagery affords an effective basis for monitoring.

5.2 THE STATE AS A WHOLE

Apart from relatively small areas in the Southwest and in the far north, most of Western Australia is semi-arid to arid. Many of the soils are saline-prone; most are very low in essential nutrients. Nevertheless, the State is richly endowed with flora and fauna well adapted to these conditions. The Southwest Region has a particularly rich diversity of plant species, a great many being endemic to the region. These highly distinctive plant communities are assets to be treasured.

Although further documentation is required, there can be no doubt that during the present century there has been an accelerating decline in the diversity of our flora and fauna. A number of species have disappeared altogether, while the distribution of many others is now restricted to isolated populations whose reduced genetic diversity limits their adaptive capabilities. Many of these face extinction in the near future as habitats are further reduced.

As the World and National Conservation Strategies both give top ranking to the maintenance of genetic diversity, the accelerating rate of loss of endemic species and genetic diversity of those remaining in this State, should be a matter of great concern throughout our whole community.

Clearing, cultivation, grazing, urban development and a range of other activities have not only impacted upon native plants and animals, but have also resulted in widespread loss and degradation of our fragile soils. Early ignorance has now been largely overcome, and in recent years both awareness and management responses have improved markedly. While in some localities, stabilisation and rehabilitation of soil quality is being achieved, much more needs to be done throughout the State to sustain this essential life support system. We can hardly dissociate ourselves from "the widespread view that land degradation in Australia is a national problem of major proportions and immediate urgency which threatens severe economic, social, ecological, and in time, political consequences. In NCSA terms, it is unquestionably the foremost example of insufficient attention to ecological principles leading to resource use and development that cannot be sustained". (10)

Water, as another life support system, is considered to be adequate to meet the direct human needs for the next 30 years. However, on present trends, supplying water for human consumption will be at further ecological cost and loss of amenity values. In the Southwest Region where population demands for water are greatest, most of the catchments and streams are now too saline for human consumption. A considerable proportion of the

remaining usable water resources are already being utilised. For the Perth-Mandurah catchment, 150 years of growth has utilised 47 percent of the usable water. (11) *If the population is expected to double in the next 25 years (see Section 4.3), at present per capita consumption there would then be no local reserves for any future growth. Planning for continuous growth in water demand does not appear to be consistent with a commitment to the sustainable use of renewable resources.*

In the Northwest Region water resources are far more limited, while through most of the Central Region there is little fresh water available at all. However, the regional distribution of available water is likely to change with long-term trends in climate. (4)

A central theme of the National Conservation Strategy is sustainability. However, our environment's capacity to sustain present developments is already being exceeded in a number of aspects, particularly in the condition of our soils. With much more care and rehabilitation, existing environmental degradation can be halted and, in some respects, repaired. If this were to be achieved, can development continue along present courses? In other words, does a long-term conservation strategy merely require a series of corrective actions, or might some more fundamental changes in approach be needed?

While a whole range of values and activities have to be accommodated within each region in order to fulfil the broadening expectations of the community and to retain options for future use, let us focus briefly on primary production alone.

From the review of the present condition of our living resources and their environment, it can only be concluded that some of our major primary industries such as pastoralism, timber and fish production are approaching or have passed peaks of long-term sustainable production. Much of the low rainfall pastoral lands are seriously degraded and will no longer sustain past stocking rates. Our meagre resources of timber continue to be reduced, while our limited stocks of fish are generally exposed to an excessive fishing capacity. As presently operated, each of these has little prospect of further growth and employment. Some increase in sheep and cattle production can be achieved by diverting poorer agricultural lands to grazing. However, unless present trends are changed, increasing demands for both fish and timber will in future be met by greater reliance upon imports.

On the less arid cultivated lands, the technology is available not only to stabilise soils and restore soil quality, but also to increase productivity. However, the latter requires continuing inputs of energy (represented by primary fuel, fertilizer, pesticides, machinery), and there is evidence that in future this will yield smaller gains in production (see Section 3.5). Thus, much of our agriculture is increasingly dependent upon imported energy.

There are increasing signs that even in Western Australia, human activities are pushing natural systems too far and that ecological processes are beginning to fail. The moral is that sustainable use of natural systems, as a basis for primary production, will not work if it is assumed that the economic parts of the biological machinery will function without the uneconomic parts. (116)

It is in the city that human re-structuring of the environment is greatest: in fact, some would regard the urban environment as totally separate from the "natural" environment. However, there is a continuum in our environment, ranging from the pristine nature reserve to the central city. These facets should be considered as a whole, as constituting our full environment, rather than as independent and unrelated systems.

Perth's development so far has successfully retained many attractive features. However, while a rapid spread of the urban area may have been planned and guided effectively to date, future growth of the city might warrant modifying planning approaches as the city matures. For example, urban consolidation with nodes of well-planned medium-density living, connected by effective public transport, would reduce reliance on cars, be more energy efficient, would reduce pressures on adjacent cultivated lands as well as on residual wetlands and other national areas, and yet could maintain varied lifestyles and a high quality of life (see Section 4.2).

While Perth continues to grow at the expense of many rural communities, there is a growing movement to rural re-settlement in certain localities where small but labour-intensive industries are increasing employment opportunities, with emphasis upon satisfying different needs for a high quality of life (see Section 4.3).

Our recent track record is one of progressively increasing per capita consumption of resources, but in times of crisis (eg fuel or water shortages) we have demonstrated an ability to manage quite well on less. There is certainly scope for reducing per capita consumption without sacrificing the quality of life. This would entail a conserver approach in the use of resources.

Environmental planning in this State has so far been rather localised and often short-term but re-structuring of statutory bodies is opening prospects for long-term regional planning. Planning for development should

emphasise socially and environmentally acceptable work, rather than weighing solely the economic return. This planning should aim at maximising the value of each unit product, rather than increasing the total through-put (see Section 4.5).

Environmental management, both in the broader land-use management and at the more specific project level, have advanced considerably in recent years. The various processes are now well structured and concepts of multiple use being applied where relevant. There is, however, still much to do, especially in the management of parks and reserves, and in the rehabilitation of degraded lands.

While community awareness and attitudes are improving (see Section 4.6), there is much scope for greater community involvement and responsibility (ie, developing an environmental ethic), rather than reliance upon legislation and enforcement.

5.3 CONCLUSION

In effect, we in Western Australia (like other communities) have been living beyond our means for some time and now have an accumulated environmental debt which must be met if we are to restore sustainability. To do this will require a great deal of leadership, community participation and funds. In order to meet the environmental debt, the community may have to accept some modification to its standard of living; but the rewards could include an enhanced quality of life. Deferring action will only compound the problems, leading toward the situation now evident in other dry countries where land once in fair condition has been degraded through over-use to the point where it will no longer support the existing population.

However, restorative actions in Western Australia will only rectify those problems already existing. While they will certainly place us in a sound position to plan confidently for the future, if we are to identify attractive pathways through the coming decades, we shall require far more than a series of cosmetic actions.

Recognising the general aridity, salinisation, low nutrient status and fragility of our environment, the existing evidence of stress, and our dependence on imported energy to maintain productivity, we should face the prospect that the Western Australian environment has a limited carrying capacity in human terms. With greater care for our environment and with more careful and more innovative use of our resources, some further increase of population can be sustainable while still maintaining a high quality of life. However, as well recognised in the National Conservation Strategy for Australia, in an environment of limited carrying capacity, there is a need to begin shaping and moving toward sustainable population and resource consumption targets.

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