A Conservation Strategy for Western Australia

Living Resource Conservation for Sustainable Development

Conservation and Environment Council
July 1983

Department of Conservation and Environment
Western Australia
Report 12

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Committee Membership

Foreword

In March 1980 the World Conservation Strategy, prepared by the International Union for the Conservation of Nature and Natural Resources, was endorsed by State and Federal Governments in Australia. Since then a National Conservation Strategy has been in preparation under the direction of a Steering Committee representative of the Australian States, Territories and Commonwealth, in consultation with representatives of conservation and industrial interests. A major National Conference was held in June 1983 which reached a consensus on a National Conservation Strategy document, now under consideration by State, Territory and Commonwealth Governments.

In May 1982 the Government of Western Australia decided to initiate a State Conservation Strategy, with the objectives of:

(a) examining former and present resource management policies,

(b) identifying possible deficiencies, and

(c) recommending means of correcting these in future, using the philosophy of the World Conservation Strategy as a guide.

Among the reasons for this independent approach was the large size of Western Australia, its small population and the extent of its dependence on non-renewable as well as sustainable resources combining to create almost unique problems in environmental management. Moreover this State has several climatic zones, an immense coastline, a large variety of endemic plants and animals, a vast arid area and enormous mineral resources. In addition to the list of living resources defined by the World Conservation Strategy, we have also included Water Resources, because of their importance to Western Australia.

In developing a Western Australian Strategy, we have examined our existing policies and experience, and endeavoured to establish priorities and values which will help shape policies to deal with future environmental issues. We hope that this document will not only serve as a record of these but will also form the basis of an environmental education programme for the citizens of this State.

It is, of course, impossible to produce a document which will reflect the views of all the individuals, organisations and government departments who have provided information and comment during the preparation of the Report. However, we hope that the issues raised here will continue to be thought about, debated and commented on by concerned persons. This continuing interest and dialogue is essential, especially when further consideration is given to the specific matters referred to in the final chapter. Thus, this response to the World Conservation Strategy represents the first stage of a continuing evaluation of the interaction of our management strategies with our natural resources. It will assist in initiating trends towards more effective means of dealing with present and future conservation problems.

The initial draft of this Report was written by Mr Thane Riney, a consultant appointed for the purpose. Following further consultation and advice, a revision of this draft was undertaken by Dr Maurice Mulcahy and other officers of the Department of Conservation and Environment, of whom Dr Graham Chittleborough and Mrs Tracy Berson provided valuable editorial assistance. Considerable input has been made by a large number of concerned Western Australians, too numerous to mention, and we hope that this input will continue, since this is a Strategy which must represent the priorities of the people of Western Australia rather than sectoral interests. However, I would pay tribute to those who accepted the invitation to participate in the Yanchep Conference in July 1982, to the Director of the Department of Conservation and Environment and his staff, and to members of the Committee set up by the Conservation and Environment Council to prepare this document. I would also express my gratitude to the Council itself which has contributed to earlier drafts of this document to great effect.

John R. de Laeter
PRESIDENT
CONSERVATION AND ENVIRONMENT
COUNCIL OF WESTERN AUSTRALIA

July 1983

Chapter 1

Introduction

Western Australia's strategy for the conservation of living resources as presented here is derived from an application of principles expressed in the World Conservation Strategy.[1] The World Strategy was prepared by the International Union for the Conservation of Nature and Natural Resources (IUCN), the United Nations Environment Programme (UNEP) and the World Wildlife Fund (WWF).

The World Strategy has three main objectives:

(a) to maintain essential ecological processes and life-support systems (such as soil regeneration and protection, the recycling of nutrients, and the cleansing of waters), on which human survival and development depend;

(b) to preserve genetic diversity (the range of genetic material found in the world's organisms), on which depend the breeding programmes necessary for the protection and improvement of cultivated plants and domesticated animals, as well as much scientific advance, technical innovation, and the security of the many industries that use living resources;

(c) to ensure the sustainable utilisation of species and ecosystems (notably fish and other wildlife, forests and grazing land), which support millions of rural communities as well as major industries.

Both the World and State Strategies are therefore concerned with the conservation of living resources. The conservation of non-living and non-renewable resources is not considered in general, but only as essential life support systems such as water, air and soil, or where the exploitation of non-living resources can affect the natural ecosystems.

There is nothing faint-hearted about the World Conservation Strategy; its aim is to make development sustainable through the use of measures to conserve living resources; its scope is planet Earth. This most remarkable document has found acceptance around the world in its call for a global effort to give practical effect to its guidelines. It recommends that every country review the extent to which it is achieving conservation of living resources, concentrating on the priority requirements and on the main obstacles to achieving them. A number of countries around the world have taken up this challenging commitment, and are preparing national strategies — the first step towards reducing the toll of over-exploited resources.

A National Strategy for Australia has been prepared in Canberra with the co-operation of the Federal Government and all States.[2] Fortuitously the timing is appropriate, as with a pause in economic growth, we have time to reflect on the implications of that growth. Is development outpacing the understanding of the resources upon which it is based? This country, so newly settled by Europeans, has a multiplicity of modern technologies imposed on it and we are demanding much more than it was ever asked to provide before — and this from a land of naturally low productivity and unstable, fragile ecosystems. Clearly we should pause from time to time and examine what we are doing.

The need for sub-national strategies is also recognised by the World Conservation Strategy. In Australia, the responsibility for land use policies rests with the State governments, and in order to begin constructing guidelines to influence land use policies and management in Western Australia, it is essential to appraise Western Australian practices.

Western Australia is 'different'. Largest, driest, hottest, oldest in terms of its landscapes, it contains all the paradoxes of isolation in a twentieth-century setting and all the extremes of an ancient land, newly settled. In 1979 it commemorated its 150th year of European settlement, about the span of two human lives. Yet it seems conscious of being a slow developer, seeing its isolation and its small population as constraints to development, to be overcome by political drive and artificial stimulus. At first, growth came from mineral discoveries, as agriculture developed more slowly, but the potential from resources of minerals and soil is still very great. With a small though growing population, it seems likely that the State's role will be to supply raw materials and food to Asian and other markets for some time to come, a role which carries certain moral responsibilities with it in terms of conservation.

1. IUCN (1980). World Conservation Strategy: Living Resource Conservation for Sustainable Development.
2. Australia. Department of Home Affairs and Environment (1983). A National Conservation Strategy for Australia. Proposed by a Conference held in Canberra in June 1983. DHAE, Canberra.

Practically all the people in the State live in an urban environment and most of these in one city, Perth, where the resource-based realities of life seem remote at times. Yet we must remember that all species, in order to survive, modify their environment to some extent, and none as greatly as large groups of humans. But no species can exist for long if that modification is destructive. In this first step towards a strategy for Western Australia we are examining how we are using the environment as development proceeds, modifying it, improving or degrading it and what condition some of the component parts are in at the present time.

For this reviewing process a term of seven to nine months was allowed. Although this means that arbitrary limitations were imperative, it was possible to look at some of the major issues of current concern in the State, and also some issues which may give concern in the future. It was envisaged from the start that the process of formulating a strategy should be seen as a long-term and continuing process, the original strategy framework only beginning a trend towards making environmental considerations an integral part of every decision involving living resource use, whether it is about the control of motor vehicle emissions or the release of Crown land for agriculture. To a certain extent this already takes place; there are many areas where the environment has been enhanced or where high standards have been demanded and attained by various methods, some of which are unique to Western Australia. To some extent the trend was started because of the very elementary questions which were being asked, such as "What is your organisation's policy for conservation?" and "In terms of a balance sheet, how much does mining take out of the community's pocket, and how much does it actually return?" Questions such as these can be very difficult to answer, but in the answering they require a review of attitudes, or a revision of the inadequate data upon which decisions are seen to be based.

Defining the conservation *status quo*, however, was a task which proved to be virtually impossible and all that could be hoped was that the task would continue. Each subject to be examined became increasingly complex as history was recounted, opposing sides reviewed, strategems exposed; while input came from an ever increasing number of sources, and vital data was withheld, forgotten, unavailable or turned up after the issue was written. Where there are faults and omissions, they are accidents of this laborious process of finding out — and that indicates the main shortcomings of this Report. Truth is said to lie at the bottom of a very deep well and the truth about conservation and the environment should be sought from the environment itself. There was never time or funding for this to be done in depth, although some information was already available, and so the Strategy for Western Australia instead came from the hundreds of organisations and individuals, private and public who invariably gave freely of their knowledge, writings, time and resources on a wave of co-operation which has characterised the preparation of this State Strategy.

Apart from the normal processes of investigation, interviewing and research, a search conference was held to plumb the status of conservation in the State, and the attitudes of a sample group of people whose work or interests involved conservation and land use. Held at Yanchep in July 1982, the conference encouraged delegates to explore the resource-based realities of life in Western Australia, make predictions, examine opportunities for and constraints to development, identify problems and suggest improvements. The results were compiled into a report which forms a broad base for the Strategy[3]. At the same time the meeting at Yanchep had other repercussions as the value of interdisciplinary exchanges was realised. A number of organisations held meetings to determine their own requirements and policies, and to consider their involvement in the Strategy. Submissions were received from people who were stimulated by the proceedings — or critical of them, which was also valuable.

The preparation and circulation of a draft document promoted a number of far-reaching suggestions. While these have all been addressed in the present document, it seems unlikely that any document prepared at the present time would satisfy all of the attitudes to conservation which exist in the community. But this is as it should be; a 'Strategy' of this type can only sift out the issues which appear to be of current concern and importance, and all we can hope to do is create or enhance a concern about these issues in individuals and the organisations to which they belong. Only with the perspective of history will it be possible to measure the performance of our community against what might have been done.

3. Conservation and Environment Council and Department of Conservation and Environment, W.A. (1982). Towards a Conservation Strategy for Western Australia. A Report on a Meeting held at Yanchep National Park, W.A. July 9-11, 1982.

The document proceeds by briefly reviewing the natural environment and the conservation of its plants and animals, pauses to consider these aspects of our natural environment which are affected by development, paying attention to official and unofficial attitudes to those aspects, and moves finally to an attempt to distil out those issues which are of particular importance to our State, bearing in mind the general guidelines of the World Conservation Strategy.

Chapter 2

The Natural Environment

It is only as a political unit that Western Australia can be thought of as a whole; its immense size — the largest State in the world — precludes a single classification on any other basis. Over an area of 2,525,500 square kilometres extending from latitude 13°30'S to 35°08'S, several types of climate occur, vegetation zones range from tropical forest to sparse desert vegetation, forms of life exist both primitive and intricate and a variety of landscapes are encountered, lacking only in significant recent geological formations. This is a vast and ancient land, weathered, isolated and possessing the oldest rocks on earth.

Climate

Figure 2.1 indicates the average annual rainfall in different parts of the State. Two levels of rainfall are emphasised as being of particular importance for conservation. The 1150 mm isohyet is important because below this level, permanent clearing of land for whatever purpose, may induce localised salinisation (that is, the accumulation of salt at the soil surface). And the position of the 300 mm isohyet indicates that the greater part of the State is classed as semi-arid or desert land, either inherently marginal to, or entirely inappropriate for conventional agriculture or pastoralism. Thus the productive part of the State is reduced to less than half the size indicated by its boundaries on the criterion of annual rainfall alone.

In addition to the simple lack of rain there are other constraints relating to where and when rain falls and to the relation between rainfall and evaporation rates.

The northern third of the State lies within the tropics, and the remainder extends into the temperate zone, having over much of the southern portion a typical Mediterranean climate. Thus there is a marked change from a predominantly summer rainfall pattern in the north to a winter rainfall pattern in the south. Between these two systems is a large region whose climate is characterised by the extreme variability of rainfall, both annually and seasonally.

Variations in rainfall, when extreme, place grave constraints on agricultural development. Where rainfall records have been kept since last century, these show the difficulties of operating in such conditions — at Onslow annual totals vary from 15 mm recorded in 1912 to 999 mm in 1961. At Whim Creek 747 mm was recorded in a single day in 1898, almost double the annual average, whereas only 4 mm fell in 1924 (Bureau of Meteorology). The random visitations of cyclones along the north-west coast are largely responsible for the summer rains falling in the arid regions, but are also responsible for the erratic nature of the rainfall in most of the pastoral areas.

The main belt of reliable rainfall lies in the winter rain regions of the south-west, extending across most of the well established wheat lands. Variability increases inland and northwards from the belt of reliable winter rain. Reliable rainfall also occurs in the tropical north (in summer in this case).

Tropical Western Australia is particularly hot compared with corresponding latitudes elsewhere. Maximum temperatures above 38°C are common in inland areas in summer, while high humidity can add to discomfort. Along the western and southern coasts, sea breezes relieve the high temperature of summer, but away from the sea, daily extremes show a greater range. Annually, these extremes of temperatures can be very great: Eucla's winter nights may fall to 2°C while the temperature of a hot January day has soared as high as 50.7°C. While native plants and animals cope with such extremes, these conditions place considerable stress on crop plants and domestic animals which are not adapted to them.

Except in the lower south-west, annual evaporation from a free water surface exceeds the annual rainfall, and in a large part of the State it is more than ten times greater than the rainfall.

In January 1975, the Federal Government asked the Academy of Science to examine the subject of long-term climatic variability in some detail. The findings of the Academy[1] were published in 1976 with the following conclusion:

1. Australian Academy of Science (1976). Report of a Committee on Climatic Change. Report No. 21.

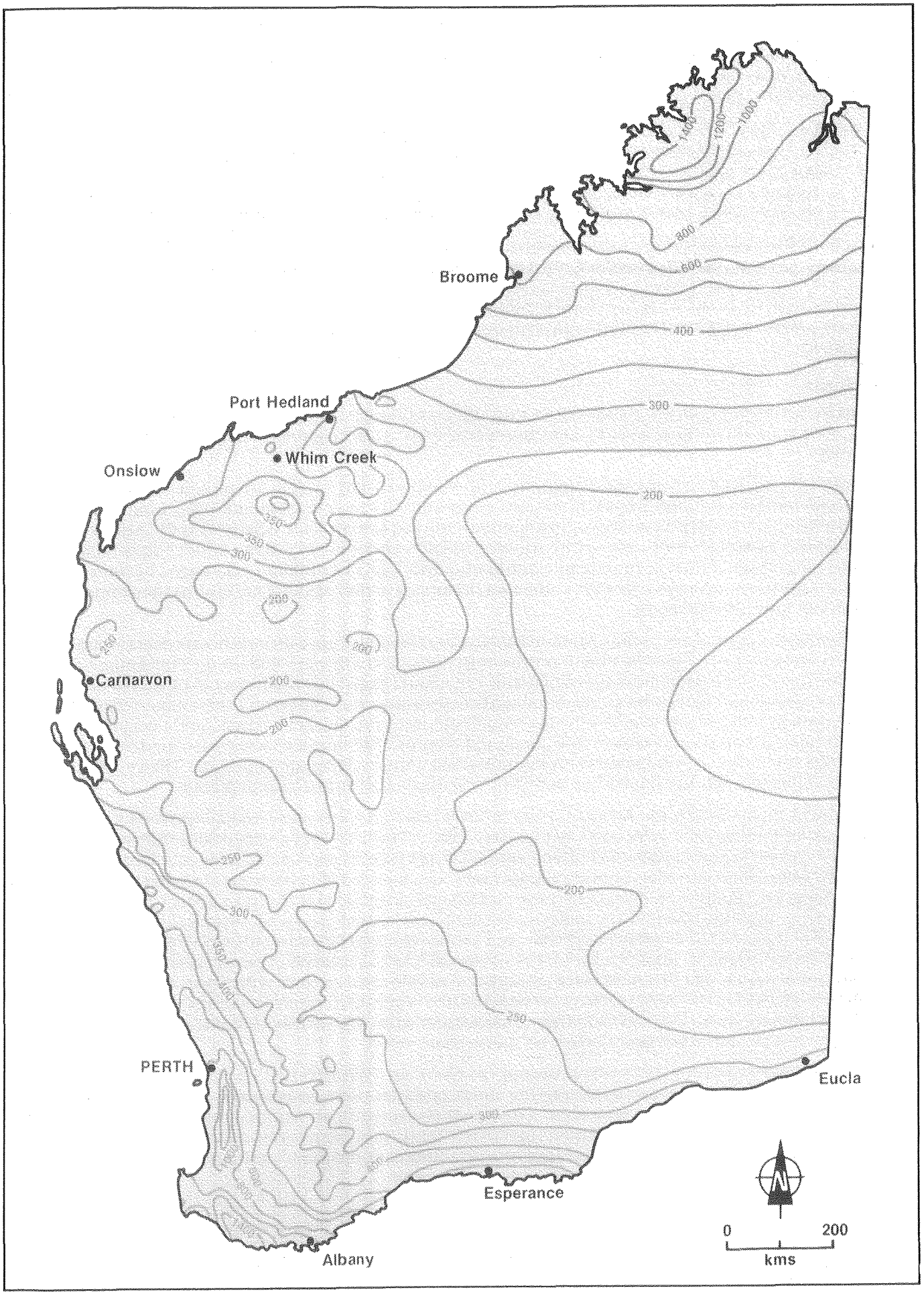

Figure 2.1 — Average annual rainfall

> Climatic variability, and the recurrence of extreme climatic events like drought and flood, are part of the normal pattern of climate in many parts of the world, including Australia. Pressure on the land (e.g. overgrazing, destruction of forests) increases its vulnerability to extreme climatic events. Climatic variability must be incorporated into economic and land-use planning.

On the subject of climatic variability the report went on to state:

> The climate of many parts of the world, including most of Australia, is highly variable, and much agricultural production is undertaken in climatically marginal conditions. The increasingly severe effects of recent droughts and floods are due to the increased human pressure on the land rather than to any increase in climatic variability.

Where the climate is only infrequently suited to present forms of agricultural development, it may be that other methods or even forms of land use may be more suitable. However, there is still much land where climate may be borderline but over which some improvements in productivity may be made in future through the benefits of improved seasonal weather prediction, and the application of agricultural research (e.g. the development of new strains of pasture plants).

Soils

The distribution and characteristics of the soils of Western Australia are described in some technical detail in the *Atlas of Australian Soils*.[2] Only a brief general description can be given here.

Due to a history of geological stability, the western third of the Australian continent is characterised by landscapes which have been subjected to extreme and deep weathering. Laterisation has been extensive, and dominates the soil pattern, particularly over the Archaean shield rocks of the south-west, with its low relief and ancient river systems, which may predate the separation of the continents by continental drift 120-140 million years ago.[3] The ancient rivers are now no longer effective, either as a drainage system, or as agents of erosion to remove the old and infertile soils.

The relief is even lower in the sedimentary basins extending from the north-west coast through the centre to the Nullarbor Plain on the south coast. Only in the Pilbara and the Kimberley have there developed landscapes of greater relief and rugged terrain dissected by an effective river system, but still with extensive areas of deep weathering. The result is that many Western Australian soils are deficient in the major and minor mineral nutrients, particularly phosphorus, and the trace elements copper, zinc and molybdenum. Soil nitrogen levels also tend to be low, reflecting low levels of biological productivity on a mineral-deficient substrate. The generally leached soils tend to be acid to neutral in reaction, even in low rainfall areas.

Thus in the agricultural areas of the south-west there are extensive sandplains in the inland areas and along the south and west coasts, with yellow and grey sandy soils. Lateritic iron stone gravels characterise the higher rainfall forest country, and while these are very low fertility soils, they are now assuming importance as a source of bauxite ore. Only in the valley systems are there limited areas of more fertile soils associated with exposures of fresher rock on river alluvium. Even in the valleys the slowly permeable clays characteristic of the lower parts of the lateritic weathering profile are extensively present in the subsoils. Due to the now ineffective drainage system, and inputs of sea salts in the rainfall, these deeper subsoils and groundwaters tend to contain large storages of soluble salts, so that hydrologic change induced by removal of the deep rooting perennial native vegetation results in salinisation of surface soils and streams. Poor soil structure is associated with high levels of sodium in many of the more clayey soil materials, hence the name sodic soils.

The pastoral areas of the central parts of the State are characterised by extensive red earth plains just below the level of the lateritic sands and iron stone gravels now generally reddish in colour. The red earths often have a dense siliceous hard pan within a metre or two of the surface. Salinisation is less common than in the south-west; some groundwaters are fresh and may even contain appreciable levels of nitrate at low concentration, perhaps derived from the nitrogen fixed by acacias dominating the vegetation.

2. Commonwealth Scientific and Industrial Research Organisation (1967-68). Atlas of Australian Soils. CSIRO (Melb.) and Melbourne University.
3. Playford, P.E., Cockbain, A.E. and Low, G.H. (1976). Geology of Perth Basin, Western Australia. Geol. Survey W.A. Bull. 124.

North-westwards and into the Kimberley, there is less known of the soils. In general, upland areas tend to be stony, with shallow soils over rock or lateritic iron stone, though there are clay plains associated with volcanic rocks. Lower levels tend to have sand surface soils over sodic clay subsoils, the latter again dense and poorly structured. These are susceptible to erosion if vegetative cover degenerates, resulting in "scalds" which are difficult to heal where the clays are exposed. Again, the best country is along the river frontages.

The inland deserts tend to have extensive plains with sandy soils derived from the sedimentary rocks. Some are calcareous, but again, neutral to acid sands are most extensive.

Vegetation

The vegetation of the State, in general terms, is determined by the different climatic patterns, although changes in geology, soils, topography and drainage may affect the composition of plant communities. A simplified map of vegetation is shown in Figure 2.2 which also indicates major botanical provinces.

The southern boundary of the Northern Botanical Province (see Figure 2.2) marks the change from pure desert to semi-desert vegetation which results from an increasing average rainfall. In response to the tropical climate here, grasslands predominate, except on the sandplains where an acacia shrubland occurs.

Throughout the Kimberley, grasses tend to dominate the vegetation. A type of grass known to pastoralists as "curly spinifex", along with other grasses, gives way to denser and more luxuriant vegetation along the banks of creeks and rivers. Further north are a number of rainforest tree species, palms and screw pines, forming an "Indo-Malesian" element among the more typically Australian evergreen trees and shrubs.

The Eremaean or Desert Botanical Province reaches across the greater part of the State, averaging around 200 mm of rainfall a year, with the driest area, the Nullarbor Plain, averaging 150 mm. In the northern half rain is more likely to fall during the tropical summer months, while further south there is an equal chance of rain in any month. However, falls of rain heavy enough to initiate plant growth are erratic and droughts lasting up to three years are not uncommon.

In the sandy deserts, spinifex steppe consisting of hummock grass, eucalyptus trees and scattered shrubs prevails. Areas of low woodland and scrub continue south to the Nullarbor, which as its name suggests is mainly treeless, having a cover of bluebush, shrubs, annual grasses and herbs.

The third major area is the South-Western Province which receives a higher rainfall, almost entirely confined to winter. In the most south-western parts grow the karri, jarrah and mixed forests, merging further inland into savannah woodland. In parts of this Province, vegetation contains a high proportion of endemic species and diversification.

Naturalised flora is also extensive in the landscape of the south-west and comprises some 700 species from many parts of the world.[4] The more successful species originate from areas of similar climate such as South Africa and the Mediterranean, and in the absence of disease and insect attack which in their native habitat would keep them in check, are able to spread at an alarming rate. Not all are weeds; some have been introduced to become naturalised self-sustaining pasture plants (e.g. medics and clovers). Hundreds of other introduced species are being cultivated for horticulture, and certain species have been introduced for specific purposes such as the reclamation of waste land and saline areas.

An interesting feature of native vegetation in the State is the occurrence in some plants of high concentrations of a poison closely related to 1080. Native animals in Western Australia can tolerate these levels of chemical which are toxic to the same animal species in Eastern Australia as well as to domestic stock. This is another instance where colonists had to learn the hard way how to adapt to the special environment of the State.

Water

All rivers in Western Australia have a markedly seasonal flow, and only a few can be considered perennial. In the dry season most streams cease flowing or subside to small base flows, either as a trickle on the surface or as subsurface seepage sustaining more or less permanent pools and water holes.

4. Green, J.W. (1981). Census of the Vascular Plants of Western Australia. Western Australian Herbarium.

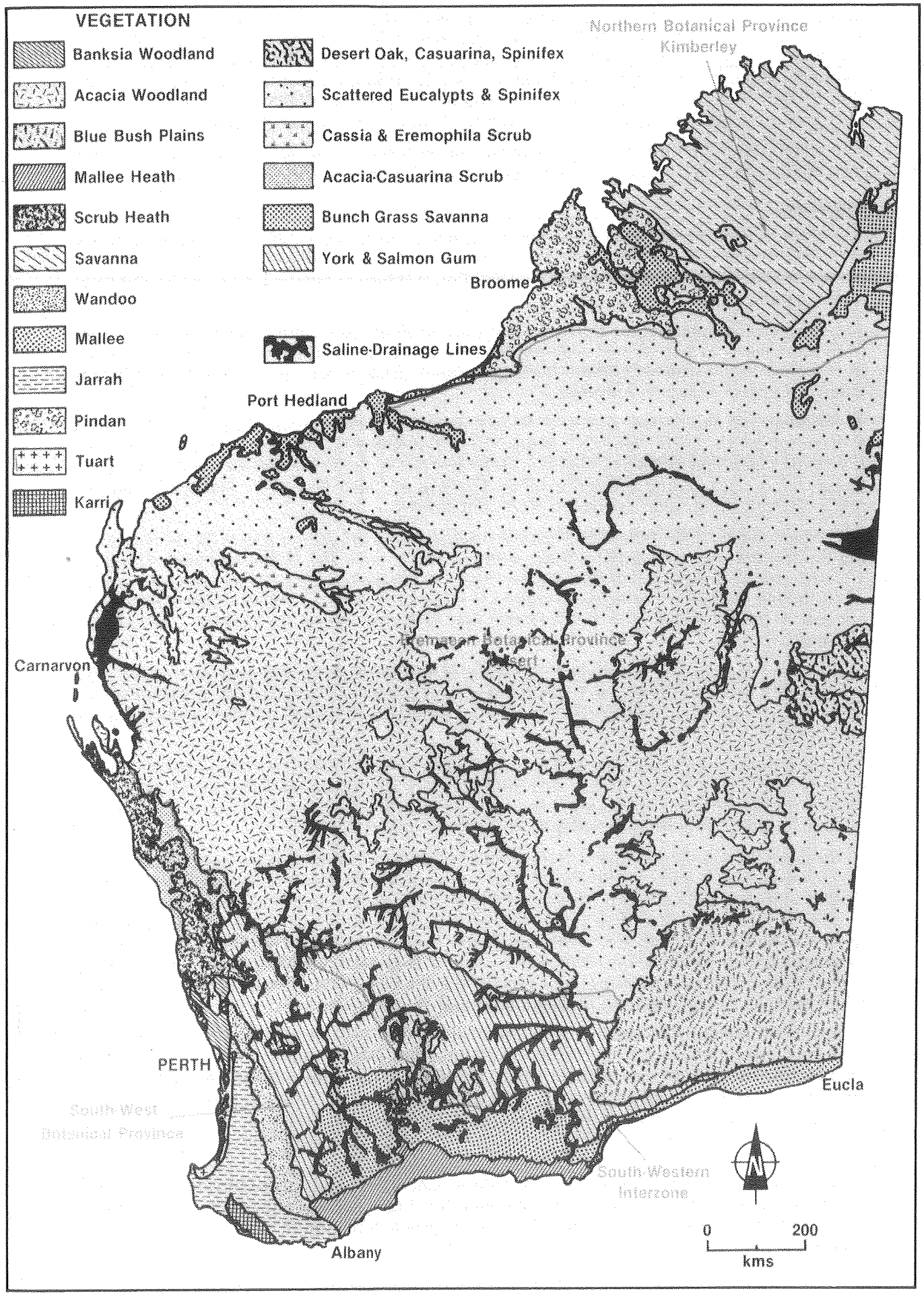

Figure 2.2 — Vegetation

In the south of the State streamflow derives from a winter rainfall pattern, and in the north from summer monsoons and tropical cyclones. The mid-latitudes — transitional between the winter and summer rainfall regions — are arid or semi-arid regions with highly erratic rainfalls, occasional intense tropical cyclones and correspondingly ephemeral stream flows.

In the arid interior, the palaeodrainage systems are no longer co-ordinated and the occasional flows along the ill-defined channels usually terminate in playas or salt lakes. In the rare flood events these systems can interconnect and flow for great distances disrupting road and rail communications.

The absence of perennial rivers and the variability of stream flow makes development of surface water supplies for domestic or irrigation use impracticable without construction of storage reservoirs to hold water to meet peak seasonal demands and to carry over into dry years. Evaporation is high, particularly in northern regions, and this coupled with the variability of runoff increases difficulties and high costs in the conservation and development of surface water resources. In recent times strategies based on conjunctive use of surface and groundwater sources have been adopted to achieve greater reliability and efficiency for water supply systems.

Many people in the State are dependent on groundwater, even though some sources may be quite small. Most towns in the north of the State rely on pumping from aquifers; mineral development projects in remote areas generally depend on groundwater. Groundwater is an important source of stock water in pastoral and agricultural areas; it is also the main source for irrigation of market gardens, and most major towns of the more populated south-west are partially or wholly dependent on groundwater.

Although the lesser resource when assessed in terms of sustainable yield, groundwater has one advantage over surface water because, particularly in the drier areas, there is a relatively more extensive occurrence of potential development sites. Groundwater development is also very often more convenient and economical for the early stages of water supply and development. The sedimentary basins of the State, particularly the Perth Sedimentary Basin and the Canning Basin, offer relatively large and extensive resources of underground water whereas outside the sedimentary basins the sources are generally more localised and often of poor quality.

Western Australia has less rain and much less streamflow than the other Australian states with the exception of South Australia and, in comparative terms, is therefore one of the dry regions of the world. The location of water at economic cost has strongly influenced the pattern of land use and settlement in Western Australia and as such has been a significant constraint on development. By comparison with states on the east coast, Western Australia's per capita use of water for irrigation for agriculture is very low. So far, in terms of adopted development patterns, lack of water has not yet been a major constraint on continued growth, although the need for efficient use of water and the protection of water resources for future requirements are recognised as prominent water management issues. These are discussed in greater detail in Chapter 9.

In the south-west region widespread clearing of the natural vegetation mainly for agriculture has caused the slow release into streams of salts stored in the soil. This has resulted in 36 per cent of the region's divertible surface water resources becoming brackish or saline, and the salinisation of soils in some parts of the landscape.

Land use

The present distribution of people (Figure 2.3) and of their major uses of the land can provide a factual basis for discussing the impact of these uses on the land and for considering future decisions relating to development and conservation. The distribution of land dedicated to various purposes is shown in Figure 2.4 and Table 2.1 and the distribution of main mining activities is shown in Figure 2.5.

Several observations are relevant in describing the factual basis of land usage as it now exists. These are:

- Most of the population, most intricate mosaics of usage and the greatest range of land uses are concentrated in the better rainfall areas of the south-west. Human activities are particularly concentrated in the south-west coastal zone.
- The present eastern limit to agricultural areas is on land marginal to agriculture by virtue of a combination of climate and soils.

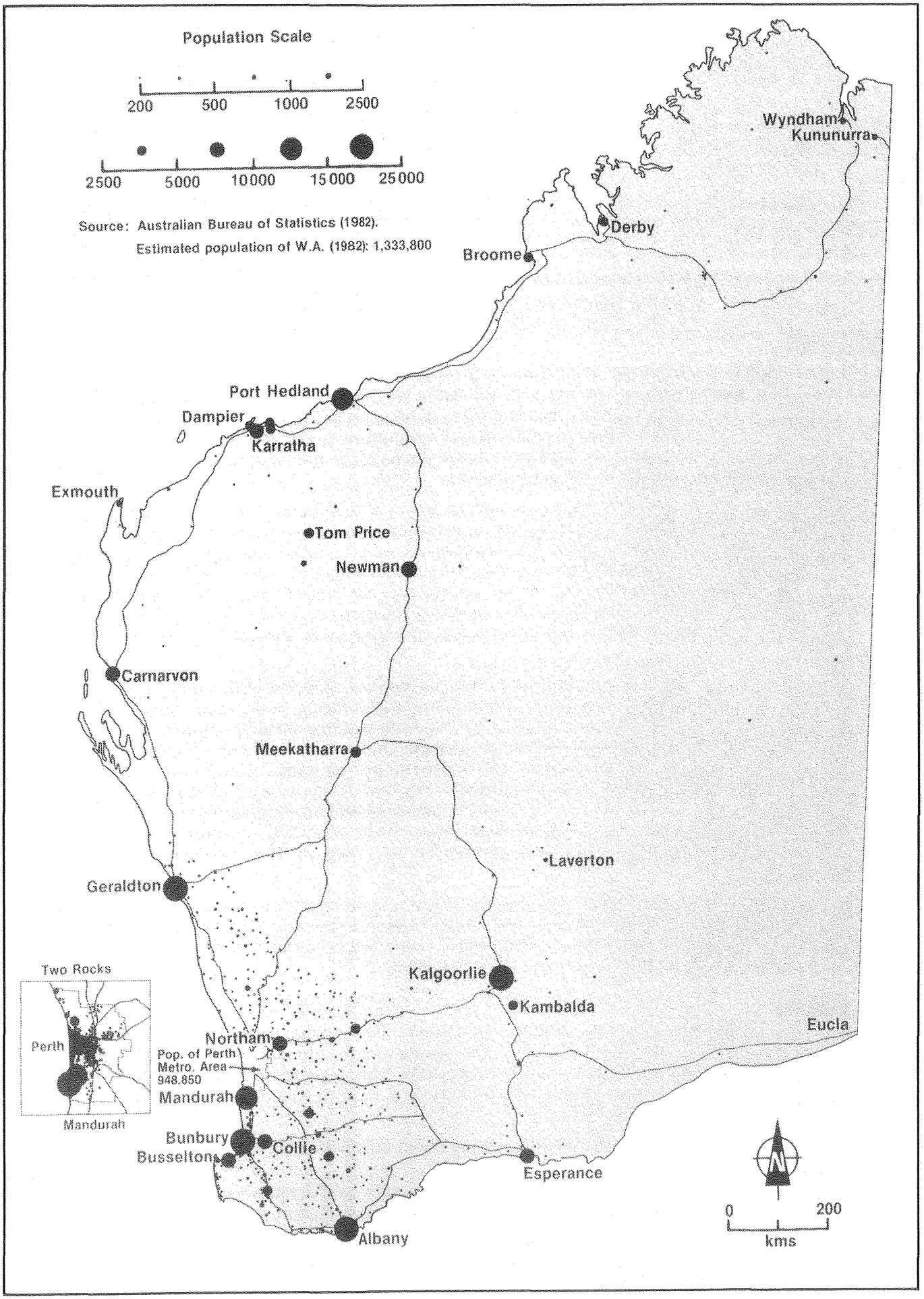

Figure 2.3 — Distribution of population in Western Australia

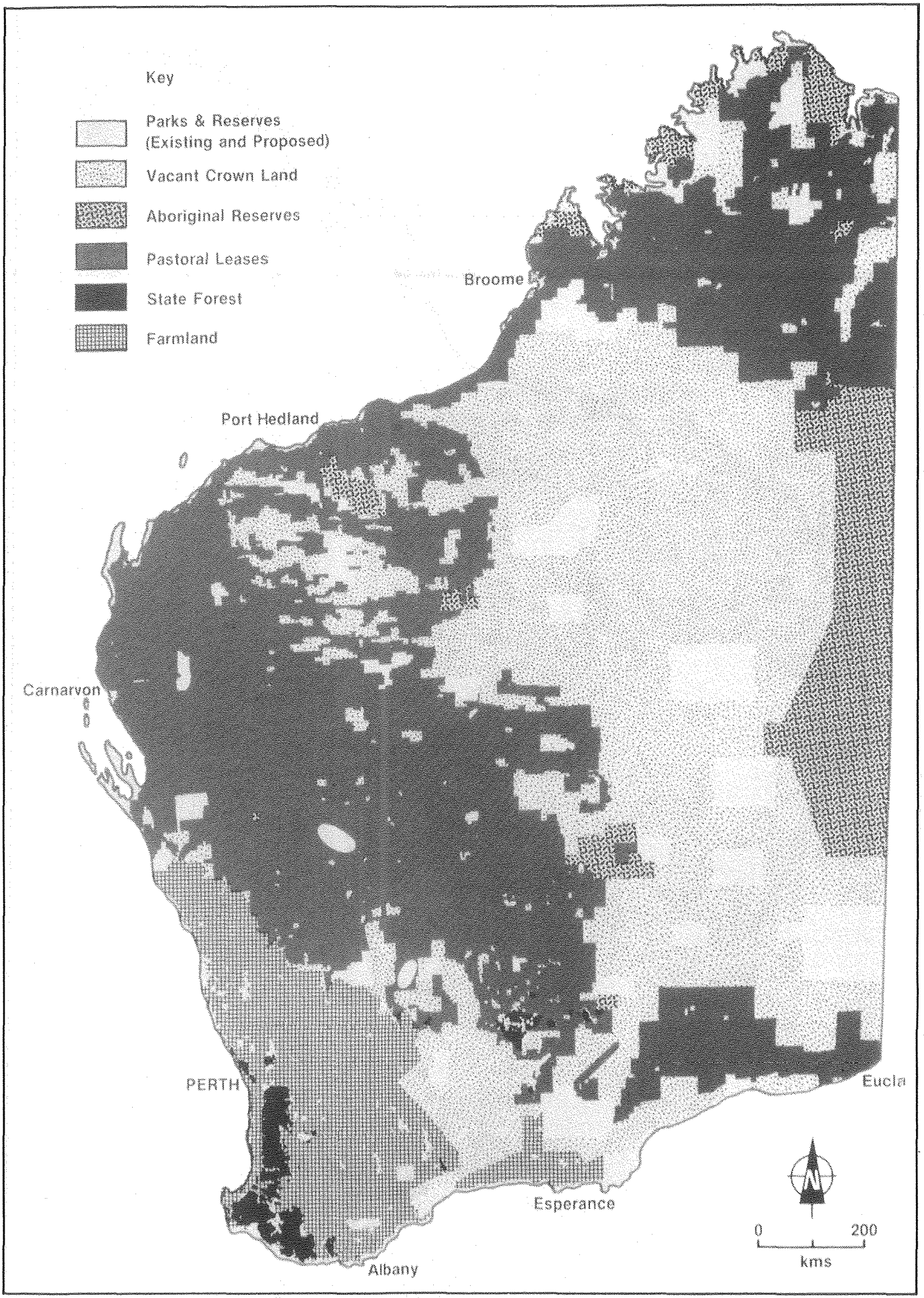

Figure 2.4 — Land tenure and purpose in Western Australia

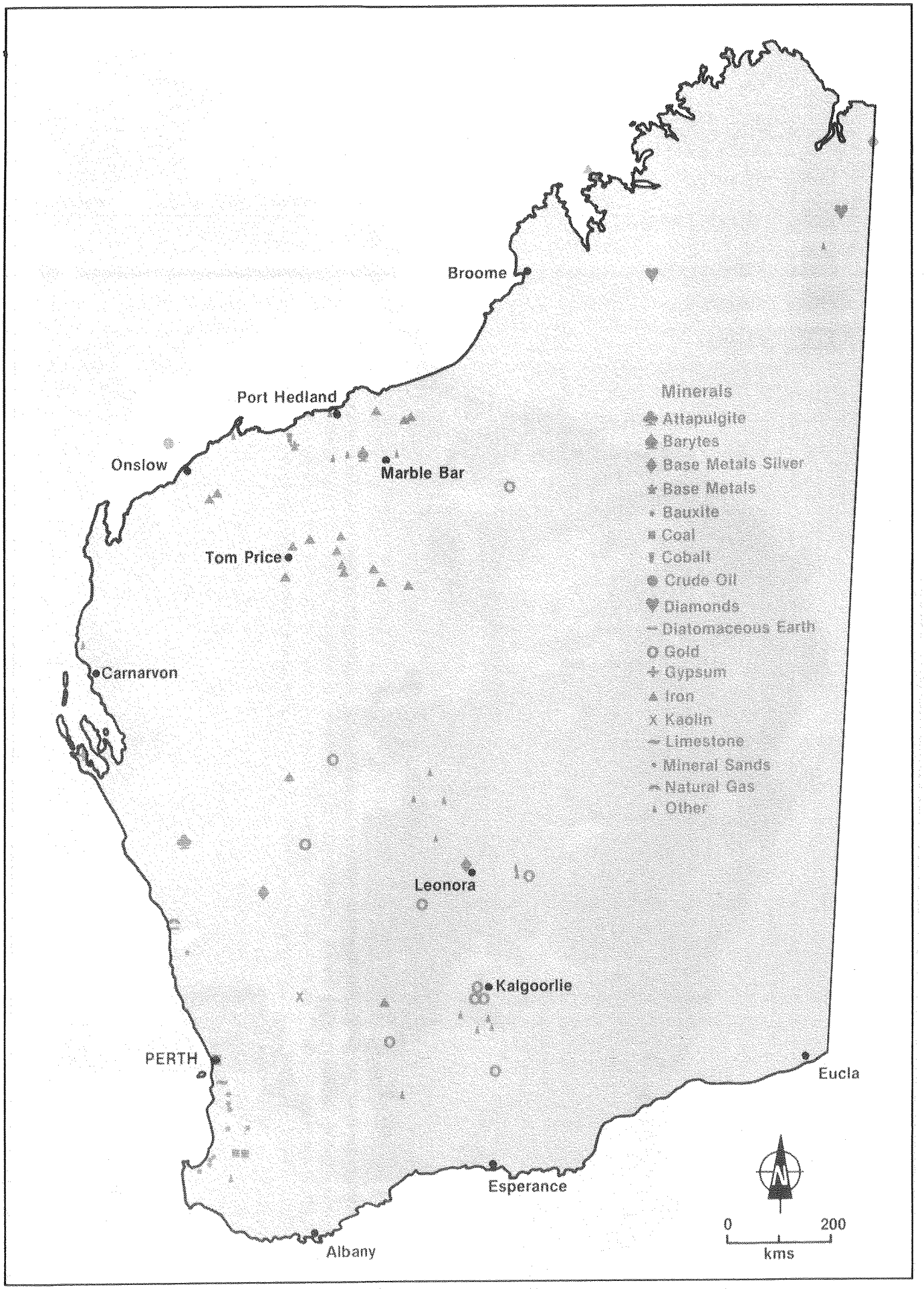

Figure 2.5 — Main mining activities in Western Australia

- Much of the pastoral land is marginal by virtue of its low and erratic rainfall and almost all pastoral areas are susceptible, following over-grazing, to erosion by wind and water. Salinisation may also be a problem in some areas.
- Almost half of the land in the State still remains as unallocated Crown land.
- The northern region, although as yet little developed, is the only area other than the south-west with dependable supplies of fresh water.

Table 2.1: Land tenure and purpose in Western Australia, 1982

Tenure/Purpose	Area (ha)	Approx. % of WA land area (252.5×10^6 ha)
National Parks and Nature Reserves		
— existing	14,255,730	5.6
— proposed*	2,640,000†	1.1
Total	16,895,730	6.7
Vacant Crown Land*	108,554,000	43.0
Aboriginal Reserves	19,000,564	7.5
Pastoral Leases*	95,093,893	37.6
State Forest	2,013,000	.8
Farmland (alienated or in process)*	19,080,348	7.5

* There is a small measure of overlap, i.e. between some farmland in the process of alienation and vacant Crown land, and some proposed reserves are currently vacant Crown land or pastoral leases.

† This figure is based on the proposals of the Conservation Through Reserves Committee (CTRC) and the System 6 Committee and is only an approximation of the proposed additions not yet implemented. Implementation, through the Environmental Protection Authority's recommendations based on CTRC proposals, will depend on mining implications and other factors.

Conclusion

Although the State covers an enormous area, there are serious constraints to the use of much of its land on a sustained basis or at a high level of production.

A great deal of the land is characterised by shallow soils, deficient in certain trace elements and vulnerable to wind or water erosion. Salt is frequently present in the soil profile. Rainfall is low and variable, and there is a severe shortage of available potable water. Native vegetation has successfully adapted to these conditions, but much of this environment is only marginally suited to introduced plants and animals. The climate and soils also limit the present commercial production of timber to a small area in the south-west.

Removal of trees and clearing of land for agriculture or other purposes can lead to salinisation of soils and even form a saline crust on the surface, killing plant life, or can enter streams in catchment areas.

The present chapter highlights the fragile nature of the State's landscapes and water supplies, the diversity and erratic nature of its climate, the range of vegetation, and the necessity for matching land use practices with the constraints imposed by these features. These matters are all taken up in greater detail in the following chapters.

Chapter 3

Conservation of Flora and Fauna

Introduction

One of the three main objectives of the World Conservation Strategy is preservation of genetic diversity (see Chapter 1). This is seen as one of the most important reasons for preserving natural communities of plants, animals and micro-organisms. Other reasons for their preservation include the ethical, involving the question of man's right to irreversibly destroy elements of nature, and the aesthetic appeal of being able to enjoy living things in their natural surroundings, as far as possible unaffected by man's activities.

Cultivated plants are highly selected for adaptation to relatively small and specialised sectors of the world environment, yet growing human populations require production of food, fibre and to some extent, energy from plants growing on a widening range of soil and climatic conditions. On a world scale, land which now has to be made productive has in the past presented serious technical obstacles to its use. Genetic diversity provides a bank of biological material from which additional useful varieties may be derived.

The Western Australian Wildlife Authority and the Department of Fisheries and Wildlife have been active in checking and listing Rare and Endangered Species in order to ensure their conservation. In this process it is important that protection is afforded before populations are so reduced that the recovered population has lost much of its genetic diversity.

Western Australia should be particularly careful to ensure that its unique resources of native plants and animals are maintained, as so little is yet known about them, in particular the characteristics they display as components of ecosystems adapted to peculiar and often difficult environmental conditions. They may one day be required to play new roles in arid land stabilisation, food production, medical research and disease prevention. Already a number of plants found in W.A. have been shown to be of wider importance in arid and saline lands. The river red gum *(Eucalyptus camaldulensis)* has been of value for shelter belts, and in time saltbush may prove valuable in various countries as arid range fodder. Also, our native plants are an important tourist attraction, with many visitors coming to admire the State's unique and diverse display of wildflowers.

Naturally occurring plants, and to a lesser extent animals, may also be a source of medicines. Naturally occurring compounds have long been used directly as therapeutic agents, and have served as models for the synthesis of new drugs. So far only a small proportion of the world's plants and animals have been investigated for their value in this way. In a recent survey screening marine flora and fauna for compounds having pharmaceutical potential, a small sponge found on the lower west coast of this State was found to have a high titre of haemolysin (Chittleborough, personal communication).

In order to ensure that genetic diversity is maintained in as wide a range of ecotypes as possible, parks and reserves need to be set aside to maintain representative assemblages of plants and animal communities. These areas must be of sufficient size, not only for the survival of individual species, but also for the maintenance of genetic diversity in each. The latter objective may require a larger population (and hence reserve area) than the former. Included here, under the general term parks and reserves, are both national parks and nature reserves. Both are managed for the protection of the flora and fauna, but in the former, provision has to be made for public access and enjoyment. In the latter, conservation takes priority. But this reservation is insufficient, since it may not be possible, in the face of other demands on the land resource, to provide adequate representation. Consequently, protection of natural communities and habitats outside the formally dedicated parks and reserves assumes a high priority.

Living resources in Western Australia

The number of species of known plants and animals in Western Australia is high, including 145 species of mammals, 480 birds, 445 reptiles and amphibians, and over 7000 plant species. No doubt many more remain to be discovered, particularly amongst the invertebrate groups. Many species occur nowhere else in the world. As noted in Chapter 2, the south-west region of higher rainfall has a high number of endemic species due to its isolation by adjacent arid areas.

Prior to European settlement, Aboriginal cultures were well adapted to sustainable exploitation of the living resources, as shown by their survival virtually unchanged for tens of thousands of years. European settlement has resulted in greater levels of exploitation over almost the whole State, yet in many areas opportunities for the protection of the natural flora and fauna are still considerable.

This is because extensive clearing of natural vegetation is almost entirely confined to the south-western corner. Figure 2.4 and Table 2.1 show that roughly nine-tenths of the State is committed to forms of use which, in principle, require the maintenance of the natural plant cover over most of the land surface. Little or none of it is in private ownership, so that there is a potential for control of use by the State Government. The major component is vacant Crown land, closely followed by the pastoral leases. Aboriginal reserves and national parks and nature reserves also occupy significant areas. Even in the south-western corner, where clearing for agriculture and urban development is extensive, a substantial area, approximately 2 million hectares, is dedicated to State Forest.

Much of the State's land area, including some of the most fragile arid regions, is subject to mineral tenements of various kinds, permitting a range of activities from exploration to active mining, the latter taking place predominantly in the Pilbara, the Goldfields and the Darling Range. Open cut mining does, of course, destroy the existing natural condition, and while this is a matter of real concern, the overall impact is confined to a small proportion of the total land area.

Thus the picture which emerges is of an enormous land mass, over 2.5 million square kilometres, where in well over 90 per cent of it, the objectives of management are the maintenance of the natural ground or soil cover, whether for sustainable production as in pastoralism and forestry, or primarily for conservation, as in the parks and reserves and certain catchments. The vacant Crown land requires protection, not only for its conservation value, but also to safeguard its potential for any future productive use.

In general, the coastal waters and marine habitats of Western Australia are in good condition when compared with localities having denser populations and being more heavily industrialised. However, this gives no cause for complacency. In fact, the State has an advantage in that it has a little more time to develop conservation strategies which will maintain satisfactory conditions in our coastal environment and will satisfy a wide range of different users' needs. This may take time to develop, but it is important to act *before* serious problems arise rather than to attempt to rectify the situation after the quality of our marine environment has been so degraded that there are few options remaining for satisfying the needs of all users. Unfortunately, there is a tendency to avoid commitment to early strategies and not to act unless specific problems have arisen.

Although there is then, in Western Australia, a valuable conservation potential, it is clear that there has been some degradation and loss, the latter particularly in the farming areas where clearing is most extensive. Nevertheless, a very significant conservation opportunity remains. This chapter concerns itself mainly with provision for conservation through parks and reserves, on private land, and uncommitted land, referred to as vacant Crown land. Pastoralism and forestry and the extent of their actual and potential contribution to conservation are considered in separate chapters.

Conservation through reserves

Western Australia has had some parks and reserves from the early days of its establishment as the Swan River Colony. However, in 1962 a Western Australian sub-committee of the Australian Academy of Science pointed out the rapid rate at which natural areas were then being cleared for agriculture, and the need for some action to ensure the establishment of a set of reserves representative of "all major communities of natural wildlife and scenery types in Western Australia"[1] Responding to this, the Environmental Protection Authority (EPA) appointed the Conservation Through Reserves Committee (CTRC) in 1972 to develop proposals for such a set of reserves.

The CTRC divided the State into twelve systems, and reported to the EPA on eleven of them[2] The Darling System, also known as System 6, which forms the hinterland of Perth was not dealt with by CTRC; instead the EPA commissioned a separate, special study for this impor-

1. Western Australian Sub-committee, Australian Academy of Science (1962). Report on National Parks.
2. Conservation Through Reserves Committee (1974), (1977). Conservation Reserves in Western Australia. Department of Conservation and Environment, W.A.

tant area in view of the other conflicting demands for land in this area of more intensive use.[3] The position now is that since 1976 the State Government has accepted in principle the recommendations which the EPA has made for the whole State, apart from Systems 6 and 7, (EPA 1975 and 1976).[4] In the case of the System 7 Report (EPA 1980),[4] the Government stated that it will use the EPA recommendations as the basis for future reserves to be created in the Kimberley. The final Report of the System 6 Study is at present under consideration by the EPA following publication of the preliminary report and the receipt of public and other comment.

There has been some delay in implementing some of the recommendations already accepted due to technical and administrative problems, lack of funds for the purchase of freehold land, and difficulty in resolving conflicts with competing uses. The System 6 (Darling System) Study Report offers some advice on how certain of these difficulties may be resolved. Nevertheless, the areas of conservation value, largely in public ownership, throughout the State, have now been identified. Together with already existing national parks and nature reserves, and management priority areas (MPAs) for conservation and recreation in State Forest defined in the Forest Department's Working Plans, they amount to approximately 6.9 per cent of the area of Western Australia. The MPAs alone provide for the dedication of 410,430 hectares or 20.4 per cent of State Forest for the primary purpose of conservation of flora, fauna and landscape, or for public recreation.

The highest degree of security afforded to reserves under the Land Act[5] is accorded to Class A reserves, whose purpose cannot be changed without consent of both Houses of Parliament. The Mining Act of 1978[6] provides that the consent of both Houses of Parliament is required before a mining lease may be granted in the South West Land Division or the Shires of Esperance or Ravensthorpe.

An equivalent to Class A reserve status is under consideration by the EPA for conservation management priority areas in State Forest, as discussed further in Chapter 4.

Class B and C reserves, on the other hand, may be altered with the consent of the Governor (i.e. without consent of both Houses), although alteration of Class B reserves requires justification to be placed before Parliament.

While a large number of existing national parks and nature reserves already have Class A status, the establishment of new reserves gives rise to concern from other land use interests, particularly water supply, mining and farming. Class A status especially makes development of these uses difficult, and consequently the establishment of a new reserve is often opposed. The solution appears to be some form of short-term reservation, during which mineral and other potential can be determined before a final decision is made, yet in the meantime, conservation and other values are protected. Such a strategy, however, will only be effective if the relevant information is sought within the required time frame, as this calls for an inventory of land, mineral and water resources.

Inventory of mineral resources seems to be the most difficult of these. While the State's policy is to maintain an inventory of known mineral and fossil fuel resources, and to assess the resource potential of all areas as an aid to long-range planning, it also recognises that private sector exploration is the major contributor of information, and that this is to be encouraged. Yet the motivation for exploration by the private sector must be the possibility that exploitation will be permitted. It seems essential that the State itself should take the responsibility for in some way assessing mineral potential of areas proposed for reservation so that implementation is not deferred indefinitely. The policies of the Mines Department may require some modification to encourage this, as discussed in Chapter 7.

Thus it can be said that Western Australia is progressively moving towards the establishment of additional parks and reserves throughout the land areas of the State. The figures in Table 3.1 show actual increases from 1969 to 1982. Substantial additional areas are under consideration arising from the activities of the CTRC and from the System 6 Study.

Despite this the parks and reserves system can hardly be said to fully represent the range of

3. Department of Conservation and Environment, W.A. (1981). The Darling System, Western Australia — Proposals for Parks and Reserves. The System 6 Study Report to the Environmental Protection Authority. Report No. 8.
4. Environmental Protection Authority (1975), (1976), (1980). Conservation Reserves for Western Australia. Department of Conservation and Environment, W.A.
5. Western Australia, Parliament, Land Act, 1933-1980.
6. Western Australia, Parliament, Mining Act, 1978-1981 (and Regulations).

Table 3.1: Management of National Parks, Nature Reserves and MPAs for conservation and recreation in Western Australia, 1969-1982

	1969		1974		1979		1982 (30 June)	
Management Body	Number of Reserves	Area (km^2)	Number of Reserves	Area (km^2)	Number of Reserves	Area (km^2)	Number of Reserves	Area (km^2)
National Parks Authority	47	14 194	63	17 708	61	45 516	63	43 662
W.A. Wildlife Authority	127	8 184	281	46 266	493	82 052	645	96 832
Forests Department MPAs	—	—	—	—	78	3 973	79	4 104

terrestrial ecosystems. This is borne out by even a cursory examination, such as that presented in Figure 3.1. The vegetation classes shown there are a highly simplified version of Beard's map[7] and it is immediately clear that many types are poorly represented, even taking into account proposed as well as existing areas. While the answer may not necessarily be to increase the number of parks and reserves, it certainly emphasises the need for care in the protection of other natural areas, notably State Forest, the pastoral leases and vacant Crown land.

In striking contrast to the present situation with land reserves, there has been little progress with aquatic reserves. In 1981 the Coastal Planning Steering Committee concluded in summary:[8]

(a) there is no agreed programme for a State-wide system of aquatic reserves;

(b) the concept of aquatic reserves is poorly understood in the community, reflecting uncertainty on the part of relevant State agencies;

(c) the current mechanisms for setting up and the management of aquatic reserves have several difficulties.

The Committee recommended that a group should prepare ". . . a State-wide programme for the creation of aquatic reserves in both coastal and estuarine waters. This programme should take into account both the desirability of protecting a representative range of environments and habitats, and likely management constraints."

Although the Fisheries Act[9] was amended in 1974 to provide some basis for the creation of aquatic reserves (section 30), few marine reserves have yet been declared, due in part to lack of resources, problems of defining State and Commonwealth waters, and uncertainty as to management responsibilities.

Biological surveys of the various marine habitats around the coasts of Western Australia are an important prerequisite. While valuable data are being accumulated by the Western Australian Museum, the Department of Fisheries and Wildlife, the Department of Conservation and Environment and tertiary institutions, these are restricted in location and content so there is a need for integration of effort and promotion of wider coverage.

It should be stressed that, as in the conservation of terrestrial resources and ecosystems, the strategy should not concentrate solely on reserving specific areas, but should be considered as only one facet of the wider management of the marine environment.

Increased allocation of terrestrial and aquatic areas to parks and reserves requires a substantial increase in staff and other resources. Inadequate management not only endangers the reserves themselves but places an undue burden on owners and users of adjoining areas.

7. Beard, J.S. (1981). Vegetation of Western Australia (1-3 million map). Forests Department, Western Australia.
8. Coastal Planning Steering Committee (1981). Coastal Planning and Management in Western Australia. A Report to the Conservation and Environment Council.
9. Western Australia, Parliament, Fisheries Act, 1905-1982.

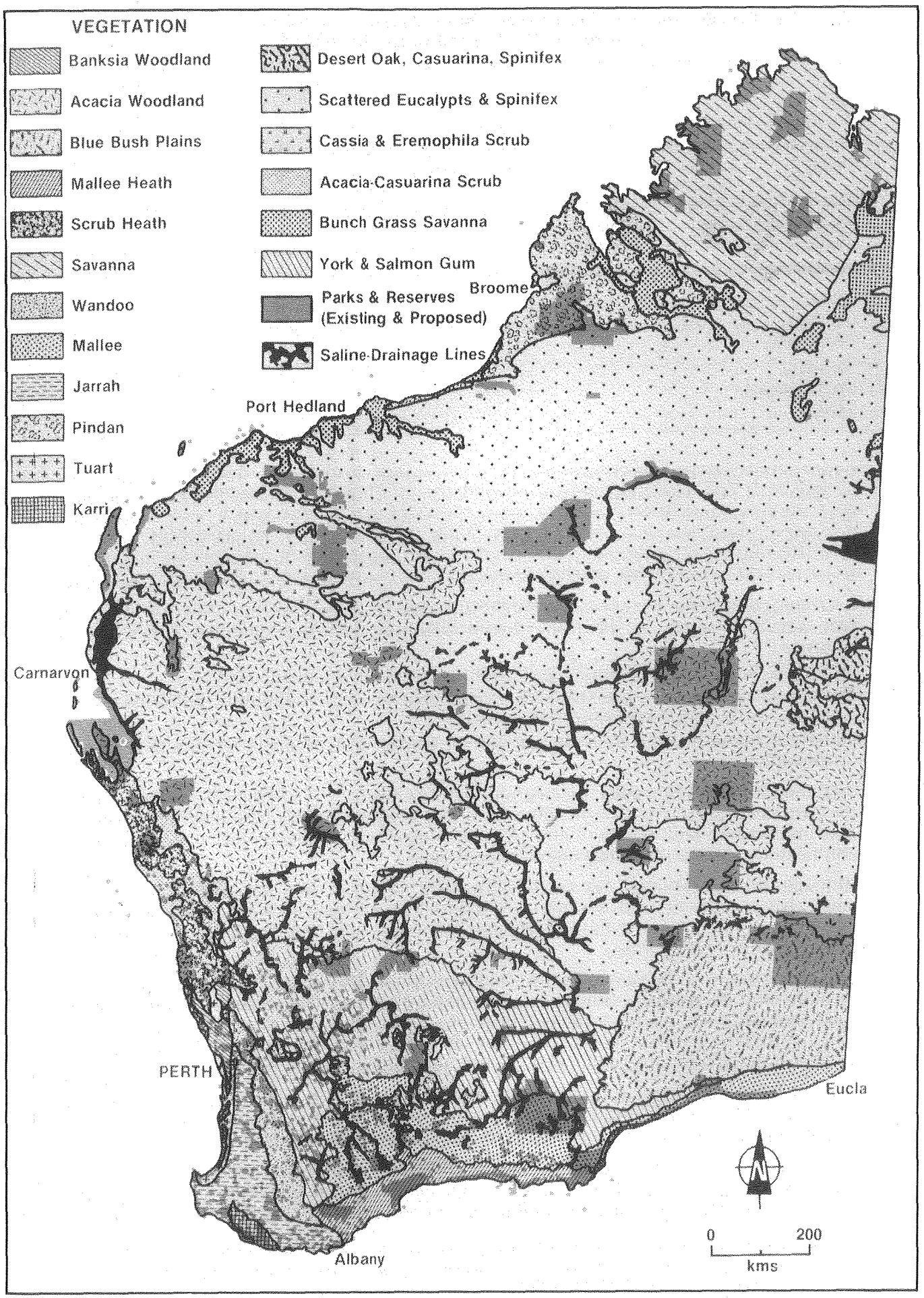

Figure 3.1 — Representation of terrestrial ecotypes in existing and proposed parks and reserves in Western Australia

Conservation outside reserves

As already pointed out, for any reasonable coverage of the diverse ecosystems of this State, conservation through a reserve system alone is unlikely to be adequate to meet the objectives of the World Conservation Strategy. However, this approach may well be supplemented by safeguarding the conservation values of other natural areas. State Forest and pastoral leases have a most valuable contribution to make, if only because of their great extent. They are therefore dealt with separately in Chapters 4 and 5. Here the concern is with natural areas on private land.

Western Australian legislation, principally the Wildlife Conservation Act,[10] is aimed at conserving as wide a range of species of flora and fauna as possible throughout the State, not only on reserves. All native flora and most fauna are "protected", which means that flora on Crown land and fauna anywhere cannot be taken without a licence from the Department of Fisheries and Wildlife. The only exceptions are dangerous snakes and the dingo. A number of species of flora have been declared as rare, and cannot be taken from any land, either public or private, without permission of the Minister.

There are, in addition, a number of Management Programmes in force to provide for the proper management and conservation of certain species of fauna, e.g. those on kangaroos and wild duck which are designed to conserve the species, even where hunting is permitted.

Conservation of flora and fauna, particularly in the south-west of the State, presents considerable difficulties because of the extent of clearing. Figure 3.2 shows this clearing, mainly for agriculture inland of the forests of the Darling Range, and in addition for urban, residential and recreational developments on the Coastal Plain. Parks and reserves are generally small, particularly in the predominantly agricultural areas, and likely to be too small to permit the survival of larger animal species or to provide adequate protective buffers between them and surrounding farmland. Even so, a well-managed small reserve can provide habitat for some species of fauna and may be important for flora.

Thus the limited but nevertheless valuable areas of forest and bush remaining on many farms assume the greater importance for conservation. Many farmers are becoming keen to retain natural areas, and in certain catchments clearing controls under the 1978 amendments to the Public Works Act[11] make it certain that significant areas of forest will remain. The 1982 amendments to the Soil Conservation Act[12] allow for controls on land use to be implemented where the current land use is resulting in land degradation. The amendments have strengthened and broadened the legislation so that the Commissioner of Soil Conservation is now concerned with all aspects of land degradation, including loss of vegetation, salinity, waterlogging and flooding as well as the active soil erosion covered in the original legislation. The new legislation provides for the establishment of district Soil Conservation Committees which have the potential to involve local communities in soil and land conservation programmes.

The acquisition of data on areas of remnant vegetation is necessary to assess their overall importance to conservation in the State and to identify sites with high conservation value. The provision of an extension service to advise landholders on land clearing is most urgent. Such action is essential if the observed decline in native vegetation is to be arrested. The maintenance of native flora and fauna will involve the landholder in expenditure, in terms of capital items such as fencing and in time devoted to managing such areas. Serious consideration should be given to the provision of incentives such as taxation concessions, rate relief on areas designated as farm reserves or direct grants to assist in natural regeneration.

There are thus several lines where future action should be considered as a priority:

(a) acquisition of data on extent, composition and current status of remnant vegetation on farms;

(b) provision of an effective extension service to provide expert advice on the preservation of native flora and fauna, with particular emphasis on regeneration strategies;

(c) consideration of government financial assistance to defray the costs of maintaining remnant areas.

There are also avenues for conservation on private land through town and country planning as practised by the Metropolitan Region Planning Authority (for the Metropolitan Region only), and by local authorities. The initial report of the System 6 Study discusses this question

10. Western Australia, Parliament, Wildlife Conservation Act, 1950-1980.
11. Western Australia, Parliament, Public Works Act, 1902-1978.
12. Western Australian Parliament, Soil and Land Conservation Act, 1945-1982.

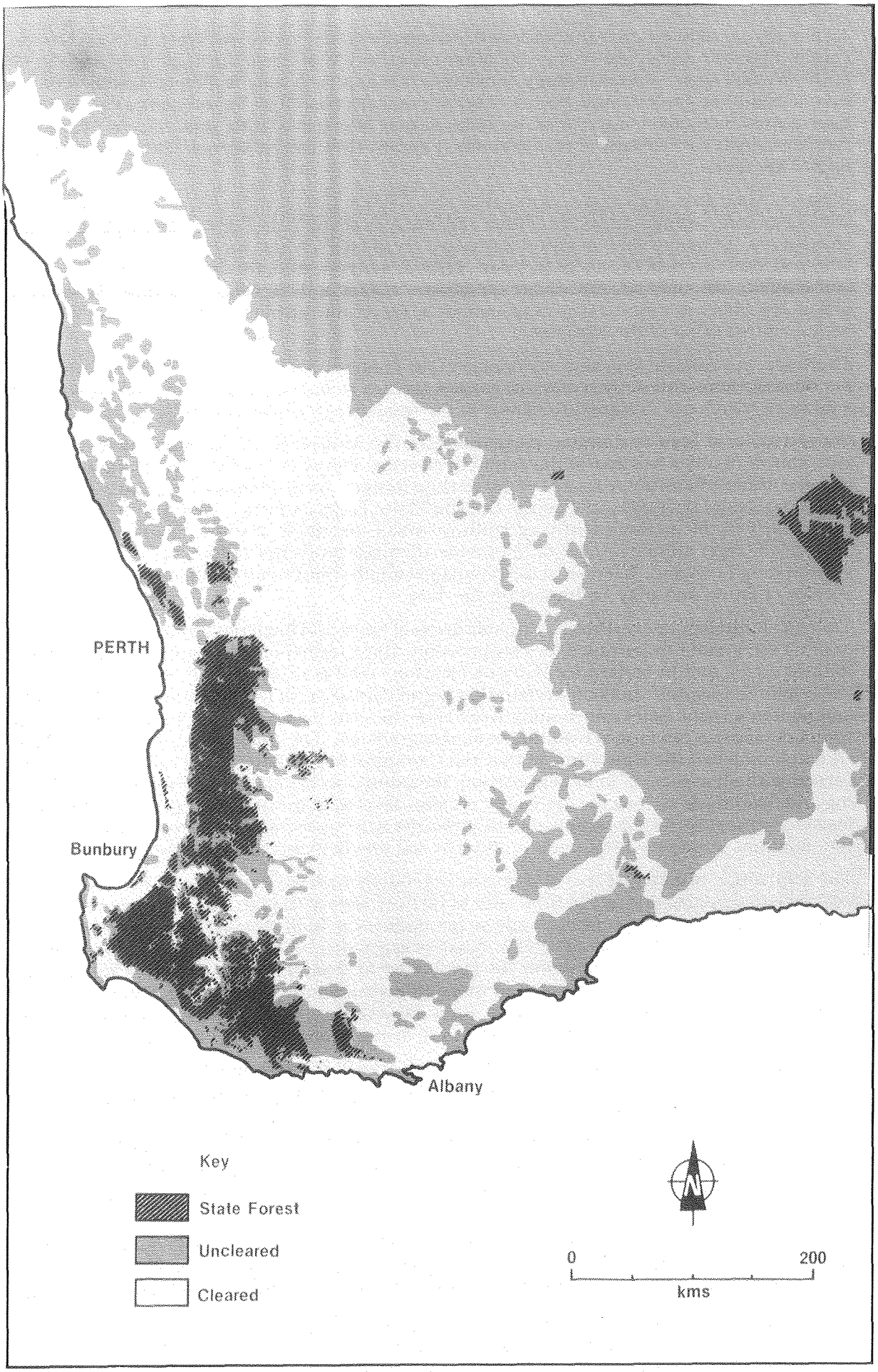

Figure 3.2 — Cleared and uncleared land in the south-west, showing State Forest

at some length, pointing out the value of setting aside land as open space of regional significance, for protection of natural areas and for public amenity purposes. It suggests a number of improvements in present planning procedures, including the need for a statutory means of designating regional open space throughout the State as well as in the Metropolitan Region, and the use of legislation similar to the South Australian Heritage Act.[13]

Planning for all forms of land use (of which provision for protection of natural areas is only one) assumes particular importance in the coastal zone. This is a part of the State where pressures for recreational use of natural areas and for competitive developments of various kinds is relatively intense. For this reason the State, on the initiative of the EPA, has given a great deal of consideration to the development of a policy for the coastal zone. This is dealt with in more detail in Chapter 11.

Uncommitted land

An area in excess of 1,080,000 square kilometres of Western Australia has the status of vacant Crown land, that is, land held by the Crown which has not been sold, leased or reserved for a public purpose.

The problems of effectively managing such an area are obviously immense, particularly having regard to manpower, financial and geographical constraints. In addition, there is limited information available for much of the land involved in respect of its living and other resources. There is still a great deal of exploratory work to be done. Some is undertaken by State agencies including the Department of Fisheries and Wildlife and the Western Australian Museum, who carry out biological surveys in selected areas, and Geological Survey which is responsible for geological mapping. Exploration for minerals and petroleum has been extensive, and while larger companies tend to be responsible in their attitudes, damage by irresponsible individuals is easily done, seldom monitored and hard to repair.

Current management therefore concentrates on areas which have been identified by a variety of means as warranting special priority. Examples include preventive fire control measures, protection of environmentally susceptible areas and control of illegal uses. Any greater scale of management would require a huge injection of Government funds. The Department of Lands and Surveys' present management profile includes co-operative assistance from other agencies.

It can be concluded that the Department of Lands and Surveys has a virtual custodial role in the management of vacant Crown lands at the present time. The Department will continue to hold these lands until future optimum land uses are determined by successive Governments in the public interest.

With the aid of modern remote sensing techniques, land use decisions will be based on an increasing stock of data on the land parcel involved. Increased monitoring of the State's holdings of vacant Crown land will also be possible.

Conclusion

The main areas for priority actions emerging from this review are:

(1) The appointment of staff and the provision of equipment to allow the State's parks and reserves to be managed in terms of the additional public pressure and their scientific importance.

(2) The need for continued review of the adequacy of the system of parks and reserves, in particular to ensure that reserves are large enough to maintain genetic diversity, not merely survival of each species.

(3) Attention should be given to developing a system of aquatic reserves fully representative of marine, estuarine and freshwater ecosystems in Western Australia.

(4) The need for continuing biological surveys, both terrestrial and aquatic, and also for mineral resource surveys so that allocation of land to parks and reserves among other uses may be made on a rational and informed basis.

(5) The importance of measures for the conservation of flora and fauna outside the parks and reserves system, in State Forest, pastoral leases, vacant Crown land and the coastal zone and off-shore waters.

(6) The need to provide technical advice to private landowners on the management and regeneration of natural forest and bush, especially in the farming areas.

(7) Research on reserve management.

13. South Australia. Parliament. South Australian Heritage Act. 1978-1980.

Chapter 4

Forests

The forest estate

The forest lands of Western Australia are confined principally to the south-west of the State and constitute a prime natural resource — one which has generated more public interest than any other land use.

Of the 2.5 million hectare total, 80 per cent is managed by the Forests Department as State Forest, Timber Reserves and freehold land held in the Conservator of Forests' name.

The remaining 0.5 million hectares consists mainly of uncleared agricultural land in private ownership although some is held by timber supply companies and in private softwood plantations.

Figure 3.2 illustrates the extent of forest in the south-west which occupies much of the Darling Range between the populous coastal plain and inland agricultural areas. Table 4.1 shows the composition and ownership of the forest estate.

The forest lands are generally identified by the two principle commercial species, karri *(Eucalyptus diversicolor)* and jarrah *(E. marginata)*, both endemic and of world-wide repute. At maturity, karri grows to one of the largest trees on earth and the richly coloured hardwood of jarrah is famous. These species occur as both single and mixed stands with other eucalypts especially marri *(E. calophylla)* as well as W.A. blackbutt *(E. patens)*, wandoo *(E. wandoo)* and bullich *(E. megacarpa)*.

Minor forest species include wandoo, tuart *(E. gomphocephala)*, brown mallet *(E. astringens)* and goldfield species including sandalwood *(Santalum spicatum)*. Commercial softwood plantations comprise the introduced pine species *Pinus radiata* and *P. pinaster*.

Table 4.1: Forest area and ownership at June 1981

Ownership	Forest	Area (ha)
Land under Forests Department control	Native Hardwood	1,960,000
	Pine Plantation	53,000
Private	Native Hardwood	520,000
	Pine Plantation	12,000
	Total	2,545,000

Source: W.A. Forests Department

The karri forest occurs in the wetter south-west corner of the State in a belt of 610,000 hectares, in which karri covers nearly 150,000 hectares in pure and mixed stands. Only a small proportion of karri forest has been cleared for agriculture and much remains untouched since colonisation by European man.

The forest is exploited commercially by logging under a clear-felling system. Unmillable karri and marri, and mill residues, are processed into woodchips as part of an integrated operation. In 1981-82 the area clear-felled was 2181 hectares.

Jarrah is the main timber-producing species in the State providing a superior hardwood with a distinctive grain and colour, which characterises much of the local building and furniture-making industries. It grows in pure and mixed stands covering about 1.45 million hectares in association with other hardwoods and a rich assemblage of understorey and fauna. A major role of the jarrah forest area is in providing catchment protection for urban water supplies — a role which is largely compatible with conservation objectives. However, the jarrah forest

has been extensively logged since colonisation. During 1981-82, a total of 24,676 hectares of jarrah forest was cut over.[1] The jarrah forest is also under pressure from dieback disease and bauxite mining. Insect attack affecting jarrah crowns seasonally is of some concern, though this is more evident on tuart on the coastal plain.

Of these various pressures, the most serious is the soil-borne fungus, *Phytophthora cinnamomi* Rands, which causes dieback. About 200,000 hectares of State Forest are affected at present. Management approaches have resulted in restricting access to a large part of the forest and imposing strict hygiene procedures to prevent infected soil from being transported by equipment.

Western Australia cannot supply local demand for timber and probably never will. For the financial year ending 30 June 1982, exports of timber and timber products were valued at $13.7 million while imports for the same period were valued at over double: $29.2 million.[1]

To contribute towards balancing sawlog removal and the renewal of native forests, natural hardwoods have been increasingly supplemented by plantations of exotic softwoods totalling about 53,000 hectares throughout the south-west. It is anticipated that the softwoods area managed by the Forests Department will stabilise at about 100,000 hectares eventually, depending on future market requirements.

Of the privately owned forest land, the major component is blocks of native hardwoods on farms which cannot be regarded as firmly dedicated forest land. Private pine plantations occupy only a small area (11,700 hectares) due in part to the scarcity of suitable soils. Thus much of the half million hectares of forest in private ownership represents the agricultural development potential on farms which are only part way through clearing programmes.

Forest policy and management

Demands and conflicts on the resource

Forests in this State are of considerable economic value, both on account of the all-purpose nature of their hardwood timbers and because of their occurrence in the higher rainfall, more densely populated part of the State. They provide the catchment areas for most of the metropolitan water supplies, they form a natural and effective protection against soil erosion and stream salinity and they provide for an increasing public demand for forest recreation. The forests also play a role in decentralisation of population and improving the diversification of rural economies. At the same time they are threatened by fire, disease and insect attack.

Correspondingly there are a number of demands, often conflicting, placed on the forest. In addition to the above, uses such as mining, townsites and roads and other utilities all put pressure on the forests.

The main competing uses on the forest resource are:

Wood production

The management objective for State Forest in relation to wood production is to satisfy local demand from local resources as far as possible but to systematically aim towards sustained yield from timber-producing areas. Private land timber resources currently provide nearly 10 per cent of sawlog supplies but this level cannot be sustained in the future as a proportion comes from agricultural land clearing. The level of the hardwood timber cut is being reduced steadily, consistent with the long-term production capabilities of the main commercial species, and is being replaced by softwoods where possible.

In the karri forest, woodchipping forms an integral part of the timber extraction operation. It must continue to be wholly integrated with the cutting of sawlogs and adhere to the prescriptions for environmental protection.

Water production

Clearing or disturbance of native vegetation in some forests of the State can result in salinisation of soils and streams. As shown in Figure 4.1, the most important surface water catchments for urban Perth and the populous Swan Coastal Plain are protected by the northern jarrah forest where maintenance of the forest cover is essential to safeguard water quality. The catchment reserves at present exclude the public. In all these areas water production and maintenance of quality is the most important use of the forest.

1. Forests Department, W.A. (1982). Annual Report 1981-1982.

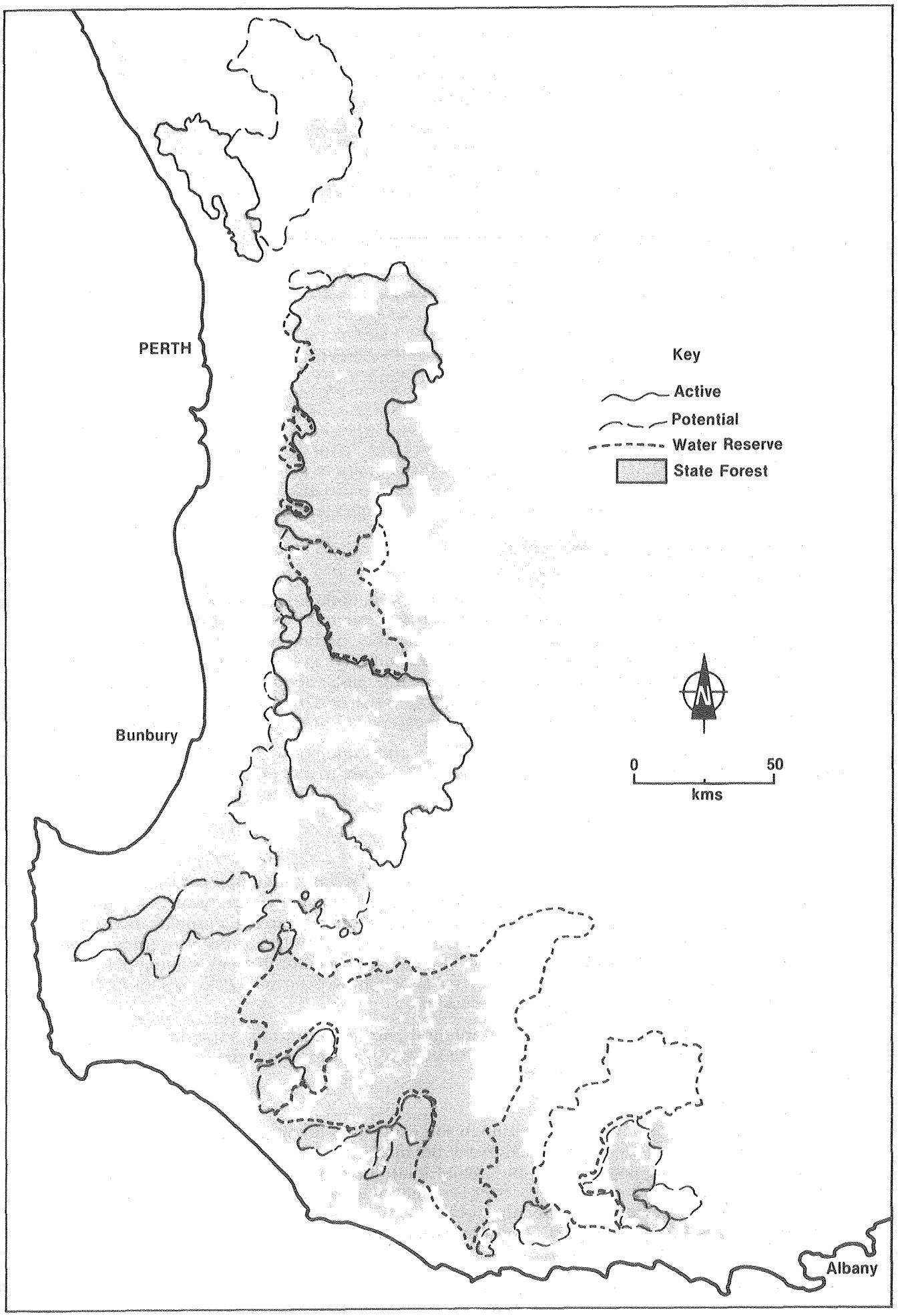

Figure 4.1 — Active and potential water catchments and State Forest

Conservation and recreation

The forest areas of south-western Australia form an almost continuous belt of natural vegetation forming the hinterland of Perth, the State's capital city, and other important population growth centres. The forest clearly has a great contribution to make in the conservation of flora and fauna and as a resource for recreation in natural surroundings. Many recreational areas and reserves already exist in forest land.

Major issues of concern involve the question of to what extent representative samples of forest are protected in parks and reserves to the extent that other uses such as the production of wood products or mining are excluded. This particularly involves representative samples of karri and jarrah forest.

Mining

Forest areas are affected by numerous mining tenements, particularly those for bauxite which cover the whole of the northern jarrah forest, and for coal in the Collie sedimentary basin. These are for open cut mining operations which directly remove vegetation, create adverse soil conditions for rehabilitation, and increase traffic movements which have the potential to spread forest disease. Smaller areas are affected by tin mining at Greenbushes and extraction of mineral sands near Capel.

Bauxite mining in the jarrah forest has the greatest capacity for widespread effects since the main ore bodies are widely dispersed. However, it is also the most effectively controlled although problems with rehabilitation of mined areas still present difficulties in terms of setting long-term objectives. A major concern is that open cut mining conflicts directly with protection of conservation areas. There are some differences too, between the contracts with the State and the two companies involved, Alcoa of Australia and Worsley Alumina. Worsley's resources occur largely on private property on the eastern slopes of the Darling Range and some of the constraints applied to Alcoa in State Forest have not been applied to Worsley.

Coal, tin and mineral sands mining affect smaller areas of forest. Coal production is presently 3 million tonnes per annum, 80 per cent from open cut mining, and could rise to about 8 million tonnes per annum by the year 2000. Tin mining at Greenbushes is also open cut although plans to mine tantalite in the same area will use underground techniques. While affected areas may be smaller, significant rehabilitation problems still exist.

Clearing for agriculture

Clearing for agriculture poses very little threat to State Forest though there is constant pressure, mainly at the inland margin, for release of State Forest or timber reserves, for the main purpose of build-up of farm areas to more economically viable levels. Rational analysis of costs and benefits of release must favour retention of the forest, since often only few farmers are affected, and the economic viability, if achieved, may not be lasting.

However, the 0.5 million hectares of freehold forest land on farms is a potential loss to the forest estate. Some is entirely suitable for and quite legitimately should be developed for agricultural production. Other forest blocks on farms should be retained for salinity control purposes. In water catchments controlled by statute, this is provided through a licensing system. Some forests will be voluntarily retained by farmers for reasons of amenity or for wood production for farm use. In cases where a significant forest area is retained on farms, it is important that it be managed for maintenance and regeneration.

Utilities

Lying as they do between the coastal cities and towns and the inland farming areas, and being the site of mining and some other industries including power generation as well as the traditional forestry activities, it is not surprising that the forest areas are traversed by numerous road and rail links, powerlines, pipelines and service corridors of various kinds.

These utilities benefit the regional economy and the standard of living within the State, but not without environmental cost. Over 100,000 hectares of State Forest have been cleared for public utilities in the last twenty years. Establishment and maintenance of services such as roads and powerlines increase the risk of infecting larger areas with dieback disease, while all permanent clearing reduces forest resources. Figure 4.2 shows the general effect of these public utilities, with their concentration around Collie — a source of coal-derived energy. Serious conflict occurs when water quality is threatened by the removal of trees, or where the clear-

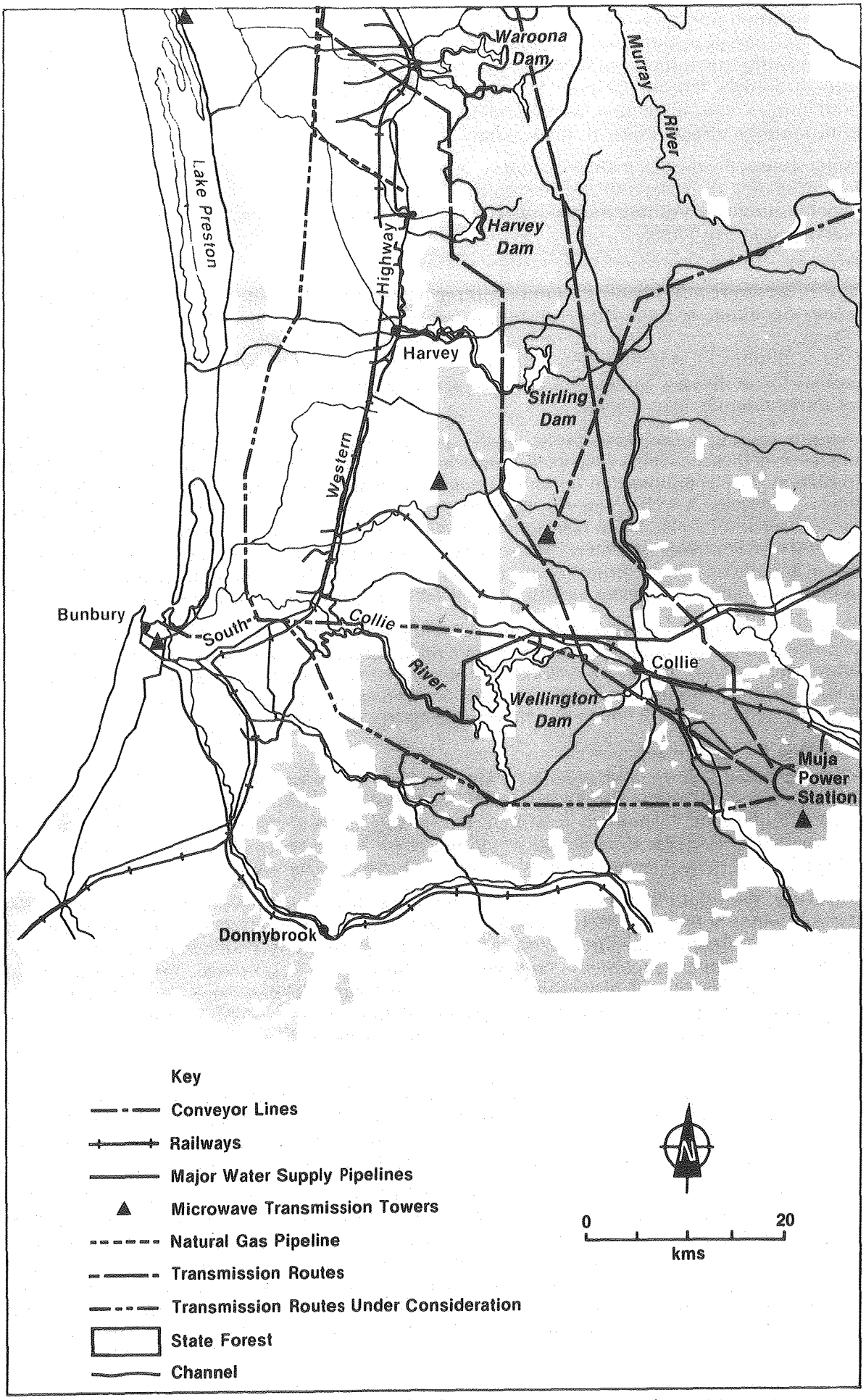

Figure 4.2 — The general effect on the forest of the provision for public utilities

ing of forest is totally incompatible with conservation of flora and fauna, and with timber production. Conflict with other land uses is usually greatest during the construction of utilities. The Forests Department has the objective of limiting development of public utilities that result in loss of forest values to those considered essential by Government, and for which there is no reasonable alternative location.

Management for multiple use

In order to rationalise all these demands, a policy of multiple-use management has been adopted by the State through the Forests Department.

Under the Forests Act, 1918-1976[2] the Forests Department has exclusive control and management of all matters of forestry policy, all State Forests and Timber Reserves and the forest produce of other Crown lands, the planting and thinning of forests, the making, laying out and maintenance of plantations and nurseries and the distribution of their trees, and the granting of all permits, licences, agreements and forest leases and authorities granted under the Act.

In general terms Departmental policy is formulated with two main concerns in mind: to ensure provision for the optimum social and material needs of the people and, at the same time, to provide for the environmental well-being of the forests themselves.

The concept of multiple use means the use of an area of forest for several purposes, some of which may be incompatible. Therefore, all of the forest areas under the management of the Forests Department have been delineated into mosaics, called Management Priority Areas (MPAs), all with a designated management priority which determines the use or combination of uses of each area through specific objectives, policies and management procedures. In this way the greatest number of compatible uses can be practised in most of the forest.

The major priority uses are:

Priority Use	Policy
Water production	To protect, control and rehabilitate where necessary those forest areas that contribute to the water supply requirements of the State.
Wood production	To regulate the removal of produce from the native forests to a level that can be sustained by the forest growth.
Other forest produce	Within the management guidelines for the forest, to ensure the future livelihood of those persons involved in smaller-scale forest industries such as honey, native seed and wildflowers, and sandalwood.
Recreation	To extend access to the forests wherever possible and to provide additional facilities for people to enjoy the many forest values that are available to them.
Flora, fauna and landscape conservation	To conserve areas that provide the habitat for the many species of flora and fauna that exist in the forests of Western Australia.
Scientific study and education	To set aside specific areas of forests for the purpose of education, reference and scientific study.
Public utility	To limit development of public utilities that result in loss of forest values to those considered essential by Government and for which there is no reasonable alternative. Utilities include powerlines, roads, townsites, water pipelines, railway and telephone lines.
Mining	To guide mining operations to areas where there will be least conflict with other land uses but considering overall balanced development including economics, to ensure that mining operations proceed under appropriate safeguards, and to rehabilitate areas affected by mining to best suit future land use.
Forest protection	To maintain and add to areas of permanently reserved forests, to protect these forests from fire, insects and other harmful agencies and to maintain and improve the health and vigour of the forest area.

2. Western Australia, Parliament, Forests Act, 1918-1976.

Regardless of how multiple use is defined, as human populations increase, competition for different uses of the forest will also increase and the policies and management of closely integrated or overlapping uses will have to be continually improved and refined.

General working plans

The regular preparation of statutory General Working Plans is the means by which forest policies are published and defined objectives are pursued through planning and management. It also enables the incorporation by the Forests Department, of public input obtained through discussions with individuals and groups. These Working Plans are produced usually every five years, the most recent being General Working Plan No. 87 of 1982. The public response to their publication provides a form of review which can be taken into account in subsequent plans. An examination of successive Working Plans shows an evolution of a land use planning framework for the forest areas.

The Forests Department is the only land-managing authority whose activities are firmly locked into a long-term, published, publicly available and periodically revised plan for management and conservation. Planning, for foresters in Western Australia, is an integral part of management, requiring a widening base of factual material on which even interim decisions must be made. To this end research and trials of various kinds have been directed at work on jarrah dieback, fire protection, research into forest ecosystems, the impact of various forest uses on both flora and fauna and better methods of improving catchment protection.

Forests on private land

Although having no jurisdiction over forests on private lands, the Forests Department has a policy of encouraging and assisting private owners to establish and manage commercial forests and, when requested, to provide landholders with advice on planting trees for their shelter and protective values in the rural areas.

In declared catchment areas, clearing controls have been placed on forest land to maintain downstream water quality. This is administered by the Public Works Department under the Country Areas Water Supply Act.[3]

At present there are no other controls or incentives and little encouragement to retain native vegetation on private land, although incentives are being examined.

Long-term strategies

Maintenance of forest productivity

A conflict is apparent in reconciling long-term conservation objectives with current timber extraction rates in that the forests are being exploited beyond their capacity to sustain present logging despite reductions in the hardwood cut.

It is relevant to note, however, that to manage the forest to achieve sustained yield (i.e. the volume of timber being extracted equalling the volume being added through growth) depends upon the length of time the forest has been managed. Virgin forest has low or negative increment rates while forests managed for timber production generally have high rates. Only in recent years have data been sufficient to define levels of timber extraction with any great precision and to use them to control the timber industry because regrowth from early logging is now reaching sufficient maturity to be harvested.

Nevertheless, the value of the forests is such that long-term sustained yield should continue to be a major objective in forest management; the attrition of the resource by logging at current rates, mining, forest disease or other demands is of concern to any conservation strategy, and therefore sustainability of forest extraction processes should be continually monitored.

To this end, the use of forests for public utilities should only be approved when no reasonable alternative exists and only then under the user pays principle.

Mining, particularly bauxite mining in the jarrah forest, as well as intensification of forest production in the woodchip licence area, have the potential to impose major impacts on the forest ecology. The effects of these developments on the forest ecology and particularly on biological productivity — in the broad sense — should be monitored.

3. Western Australia, Parliament, Country Areas Water Supply Act, 1947-1981.

Before the conclusion of developments which affect the productivity of the forest, objectives for rehabilitation need to be defined and management techniques used in rehabilitation require monitoring to ensure that the objectives are being met.

Research into the effects of bauxite mining and woodchipping on water quality in the jarrah and karri forests has been underway for some years under a Research Steering Committee. More recently, projects have been undertaken into wider issues. However, in keeping with long-term conservation objectives and in particular sustained yield, monitoring of long-term nutrient cycling and soil losses is necessary to predict any changes in forest ecology.

Conservation areas

Within the State Forest Management Priority Area (MPA) system, certain areas have been set aside as MPAs for the conservation of flora, fauna and landscape. These areas have been identified in the course of investigations of conservation reserves in the State initiated by the Environmental Protection Authority in 1972, as discussed in Chapter 3. The Forests Department's MPAs for conservation and recreation are shown in Figure 4.3.

MPAs in the karri forest have been re-examined recently and confirmed as providing a sound basis for a system of reservation of a range of karri forest ecotypes for conservation and recreation.

In the jarrah forest, the Forests Department's General Working Plan No. 86 of 1977 and the Environmental Protection Authority's System 6 Study have selected similar areas based on representation of ecotypes, freedom from disease, ease of definition of boundaries and feasibility of protective management.

An important point regarding MPAs in State Forests is that they are not isolated reserves but are surrounded by forested land. This surrounding forest needs to be managed in sympathy with the objectives of management for the MPAs so as not to endanger their primary purpose.

As part of the State Forest, these MPA areas have adequate security of tenure, but lack sufficient security of purpose at present to satisfy long-term conservation objectives. This is particularly important in the northern jarrah forest where conservation MPAs can be mined for bauxite under present contracts.

It is essential that the security of purpose of conservation and recreation MPAs in State Forests be given comparable status to Class 'A' reserves created under the Land Act.

In conservation and recreation MPAs and in State Forests in general, there are considerable gaps in knowledge about forest ecology, particularly fauna. This is largely because the Forests Department lacks the resources for research and other agencies are reluctant to investigate ecosystems not under their management control. Nevertheless, as a long-term conservation objective, studies on native fauna in conservation MPAs and their relationship to the surrounding forest should be a priority.

Private forests

The security of forest land held privately cannot be assured. This resource is an important supplement to State Forest in terms of supply of forest products, buffers to State Forest, maintenance of water quality and landscape, flora and fauna conservation. Although clearing is controlled in some water catchment areas by statute, an objective for conservation of the resource could be best achieved by providing positive incentives not to clear all the land, and investigations into appropriate mechanisms should be encouraged as soon as possible. Encouragement should be extended to management of private forests.

In addition, the results of past land clearing in the south-west resulting in salinisation and soil erosion indicate that reforestation of some already cleared areas is desirable. Research into regeneration of forest on private property should be a priority and the results disseminated through an advisory service.

Policy

Despite the publication of General Working Plans with an implicit invitation for public comment between successive plans, there is no clearly identifiable formal mechanism for public participation.

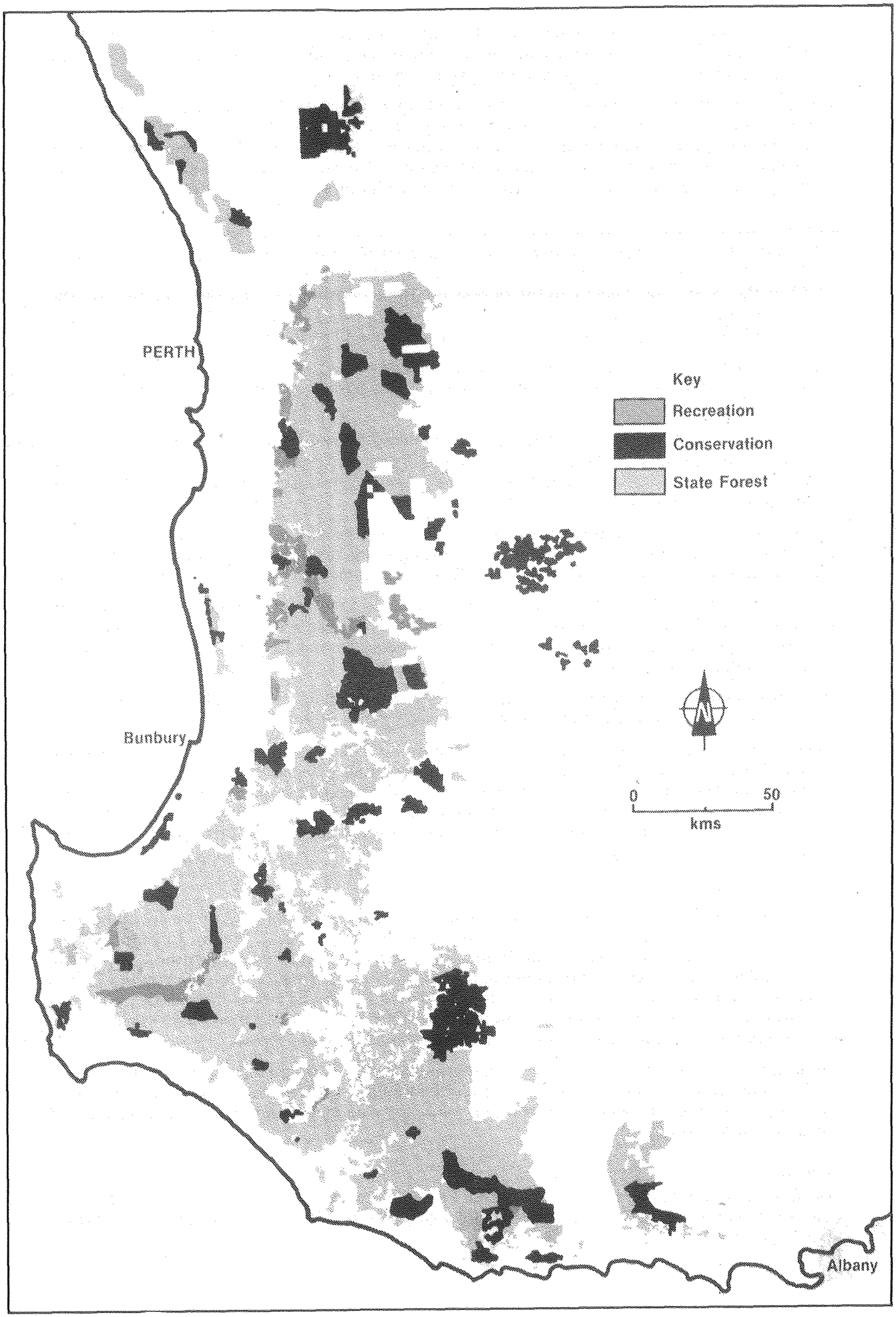

Figure 4.3 — Forests Department Management Priority Areas for conservation and recreation

Public interest in the forests in Western Australia is relatively high and genuine concern is felt for the long-term future of forests. High levels of awareness have been found for ravages of dieback disease, woodchipping and over-cutting for timber, and this has led to bitter public debate on forest management over a number of years.

In view of the widespread and deeply felt public interest, a formal mechanism for including public comments into revision of General Working Plans should be developed. In this way, input can be made by concerned persons and groups into future management policies.

Conclusions

Examination of forestry practice in Western Australia shows that it has developed along lines consistent with the aims of the World Conservation Strategy for a number of years.

Forestry practice has been concerned with soil erosion, water quality and degradation of catchment areas as well as monitoring support systems for flora and fauna. The approach to conservation has been broad rather than sectoral and the inclusion of conservation is an integral part of planning and management.

At present the Forests Department's General Working Plans are the only major resource management plans revised and published at regular intervals in the State.

Generally, conservation of State Forests in Western Australia has formed part of management policy for a number of years. With implementation of public review of working plans, forests should be in the forefront of achieving long-term conservation strategies.

Chapter 5

Pastoralism

Introduction

The occupied pastoral lands of Western Australia cover about 951,000 square kilometres or 38 per cent of the State's area. They are those semi-arid and arid parts of the State where the major land use is the grazing of sheep and cattle on native vegetation under conditions of leasehold tenure. With the exception of the isolated North Kimberley area, rainfall is too low and erratic to sustain agricultural cropping or broadscale pasture development.

The pastoral lands of Western Australia currently support (1982) about 2.2 million sheep (6 per cent of the State's total sheep population) and 1,000,000 cattle (47 per cent of the State's total). Sheep numbers have declined markedly since the peak of about 5.5 million in the early 1930s. Cattle numbers are now above those of the early years of settlement. There are about 450 station businesses operating today in the sheep and cattle areas.

There is increasing pressure for multiple or alternative use of pastoral lands and much of this is directly competitive with traditional pastoralism. The requirements of the mining industry and the need for water catchment reserves, national parks and flora and fauna reserves have already taken precedence over the interests of the pastoral industry. This trend is likely to continue in the future and, in some instances, such changes are desirable in respect of the objectives of the conservation strategy.

The pastoral resources and their present condition are shown in Table 5.1. The regions described in the Table are shown in Figure 5.1.

Recognised problems

Pastoral or grazing

Damage to the renewable resources as a result of grazing on pastoral lands occurs as vegetation degradation and soil erosion. Vegetation degradation results in loss of genetic diversity and loss of productivity for livestock. Soil erosion results in changes to soil physical and chemical properties which are detrimental to plant growth. Degradation has detrimentally altered wildlife habitats in some instances, although in other cases pastoral development has favoured native fauna. Degradation has resulted in altered characteristics in water catchments with increased runoff, increased stream turbidity and increased sedimentation in lower reaches.

Resource inventory and condition surveys of the State's pastoral lands have been undertaken in a number of regions in Western Australia. These surveys have been commissioned by the Pastoral Board and carried out jointly by the Department of Lands and Surveys and Department of Agriculture. The surveys are about half completed and it is expected that they will cease in the 1990s when all the State's pastoral land has been covered.

The results of four surveys have been published: the Gascoyne River catchment (Wilcox and McKinnon, 1972)[1] the West Kimberley region (Payne *et al.*, 1979)[2] the Nullarbor Plain (Mitchell *et al.*, 1979)[3] and the Ashburton River catchment (Payne *et al.*, 1982)[4]

The results of surveys (Table 5.2) clearly show that environmental degradation has occurred to a greater or lesser extent in all the pastoral areas surveyed to date. The Table also demonstrates the fall in total carrying capacity in the regions for which surveys have been completed.

An additional study of the arid pastoral areas in Western Australia was made for the Commonwealth and State Governments' collaborative soil conservation study 1975-1977 (Anon.,

1. Wilcox, D.G. and McKinnon, E.A. (1972). A Report on the Condition of the Gascoyne Catchment. Dept. of Agriculture, W.A. pub.
2. Payne, A.L., Kubicki, A., Wilcox, D.G. and Short, L.C. (1979). A Report on Erosion and Range Condition in the West Kimberley Area of Western Australia. Tech. Bull. 42. Dept. of Agriculture, W.A.
3. Mitchell, A.A., McCarthy, R. and Hacker, R.B. (1979). A Range Use and Condition Survey of Part of the Western Australian Nullarbor Plain. Tech. Bull. 47. Dept. of Agriculture, W.A.
4. Payne, A.L., Mitchell, A.A., and Holman, W. (1982). An Inventory and Condition Survey of Rangelands in the Ashburton River Catchment. Tech. Bull. 62. Dept. of Agriculture, W.A.

Table 5.1: Pastoral regions in Western Australia showing area, condition and treatments required

Pastoral and Arid Zone (see Figure 5.1)	Area (sq.km.) and % used	Rainfall (mm)	Types of Country	%	Tenure	Problems	Controls
Kimberley Non-arid	110 000 50%	750-1300 summer	Hills. Perennial grasses. Sandplain.	65 25 10	Area recently settled. 16 pastoral leases. 8 aboriginal stations and 2 reserves. Contains Ord Irrigation area.	Little degradation on irrigated land. Some degradation in grazed valleys. A potential for overuse exists.	Proper stock management. Development of introduced species (e.g. *stylosanthes* spp.)
Kimberley Arid	219 500 81%	350-750 summer	Hills and sandplain. Black soil plains. Perennial grasses.	65 10 25	First settled 1880's. 80 stations running all cattle.	Severe water erosion of the valley floors in the hills, and in the east region. Severe wind erosion on frontage country.	Reduced stocking rates. Rehabilitation of affected land, and proper stock management.
North-West Spinifex	220 000 all used	250-350 summer	Ranges and stony upland. Tussock and Hummock. Grasslands sandplain. Outwash.	90 38 12 10	Settled 1860. 80 stations mostly cattle.	Overuse has resulted in vegetation degradation with rangeland degrading to spinifex. Little soil erosion has occurred.	Increase in managerial inputs.
Northern shrublands	136 600 all used	200 mm summer or winter.	Extremely varied (9 types). Gascoyne and Wooramel river systems.		100 stations mostly sheep. Intensive irrigation at Carnarvon.	Some flooding at Carnarvon, increasingly erratic flows of the Gascoyne River. Rangelands of low productivity. Wind and water erosion on run-on areas. Degradation of vegetation on rocky uplands.	Reduced stocking rates. Rehabilitation probably uneconomic.
Southern shrublands	306 000 97%	180-250 winter	Extremely varied (9 types). Murchison River.		180 stations mostly sheep grazing.	Widespread vegetation degradation. Erosion confined to alluvial plains and saltbush areas.	Reduced stocking rates.
Goldfields	230 800 98%	200-250 winter	7 types of country. Salt lakes are common.		120 stations mostly sheep.	Erosion is minor, mainly vegetation degradation.	Proper grazing management.
Nullarbor	197 000 66%	150-275 winter	Limestone plateau and low coastal plains.		30 stations grazing sheep. Little use until 1963.	Fragile ecosystem and vegetation degradation is obvious; groundwater and surface water shortage.	Strict control of stock numbers; unalienated land prevented from pastoral use.

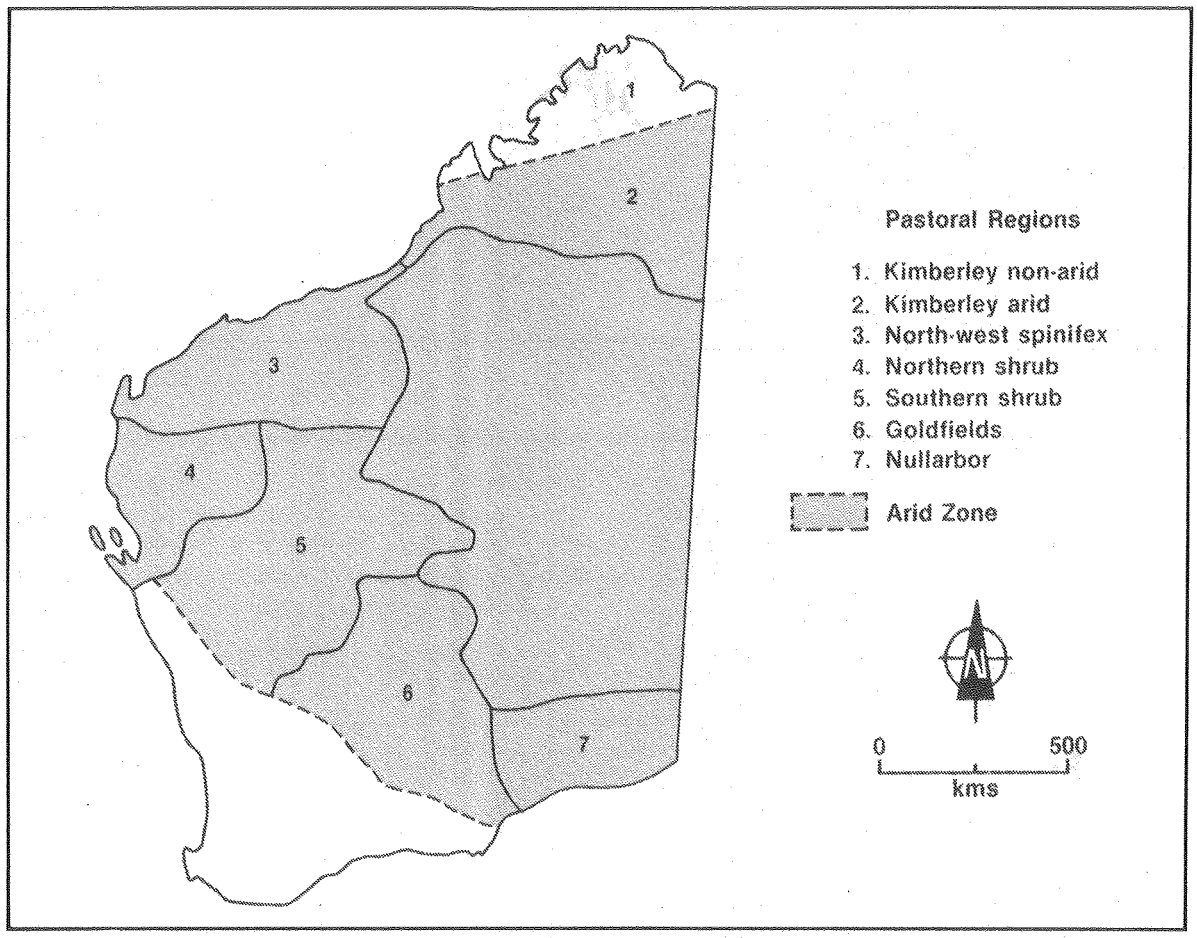

Figure 5.1 — Regions adopted for pastoral zones in Western Australia for the soil conservation study (Anon., 1978)

Table 5.2: Range condition classes and carrying capacities for five surveyed areas

	Area (sq km) and % in condition shown				Survey safe carrying capacity	
Region Surveyed	Good	Fair	Bad	Total sq km	Good condition	Present condition
Gascoyne Catchment (1970)	21,300 32%	32,800 53%	9,300 15%	63,400	317,985	255,260
West Kimberley (1972)	17,500 20%	45,400 50%	26,700 30%	89,600	318,620	177,000
Nullarbor Plain (1974)	23,700 50%	4,700 10%	19,000 40%	47,400	No further releases of land for pastoralism	
Ashburton (1976-78)	39,100 64%	16,500 27%	5,500 9%	61,100*	536,800	368,800
Exmouth-Shark Bay (1981-82)	35,000 50%	28,000 40%	7,000 10%	approx. 70,000	n.a.	n.a.
All areas surveyed	136,600 41%	127,400 39%	67,500 20%	331,500		

* 32,500 sq km of vacant Crown land and reserves not included.

1978).[5] Table 5.3 shows the areas of pastoral land needing treatment. It shows that 20 per cent of the pastoral lands in Western Australia were in need of special range management practices involving stock reductions and mechanical treatments to restore them to their former productive capacity. However, it should be pointed out that such restoration of productive capacity would not necessarily restore the original community structure.

Table 5.3: Areas of Western Australian pastoral land needing treatment (revised)

Treatments	Areas	
	km^2	%
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

Other problems

In addition to the biological and environmental problems described in the foregoing section, a number of social problems can be recognised. These include the following:

(a) Competitive uses

Pastoralism is no longer the only form of land use in the rangeland areas. New towns and increasing populations in this arid environment are placing strains upon the ecosystems in some instances. Mining activities have introduced problems of environmental damage to restricted areas.

The community demand for recreational activities along the north coast and for nature reserves in the hinterland has already affected some pastoralists. Tourist activities are generally uncontrolled and impose strains. In the future they will need to be better organised as the demand for this form of land use will increase rapidly.

(b) Attitudes of pastoralists to the resource

Although most pastoralists no longer regard the resource as capable of indefinite renewal, some still have expectations which are beyond the capacity of that resource. Droughts, which are a feature of the environment, demand special management skills if their effects are to be minimised. These are not sufficiently recognised or practised.

(c) Social problems

Distance, isolation and small populations impose special problems of regulation, conservation and education in the pastoral areas. It is important to note that this situation is one peculiar to Australia and to Western Australia in particular, being unlike that in any other nation of Western European origin.

Current management systems

Kimberley region

Traditionally the cattle industry in the Kimberley region has operated on the open range or "cattle hunting" principle and, to a large extent, still does. Improvements amount to a horse paddock, a bullock paddock and a few other paddocks, wind mills, water tanks and numerous branding yards at different points on the station.

Animal husbandry practices are minimal. Bulls run with the herd all year, weaning is not practised and mustering to separate saleable animals and to brand, earmark and castrate takes place during the cooler months, April to September.

5. Anon. (1978). Land Degradation in Agricultural and Pastoral Australia. Report 13. Commonwealth and State Government Collaborative Soil Conservation Study 1975-77 (unpublished).

Pasture management, with the exception of burning on spinifex pastures, is virtually non-existent. Most Kimberley pastures are grazed on a continuous year long basis and levels of use are frequently excessive. Preferential overuse has occurred on many valuable pasture lands adjacent to major rivers.

On many Kimberley properties permanent waters are 15 kilometres or more apart with up to 1000 cattle watering on each. In these circumstances extensive degraded areas or "sacrifice" zones around watering points are common.

Spinifex, shrublands, goldfields and Nullarbor regions
These regions were developed for sheep production, although some parts now support cattle only. For the most part, however, sheep grazing for wool production remains the principal activity. Sheep properties are usually well improved with adequate fencing and with water points about seven to ten kilometres apart. Sheep are segregated by sex and often age group, and the lambing time is fixed to one period of the year.

On most stations sheep are run for the whole year in paddocks in a continuous set stocked operation. Stocking rates have been established on the basis of experience and it is possible to show that the over-optimism of the past had reduced the more valuable components of the pasture. In general terms, stocking rates today (1982) are about one-half of those practised in 1920 as a result of the decline in the productivity of the resource.

Conservation of pastoral lands

Individual, community and State attitudes to rangeland use have undergone considerable change in the past two decades. The need to have more information on the nature and the condition of the resource has been recognised and surveys of the pastoral lands are in progress. The Department of Agriculture now has a professional rangeland management group providing research and extension inputs upon which better decisions on use can be based. The Pastoral Branch of the Department of Lands and Surveys has been expanded since 1960. There is now a much greater degree of consultation between the pastoral administrators and the industry. Policies for conservative management should take account of the following points:

The continued use of some areas of pastoral land in Western Australia is incompatible with conservation objectives. These would include:

- properties marginal to the Great Sandy, Gibson and Victoria Deserts and on the stony spine of Western Australia where the environment is very arid;
- the Nullarbor Plain, and
- areas with special constraints, e.g. the Ord River Catchment Regeneration Area.

The community should accept that the cost of pastoral land rehabilitation is one that will have to be shared if the objectives of the strategy are to be met. Much land degradation occurred due to ignorance and in the absence of Government advice on proper land use practices. A start on the reclamation process has been made in the Fitzroy Valley and was undertaken on the Ord Regeneration Area.

Property sizes need to be large enough so that lessees may generate sufficient income without having to stock at excessively high levels.

Stocking rates on pastoral lands should be set so that they permit the conservation of species habitats and allow the maintenance of genetic diversity. If necessary, incentives to compensate for production thereby foregone should be provided where necessary.

It should be accepted that land degradation and erosion have taken place in pastoral regions. The present condition of the rangelands should be taken as the base upon which improvements in the quality of the resource will be built. It is important that there be no apportioning of blame and that it be recognised that the rangelands are a resource available for use by all sections of the community.

Motivating change in current approaches to rangeland use

A forum for the exchange of ideas and views on the use of the rangelands needs to be established. It should include representatives of the pastoral industry, government, miners, tourists, Aboriginal people and conservationists. It should anticipate and resolve conflict, advise government as required and suggest ways of achieving the conservation and multiple use of those lands. A forum such as this was recommended by the Pastoral Industry Inquiry (1979).[6]

6. Department of Lands and Surveys, W.A. (1979). The Present and Future Pastoral Industry of Western Australia.

Extension services to the pastoral industry and to others using the rangeland areas need to be improved. The Department of Agriculture provides an extension service to the pastoral industry. However, the development of responsible attitudes to the multiple use of the fragile ecosystems of rangelands still lags behind that which is desirable. Particularly is this so in the tourist industry, where few of the precepts of proper use appear to be either recognised or practised.

The Department of Agriculture has a research programme aimed at achieving better rangeland management in all the regions shown in Figure 5.1. This multi-faceted programme is carried out by twelve professional officers with the support of technical officers on research stations and on pastoral leases. Together with the work of Herbarium staff and the Department's resource team, the Department has developed a significant level of professional competence on the use of arid areas. It would seem desirable that it be better utilised by both government and the private sector.

Management systems employed by pastoralists will only change if they are convinced themselves or by their peers that change is necessary.

The development of range condition monitoring systems and the establishment of locally based conservation groups are two complementary activities which will promote the implementation of change in management practices. Range condition monitoring systems have been developed by the Department of Agriculture and are able to detect changes in pasture condition as a result of management practice. Some 1000 sites have already been established. It is estimated that about 12,000 to 15,000 will be required if the grazed area is to be monitored adequately. Consideration ought to be given to the involvement of pastoral administrative staff in the establishment and recording of the sites. The data are readily usable and can be interpreted by pastoralists and administrators alike, and can direct the shifts towards more conservation-oriented management practices.

Because of the inability of the State to supervise land use it is suggested that a number of locally based soil conservation committees should be established under the Soil and Land Conservation Act, 1945-1982, consisting of landholders and government members. Their responsibility would be the review, from time to time, of the results of the monitoring programme. Such committees would be in a good position to promote the changes in management practice required should the analysis of the monitoring data reveal that this is necessary. Peer pressures and peer review are more effective than government regulations, especially where the latter cannot be enforced.

Chapter 6

Agriculture

Introduction

Before white men came to the colony as settlers in 1829, there was no agriculture in Western Australia. The Aboriginal people were tribal nomads who obtained their food by gathering seeds, berries and small fruits from the native flora, hunting the native fauna, and catching fish and other seafood in the estuaries and rivers and on the ocean shores.

The first white settlers brought seeds and plants, livestock and implements, and immediately set about seeking land suitable for growing food crops and for grazing livestock according to British systems and traditions. The settlers soon found, however, that the 30 to 40 kilometres wide coastal plain was for the most part composed of very sandy soils, and that alluvial soils from the rivers were very limited or poorly drained. Much later, when exploration had revealed more fertile land and better natural grazings, it was seen that the better land existed in pockets that were separated by large tracts of sandy and gravelly soils with poor grazing potential.

For a long time the colony did not prosper. Its population increased slowly and it struggled to feed itself. Agriculturally the first sixty years provide a striking contrast to the last fifty years. Between those two periods, the forty years 1889-1929 saw the colony/state make rapid progress under the impetus of gold discoveries, population growth, the introduction of superphosphate (which made poor soils fertile) and the changes in methods of clearing the land, cultivating the soil and harvesting hay and grain. Agricultural science began to help farmers solve their problems. Scientific research and advisory services were added to the initiative and hard work of the farmers, and, aided by the favourable climate, Western Australia revealed itself as an area of great agricultural potential in the winter rainfall areas.

The development and expansion of agriculture in the winter rainfall region is not a story of continuous success and prosperity. After the First World War the decade 1920-29 was a period of expansion, but between 1930 and 1950 there were severe problems owing to the Depression, the Second World War and post-war shortages. The years 1950-68 brought great progress stimulated by high wool prices during the Korean War and aided by new research findings about rabbit control, fertilisers, trace elements, clovers, medics and lupins.

After the Second World War the mechanisation of land clearing went ahead rapidly with bulldozers, large crawler tractors, logs and anchor chains. Many new chemicals for the control of insects and seeds became available, and rabbits were reduced to minimum numbers in the 1950s by the myxomatosis virus and by 1080 poison.

Agriculture in Western Australia is thus largely a post-World War II phenomenon. The 1950s and 1960s were decades of rapid agricultural expansion largely made possible by applying technologies to utilise the so-called light lands of the State. These lands, considered unproductive before the introduction of suitable legume pastures and the understanding of severe trace element deficiencies, now represent about a half of the State's used agricultural land.

Western Australian agriculture is today dominated by export-oriented, highly efficient, broad area industries producing grains, wool and red meats. Other small agricultural industries, such as dairying and poultry, are more labour intensive and oriented toward supplying domestic markets.

Briefly, agriculture fulfils dual economic roles in the economy. It is a low-cost source of food and fibre for local consumers and processors, and a main source of foreign exchange earnings. Both these roles are related, for as long as agriculture continues as a low-cost source of food and fibre then its ability to compete on export markets is aided.

It is important to appreciate that the development of agriculture to its present level of production and efficiency has been attained in a comparatively sparsely populated State, with a unique and relatively isolated natural environment, where most soils were inherently infertile, potable water supplies were deficient and many natural hazards for livestock had to be overcome. This development has occurred in a comparatively short time, and when viewed in relation to the constraints of the environment represents a considerable achievement by farmers, scientists and engineers.

In terms of conservation, the development of agriculture to its present status has had significant impact on the Western Australian environment, as other colonial efforts have had similar impacts on other environments throughout the world. The effects here included widespread destruction of native vegetation, with an almost complete elimination of woodland in what is now the wheatbelt. Problems of soil erosion by both wind and water have become prevalent, and salinity in both soils and water has increased.

However, now that the pattern of land use is fairly fixed, and we are unlikely to make major inroads into presently unalienated lands in the future — unless some new sources of fresh water and inexpensive power eventually develop — we must consider carefully the degradation in agricultural lands and examine ways and means of ameliorating these existing problems.

Land degradation and soil conservation

Agricultural development has involved greatly increasing natural productivity of the land. Degradation of farm land, considered in its most favourable light, represents not a decline from an original level but a reduction of expected benefits. At worst, inappropriately managed farm lands can become non-viable, become eroded or saline and be abandoned.

Crop rotations and soil structure

Over the last ten years, the proportion of broad-scale farming land being cropped each year has been increasing. Certainly, in the drier part of the wheatbelt, it is quite misleading to talk about a rotation system of farming. In some areas, two-thirds or more of the arable land is in crop in any one year. There is no evidence that farmers are moving towards any particular new equilibrium, other than the natural limitation imposed by cropping 100 per cent of the arable land.

On fine-textured soils, the cultivation practices used up to the present appear to have caused a deterioration in physical condition, so that many of these soils may not be so easily worked as in the past. However, reduced cultivation systems hold promise of allowing improvements in soil structure despite continued cropping. On the other hand, there can be no doubt that soil nitrogen status is declining, although few sites have been cropped long enough to be showing the effects yet.

Compression by heavy machinery has been shown to cause deterioration in soil structure on some coarse-textured soils, but methods of alleviating this problem are available — at least in the short term.

The particular difficulty in relation to more intensive cropping is that the long-term effects cannot be predicted with enough precision without actual long-term research, yet farmers would not be happy to refrain from further changes in farm practice until the long-term research has been done. Research which is being carried out currently on the effects of more intensive cropping should be continued and, if possible, intensified.

Erosion

Almost any land will erode under bad management. About one-third of the total area of cleared farm land is estimated to be stable under present management systems. The two-thirds majority needs special care and improved land management practices. This need is greatest in the cereal-growing districts where legume pastures have run down or failed in the dry years since 1969, combined with the trend to intensified cropping. About half the cleared farm land needs some combination of works and practices to control water and wind erosion.

A wide range of conservation practices may be applied to farm land. These include contour structures ranging from large absorption banks, narrow or broad-based grade banks, and contour sills, to guidelines for contour cropping, gully filling and gully control structures. Vegetative measures include retaining or planting trees on hazardous areas or as windbreaks.

Water erosion in the agricultural zone, though widespread especially in the wheatbelt, is generally moderate compared to erosion in the summer rainfall regions of the State and elsewhere in Australia.

Basically, that is so because rainfall intensities in the winter rainfall climatic regime of the agricultural zone are generally lower than in summer rainfall regimes.

Water erosion to a point beyond economic reclamation is restricted on farm land to extremely limited areas in the Irwin valley, and to some pediment slopes below ironstone breakaways.

Deep gullying is almost absent, to an extent which tends to surprise visiting conservationists from the Eastern States, due to generally shallow soils.

Even moderate water erosion, however, is of concern, because soils in the agricultural zone are mostly shallow and the risk that erosion, once started, may develop and spread is a serious one.

The inner (western) wheatbelt, with its steep slopes and many water-shedding features high in the landscape, tends to have the greatest concentration of water erosion. The outer (eastern) wheatbelt, though with less concentrated erosion, has a high proportion of erosion problems due to its sheer size.

The farm conservation measures developed for the inner wheatbelt — contour farming, pasture improvement and re-alignment of fences, roads and firebreaks allied with careful land management — are generally adequate though they still need to be more widely applied. The recent trend towards using minimum cultivation techniques, and the capability of modern farm machinery to ensure timely and early planting of crops, have also had positive benefits in the inner wheatbelt.

Less certainty prevails for the outer wheatbelt, especially its drier margins. These districts have been much affected by drought since 1969. Over large areas of sandy soils, improved pasture species have been unable to survive. Stock numbers were reduced during the droughts, and profitability clearly favours wheat growing for the long term. More frequent cropping, however, tends to increase the erosion risk. Bigger machines are being introduced, and there is much experimentation with crop management techniques. Land management in general is in a state of flux so that for the outer wheatbelt, conservation measures developed for the inner wheatbelt are not entirely appropriate. In particular, grassed waterways, an essential feature of contour systems in the inner wheatbelt, are of doubtful stability and may be ill-defined, widely separated or virtually non-existent.

Research over recent years suggests that considerable economic losses occur on farmland from sheet removal of soil by wind and water, and that damage by wind is of greater significance.

Wind erosion is caused by summer grazing, cultivation for cropping, and by the operations associated with the harvesting of subterranean clover seed. No part of the wheatbelt is free of wind erosion effects, though the western portion, due to its more reliable rainfall, heavier soils, hilly topography, better plant cover and lower economic stress, suffers from wind erosion less widely and often, and to a lesser degree. The southern coastal plain appears to have a greater incidence of wind erosion, probably mainly due to more frequent strong winds and in parts variable rainfall. Some parts of the southern coastal plain have very fine deep sands, with low clay content, which seem to be particularly vulnerable.

Summer grazing of dry pasture causes severe loosening of the soil surface. In poor pasture seasons the plant cover can become so thin that wind erosion will occur. Wind erosion due to summer grazing occurs widely so that it is probably the most severe erosion problem in Western Australia. The summer grazing of cereal stubble seldom causes wind erosion except in drought seasons when stubbles are thin and brittle and grazing pressure is high because of poor pastures.

Sandblast damage to crops and drift damage to fences and roads are obvious costs of wind erosion. The loss of productivity due to wind erosion in a single season can lead to crop yield loss as high as 25 per cent with losses in subsequent crops continuing for several years.

Wind erosion control methods are based on reducing wind velocity at the soil surface, stabilising the soil surface or making the soil less erodible.

Windbreaks which reduce wind velocities at the soil surface are effective at preventing wind erosion, but costly labour intensive establishment methods prevent general use. Their acceptance might be achieved after development of practical methods of direct seeding and cheap methods of protection from stock.

It is necessary to build up land management and conservation systems to guard against the more common erosion events and hazards. This entails continuation and intensification of research and extension activities, coupled where necessary with administrative and statutory action.

The present rapid changes in cropping and land management techniques, particularly in the drier districts, need to be monitored and guided, with conservation aspects given a high priority. A critical point is maintenance of sufficient plant cover to protect soils against both water and wind damage.

It is obviously impossible to eliminate wind erosion but high priority must be given to identifying the most erosion-prone situations on land already alienated or being considered for release, and giving them special protection.

Remnant native vegetation on farms, roadsides and other reserves should be given enhanced protection as a matter of high priority.

Salinity of soil and water

Soil salinity was present to some extent in the areas now used for agriculture in Western Australia even before European settlement. Salinised soils dominated the subdued drainage channels and were most evident as an interconnected series of salinas. In some areas of the outer wheatbelt this primary salinity occurred on up to 10 per cent of the landscape.

Land salinity is now the most important salinity problem in the State and has three manifestations:

(a) A restricted occurrence in, and in the vicinity of, natural salt lakes, the salt lakes being the remnants of very ancient river systems.

(b) A more widespread occurrence of saline seepages from unconfined aquifers on hill slopes; the aggregate area of these is not great.

(c) The most widespread form occurs in valley bottoms from shallow saline groundwaters. This form may spread from salt lake chains and eventually occupy large areas in the wide valleys of the wheatbelt. It may also occur on the floors of smaller valleys of higher elevation. This form is essentially man-induced secondary salinisation.

Since agricultural development some 2 per cent of the once arable land has become non-productive due to secondary salinity. A survey done in 1979 indicated some 264,000 ha of secondary salinity in the agricultural zone. The occurrence of secondary salinity is not equitably distributed — some local government areas having less then 0.5 per cent of the cleared land affected, while others have more than 6 per cent affected. Further, farmers within a given area bear vastly different proportions of the burden, with the farms lower in the landscape suffering the most. In one local government area in the north-east of the outer wheatbelt, twenty-two out of ninety-seven farms had greater than 200 ha of secondary salinity.

If the simplistic approach of extrapolating the rate of increase of salinity over the last thirty-five years is applied, then it would be predicted that there would be more than 800,000 ha of land affected by secondary salinity by the year 2000. If the growth rate between 1974 and 1979 of 9.5 per cent per annum is applied, then the potential is for 1,750,000 ha by the year 2000.

Because of the time lag between land development and the surface expression of secondary salinity, the growth rate between 1974 and 1979 probably reflects the large amount of land clearing which occurred during the 1960s. This higher growth rate of salinity will probably continue for the next two decades.

Water salinity — It is estimated that 99 per cent of the freshwater swamps, lakes and streams in the agricultural zone are now saline. This has severely affected the ecology and amenity of these systems.

The high rainfall region of the old plateau in the south-west provides all of the surface water supplies for urban, industrial and irrigation use in the region. Some 60 per cent of the potential surface water supplies in this area have become too saline for these purposes.

Costs of salinity

Land salinity affects stream salinity and both have off-site repercussions which make it very difficult to assess the total cost of salinity. However, some of the on-site costs can be reasonably assessed. The following costs assessed by the W.A. Department of Agriculture are in 1982 dollars.

Capital costs:

Land value lost — 264,000 ha at $400/ha = $105.6 million.

Annual rate of loss of land value — The rate of increase in the area of salt-affected land in the agricultural zone between 1974 and 1979 was 9.5 per cent per annum. Using the 1979 base figure, 25,000 ha per annum is being affected which, at $100/ha, represents an annual capital loss of $10 million.

Loss of farm water supplies — It is estimated that some 3000 farms have had to make alternative stock watering arrangements after bores, soaks and dams have become salt affected. With the average cost of the alternative being $4000 then $12 million of water supply capital has been lost.

Annual costs:

Farm output — Using the 1979 estimate of area of secondary salinity and an average gross value of production of $100/ha, the annual loss in farm output is $26.4 million.

Urban water supplies — The Public Works Department of W.A. estimates that the additional cost to the community of secondary salinity in the provision of water supplies is more than $15 million per year.

Total costs:

The costs detailed above do not include any of the off-site costs and therefore the estimates are extremely conservative. On this basis, salinity has cost the State $120 million in terms of lost resources. The annual cost, not including an interest factor on the written-off capital, is more than $50 million.

Reclaiming or arresting secondary salinisation

Land salinity is a result of hydrological imbalance in the landscape. It is therefore complex and does not have a readily accessible, short-term solution. Three general approaches to treating salt-affected land are considered. Each approach involves either lowering the groundwater or ensuring that it remains at depths where it is no longer within capillary range of the ground surface, and at which it can no longer adversely affect plant growth, whether trees, pastures or crops. These approaches are:

(a) To establish suitable plants, especially on the 'intake' or recharge areas of the groundwater, the objective being to increase transpiration and restore the balance between soil and water, keeping groundwater levels down to something approaching its original state under native vegetation (i.e. before salinisation appeared). This approach may involve consideration of reforestation, or some form of agroforestry, or changing rotations and cropping practices on identified salt intake areas.

(b) Another basic approach is to remove or lower the groundwater by open drains of various depths, or tile or pipe drainage.

(c) The third approach is to prevent the encroachment of secondary salinity. This can be attained if land use systems can be devised which maintain groundwaters at their present levels. Options to achieve this are reforestation, agroforestry and agronomic manipulation by changed rotations, and alternative tillage and drainage techniques.

Various aspects of these approaches are subjects of current research by CSIRO, Department of Agriculture, Public Works Department and Forests Department. Neither the technical nor the economic limitations of these approaches have been satisfactorily resolved and both are still being explored.

This points to the need for developing more local strategies for conservation and development to facilitate the relevant fine tuning. Local co-ordination must involve local interests and local bureaucracies in a way that may well be outside the scope of a Statewide strategy. It is to be hoped that the local user groups to be set up under the new Soil and Land Conservation Act will go a long way toward improving co-ordination of activities affecting conservation on a district basis.

Future outlook

For a sound conservation strategy it is essential that the saltland in Western Australia be stabilised, that in so far as possible, production be achieved from it and that measures be taken

to reclaim present saltland and prevent any further deterioration in the land base. As mentioned above, some methods are available to achieve this aim. Implementation of appropriate land management strategies is being hindered by lack of information on such issues as improved means of identification of landscape units with different characteristics in water and soil relations. More information is needed on plant species that will grow on saline soils, in developing improved drainages appropriate to the Western Australian landscape, in identifying recharge areas and developing management systems to minimise recharge.

Problem soils

Deep infertile sands

As discussed in Chapter 2, there are many areas of deep infertile sands in Western Australia. The largest areas of deep sand occur on the western coastal plain and in the West Midlands. These include the Bassendean sands which may be among the least fertile soils occurring anywhere in the world. Deep white sand also occurs in large areas on the sandplains between Albany and east of Esperance, as well as in small areas throughout the Darling Plateau.

In all cases these deep infertile sands tend to have a grey siliceous, sandy surface over white sand which becomes pale yellow with depth. Vegetation usually includes *Banksia* although the species differ in various areas. Native flora on deep sands employ a variety of adaptive mechanisms to survive and flourish on these sands. In their natural condition they are well vegetated and recover quickly from a single fire.

Deep sands are, however, unsuitable for the growth of annual agricultural plants such as subterranean clover pasture and cereal crops. Because they consist mainly of silica and because there is virtually no fine material, either clay or silt, in the soil they have little capacity to hold water or plant nutrients against leaching. Because of their low fertility and poor water-holding capacity these soils frequently have a very thin plant cover when developed for agriculture and as a consequence, they are very vulnerable to wind erosion.

On the south coast areas, wind erosion is frequent, mainly because the sand particles are smaller and blow more easily than the coarser-grained sands of more inland areas. Although wind erosion on the south coast is a complex problem, much of it can be avoided if the least fertile sands are excluded from alienation or clearing.

In current Crown land allocation for agriculture substantial areas of deep sand are withheld. In future it may be possible to fence off islands or corridors within some blocks.

Land which has already been alienated needs to be assessed. In some cases advice against clearing may be sufficient, in other cases incentives may be necessary, such as fencing subsidies, or relief from local government rates.

Soil acidity

Soil acidity can occur in three ways in the agricultural areas of southern Western Australia. Firstly, in the wheatbelt there are substantial areas of coarse-textured sandplain soils which, although moderately acid at the surface, have subsoil acidities below pH 5.0 which can affect the growth of agricultural plants. Although this is unfortunate it is not a result of human activity nor is it likely that such soils will revert to 'desert' following clearing because of this subsoil acidity.

A second type of soil acidity in Western Australia is also a natural condition associated with coarse-textured soils of impeded drainage and high organic matter content — mainly in high rainfall areas of the south-west. These soils offered many difficulties for successful agricultural use in the past, but current technology allows them to be used. In some cases lime treatment is required.

The third type of soil acidity problem is one which has much more relevance to the objectives of the National Conservation Strategy, and that is the gradual increase in acidity which appears to occur in Australian agricultural soils as a result of nitrogen fertilisation and legume nitrogen fixation and plant uptake. Up to the present, this type of soil acidity has not been recognised as limiting agricultural production in Western Australia. For this reason it has not been allocated research resources for proper investigation. Theoretical studies[1] and work such as that carried out for New South Wales by CSIRO[2] need to be supplemented by local

1. Helyar, K.R. (1976). Nitrogen cycling and soil acidification. Journal of the Australian Institute of Agricultural Science. Vol. 42: 217-222.
2. Williams, C.H. (1980). Soil acidification under clover pasture. Australian Journal of Experimental Agriculture and Animal Husbandry. Vol. 20: 561-567.

studies in Western Australia. It is very important in a case like this where potential long-term fertility decline is involved to be aware of the rate of decline and whether the process can be arrested. In this case, the remedy is simple — application of calcium carbonate — but no work has yet been done on methods of amelioration. Possibly, modification of the fertilisers used — by the incorporation of lime — might be an economic solution.

Increased research needs to be carried out on the rate of acidification of Western Australian agricultural soils and on methods of overcoming it.

Introduced plants and animals

Introduced plant species

Agriculturalists are concerned with unwanted plant introductions or 'weeds' and when they occur control methods must be devised. These include strategic cultivation or grazing, application of chemicals, or some form of biological control.

Much more needs to be known about the influence of chemicals on agriculture. A special need is to know more about the residual effects — the long-term impact — of agricultural chemicals on trees, wildlife, pest resistance tolerances, etc. Some effects of agricultural chemicals as they affect quality of stream waters and estuaries are mentioned in Chapter 9.

Strong emphasis must also be maintained on the possibilities for biological control. For example, new research programmes are being initiated in Western Australia into the use of a stem boring weevil for the control of double gees and candida insects for dock control.

Introduced and native animals

Problems of introduced feral animals are important in some areas. The animals involved are, in various areas, camels, donkeys, pigs, wild horses and the widespread feral goat. Along with the dingo in sheep areas, these animals are classed as vermin and may be taken at any time. The Agriculture Protection Board is responsible for vermin control.

In terms of maintaining a stable healthy vegetation, too many animals of any kind can cause downgrading trends. For example, the setting up of permanent watering spots on pastoral land has enabled red kangaroo populations to increase dramatically, increasing pressure on vegetation. However, fauna control is a controversial subject; it is common in most countries to blame wild or introduced animals for downgrading trends rather than sheep or cattle when they occur together. Two points should be mentioned here.

Firstly, if Western Australia is to profit from experience in other countries, rapid survey methods must be developed for determining the extent to which feral animals are in fact competing with stock. Secondly, control operations are not always effective in reducing feral populations.

Problems of introduced and native animals which have been afforded conditions enabling them to expand to the detriment of a stable vegetation cover, warrant further attention. It is important to consider the impact of introduced animals as an integral part of the process of evaluating and managing both pastoral and agricultural lands.

New land release for agriculture

Government release of areas of vacant Crown land for development for agriculture is a matter of considerable environmental importance and is inevitably demanding greater attention as potential areas dwindle.

A Rural and Allied Industries Council Land Release Policy Review Committee (1979)[3] identified 122,000 hectares of land which could be considered for possible release within existing agricultural areas plus nearly 3 million hectares in areas where climate and soils might also be suitable for agricultural development.

In 1982, Government decided to increase the rate of new land releases and proposed the release of up to fifty farm blocks a year, mainly in the south-east region near Esperance. Such an increase represents approximately 100,000 hectares/year.

The policy has met with a certain amount of comment and criticism, mainly from various sources outside government. The reactions of three private organisations concerned with and involved with farming differ considerably in their approaches to land release, but all are united

3. Rural and Allied Industries Council (1979). Rural Land Release Policy in Western Australia. Report by the Land Release Policy Review Committee. Premier's Department, W.A.

in advising the government to consider carefully and proceed slowly with decisions as to proposals for future land releases. The organisations are the Primary Industry Association, the Pastoralists and Graziers' Association and the Land Release Study Group, the last being a group of concerned individuals including farmers. The various concerns expressed centre on the suitability of the land for permanent settlement and the consequences of the resulting environmental disruption.

Present procedures

A Working Group on Land Releases was set up in 1978 to advise the Environmental Protection Authority on the environmental aspects of proposed releases of vacant Crown land for agriculture. On receipt of advice from the group, the Authority considers the proposal and advises the Under Secretary for Lands accordingly. The final decision rests with a Cabinet Sub-Committee on Land Releases. The four members of the Working Group consist of the Assistant Surveyor-General of the Department of Lands and Surveys as Chairman, and members from the Department of Agriculture, Department of Fisheries and Wildlife, and Department of Conservation and Environment. The Group co-opts others as and when needed, such as water resource engineers or Forests Department officers.

The evaluation procedure is mainly in the hands of the above Working Group on Land Releases and the broad objective of their assessments is to ensure that land release for agriculture is suitable and safe in the long term, and that its release will not adversely affect other significant and important elements in the environment.

Consideration of the suitability of new land areas for agriculture deals with a number of aspects — climate, soils, water supplies and the various hazards which may be encountered, the most important of which are salinity, erosion by wind and water, and flooding. For example, areas of poor soil and those highly erosion prone are recommended to be excluded from the subdivision.

Climatic considerations are of the greatest significance. Development of new land areas has now proceeded into areas for which long-term rainfall records do not exist. As a consequence, assessment of rainfall quantity and reliability for these areas must, of necessity, be based either on short-term records from adjacent and nearby newly developed areas, or on extrapolations from long-term data which have been obtained at some considerable distance from the subject area.

As a result of considering the separate "parcels" of land the Working Group recommends land be placed in one or more of several categories, which include:

(a) recommended for agriculture (including areas for later settlement)

(b) recommended for national parks or nature reserves of various kinds

(c) unsuitable for agriculture because of soil or climatic factors

(d) unsuitable because of doubts about the viability of the farming system

(e) excluded from agriculture because of its value in protecting headwaters and in controlling erosion

(f) left, pending resolution of mining interests.

Public concern is still expressed over land releases for one or more of the following objections:

(a) the flora or fauna are more important in a particular area

(b) enough land has been released already

(c) mistakes make in earlier land releases should not be made in the future; a particular area used as an example is the Jerramungup area

(d) salinisation developing following releases

(e) other objections are based on a criticism of the system itself, mainly that government is not looking at enough detail before releasing land.

However, the Working Group is itself genuinely concerned over these same issues and seems to be increasingly effective in dealing with each of them. As the work has evolved, two important principles seem to have been accepted by this Group: that in many of these marginal areas decisions will have to be deferred until better information is available; and recognition of the need to monitor new releases.

Since 1978 approximately half of the areas considered by the Working Group on Land Releases

have not been recommended for agriculture, either because of unsuitability, or because of greater suitability to alternative uses, i.e. flora reserves. In short, it is clear that we are close to the end of large-scale land releases for agriculture in the south-west.

Future procedures

The development of new dryland farming areas ideally should only take place where all the factors which influence the development of sustainable and economically viable agricultural production are known, with great confidence, to be satisfactory. For a variety of reasons, it is almost inevitable that the completely ideal requirements will not be met. However, every endeavour must be made to get as close as possible to the ideal.

The current assessment of land releases by a Working Group for the Environmental Protection Authority provides a mechanism for parcels of land to be considered carefully from an environmental and technical viewpoint. However, because of its importance to the State, consideration could be given as to ways and means of accelerating an already improving trend in the effectiveness of this working group. Two possibilities have been suggested.

First, consideration could be given to the possibility of preparing Environmental Review and Management Programmes (ERMPs) and making them available for public comment. Preferably such statements should deal with large parcels of land, for example, blocks larger than 250,000 hectares, or all releases within a shire. Where defined drainage systems exist, natural catchments should remain the preferred units of investigation, for example, the upper catchment of the Oldfield River.

Implementation of such a system would provide a formal framework to encourage:

- the comprehensive collection and assessment of available data and the identification of unavailable but necessary data for agricultural purposes, e.g. climatic information
- planned programmes for biological surveys
- the opportunity for the public to be informed
- the opportunity for public comment.

Adoption of this approach would mean that virtually no further extensive land releases would occur until comprehensive ERMPs have been completed. Such delays are seen as providing desirable means of ensuring more detailed investigations of all the factors involved in land assessment. As mentioned earlier in this section, the areas available for future land releases have very poor data bases and are likely to be less suited to agriculture.

The second approach is simply the common sense attempt to profit from our own past and ongoing experience. This can be done in ways that emphasise the gathering of most relevant information for use in making decisions, not only by the Working Group but by farmers on recently released land.

The Working Group has already taken an important step in profiting from ongoing experience by recognising the importance of monitoring. Periodic checks on the implementation and effectiveness of ERMPs would provide invaluable and relevant cross-checks on the suitability of decisions regarding land allocation.

To take advantage of past experience the Working Group, perhaps through the Environmental Protection Authority, could encourage special studies of selected earlier releases in areas similar to those under current consideration. In recognition of the fact that it may take up to twenty years for some of the downgrading trends to appear, some of the studies of the status and trend of the basic resources supporting existing types of land use should be made not only on recent releases but on releases extending back five, ten and twenty years. This should assist greatly in developing standards and criteria for rapid evaluation of present status of these properties. Not least of the values of this approach is that if the farmers concerned are kept closely informed they will be able to modify their management and plan their own futures accordingly, using easily understood facts gathered from their own region.

Conclusion

It will be already evident that agriculture in the south-west of Western Australia has had a significant impact on living and other natural resources. Extensive clearing of native vegetation and salinisation of soils and streams are the most serious. But the existence of a highly productive and sustainable farming industry is evidence that the productivity of the land has been increased, despite the low levels of natural fertility of many agricultural soils.

The potential for increased production is not yet fully realised, and agricultural technology is still developing rapidly. New crop and pasture varieties are becoming available, large machinery, reduced tillage and widespread use of chemical sprays for weed and pest control facilitate early establishment after the onset of winter rain, and enable full exploitation of the growing season. All these factors have been operative over the last ten years, together with market conditions favouring cropping rather than pasture production. The area under crop has doubled during this period, partly due to the opening up of new land, but mainly because many farms in the central and eastern wheatbelt are 60 to 75 per cent under crop. Apart from better returns to the farmer, increased production, especially from crops as opposed to pastures, means increased water use by plants, and hence less salinisation. Minimum tillage, using herbicides for weed control, will reduce risks of soil erosion.

However much of the technology is new and time is needed to fully adapt it to local conditions. In the meantime, there are possibilities of adverse as well as beneficial effects. These include:

(a) large machinery requires large paddocks and removal of trees, leading to exposure and risk of erosion — there is evidence of the development of compacted soil layers;

(b) combination of intensive cropping and dry years may lead to pasture deterioration and consequent effects on nitrogen nutrition and soil stability;

(c) higher fertiliser costs result in lower levels of application, especially in drought years, and also lead to pasture deterioration and compound the risk of erosion; and

(d) chemical sprays may cause damage to human health and the environment, if not properly used.

Chapter 7

Mining

Introduction

Modern living demands a steady assured supply of minerals and metals. Apart from providing raw materials for industry, mining can often assist land resource management. For example, mining provides fertilisers to upgrade nutrient-deficient soils and provides opportunities for substitution when other resources such as timber are scarce.

Mineral and petroleum exploration occurs throughout the State whereas exploitation is very localised. In the past two decades the search for, and exploitation of, the State's mineral wealth has been accompanied by a corresponding increase in measures to protect the environment and to restore ground disturbed by mining. Private enterprise companies and State government departments co-operate at all levels to maintain a balance between development and conservation.

Resources

Western Australia is rich in metallic and industrial minerals, and has significant reserves of natural gas and oil. Mineral production in 1982 had a value of $3,334 million : of this value, 40 per cent was contributed by iron ore, and the remainder by alumina, nickel, gold and other minerals.[1] Western Australia is the premier mining State in Australia and provides the western world with 20 per cent of its iron ore, 14 per cent of its alumina, 20 per cent of its heavy mineral sands and 12 per cent of its nickel.

Western Australia receives benefit from mineral production in the form of taxation, lease rentals and royalties. In addition incomes and employment levels throughout the State have been stimulated. Towns, ports and transport routes have been established in remote locations or existing infrastructure expanded in previously settled regions.

Management

Mineral and petroleum exploration and exploitation in Western Australia is carried out by private enterprise under the control of the State Government. In common with all other States of Australia the ownership of the mineral and petroleum resources and allocation of tenements are vested in the State.

Legislation

The Department of Mines administers the mining industry using the 1904 and 1978-81 Mining Acts, and the petroleum industry using the Petroleum Act 1967[2] and the Petroleum (Submerged Lands) Act 1967.[3]

Local authorities and the Department of Mines administer the quarrying of hardrock and industrial minerals, such as sand and clay, using the Local Government Act[4] and Mining Acts.

These Acts make special provision for environmental controls on private land, State Forest, all reserved land including national parks and nature reserves, the coastal zone and State waters and sea bed.

The 1978-81 Mining Act makes exploration and mining two separate operations, each with its own set of conditions. It establishes procedures to permit exploration and mining activities throughout the State. Each application is referred to the Warden's Court and judged on its own merits. Evidence in support and against the application is heard and the consequent approval or dismissal of the application is recommended by the Warden to the Minister of Mines.

Petroleum legislation makes similar provisions and jurisdiction of offshore areas is divided between the State and Commonwealth.

Under the Environmental Protection Act 1971-80[5] the Environmental Protection Authority

1. The Chamber of Mines of W.A. (1983). Eighty'Second Annual Report.
2. Western Australia, Parliament, Petroleum Act, 1967-1981.
3. Western Australia, Parliament, Petroleum (Submerged Lands) Act, 1967-1970.
4. Western Australia, Parliament, Local Government Act, 1960-1981.
5. Western Australia, Parliament, Environmental Protection Act, 1971-80.

(EPA) was established to enhance the quality of the environment and to control pollution. Under this Act matters of environmental concern can be referred to the EPA by relevant ministers or members of the public. The EPA can then call for documentation on which it can assess the environmental consequences of a given proposal.

In the case of environmentally significant mining projects this documentation can involve a Notice of Intent (NoI) and in the case of large development projects or particularly sensitive localities an Environmental Review and Management Programme (ERMP) is required. Following assessment by the Department of Conservation and Environment (DCE) the EPA makes recommendations on the environmental acceptability of the proposals to the State Government.

For the majority of tenement applications the tenement holder has only to communicate in a report the main features of the proposed operation and the measures to be adopted to protect the environment. The report stops well short of NoI or an ERMP.

Where large energy resource and industrial developments are involved the State Government enters into an agreement with the developer. These agreements are subsequently ratified by Parliament as Agreement Acts. In recent years these Acts have included clauses which ensure consideration is given to environmental management aspects of the development project.

Administration

The Department of Mines is the only department that deals specifically with minerals, fossil fuels, groundwater, mines and petroleum production. The Department's statutory role is to regulate and to provide technical services and support for the mining and petroleum industries. It works closely with industry, the Department of Resources Development and other government departments.

The role of the Department of Resources Development is one of co-ordination between all arms of government. It supervises the negotiation, drafting and operation of Agreements between the State and private enterprise. It ensures that resource development guidelines are followed.

Special environmental conditions can be applied to mining or petroleum tenements by the Mining Warden as a result of a Warden's Court hearing; the Minister for Mines, other Ministers or government departments. The last employ regulations from Acts such as the Rights in Water and Irrigation Act[6] and the Clean Air Act.[7]

The Department of Mines, through its district inspectors and mining engineers, has the responsibility to see that all agreed conditions are adhered to.

Policy

The basic tenet of the Department of Mines policy is:

> to encourage the orderly exploration, exploitation and refinement of minerals and petroleum, in Western Australia, with due regard to the conservation of the biosphere and lithosphere. These activities are to be done in the interests of present and future generations by the private sector, in an organisational framework controlled by government.

To implement this policy the Department undertakes to grant in an orderly and equitable manner the rights to explore and exploit the mineral and petroleum resources of the State. It also compiles and maintains an inventory of known mineral, fossil fuel and groundwater resources of the State and geologically assesses the resource potential of areas to aid long-range planning by State and local government. In addition the Department provides a number of services to support mineral development. Technical divisions such as the State Geological Survey, Government Chemical Laboratories and Explosives and Dangerous Goods Division, contribute data for environmental management and monitoring.

The Department of Mines and industry contend that all areas of Western Australia should be available for responsible exploration programmes. Resources only become assets once they are discovered. To be fully effective access has to be on a perpetual basis as changes in exploration techniques, mineral economics or tenancy may warrant the re-appraisal of previously tested ground.

Experience demonstrates that responsible explorers can, and do, adopt environmental pro-

6. Western Australia. Parliament. Rights in Water and Irrigation Act. 1914-1981.

7. Western Australia. Parliament. Clean Air Act. 1964-1981.

tection measures so that their operations have minimal environmental impact. However when environmental conditions are imposed they need to be realistic and tailored to suit the requirements of the operation and ecosystem involved. An over-zealous, regulatory approach on the part of the government would stifle exploration.

Exploration

Mineral development starts with exploration and ends in exploitation. Exploration is a land evaluation tool that may, in rare circumstances, lead to exploitation. The urge to explore is always present because the mining and petroleum industries are drawing on a depleting resource base. Exploration takes time and money, as well as geological ingenuity. The incentive to engage in exploration is determined by the opportunity given to the discoverer to exploit the find.

Economic concentrations of minerals are difficult to locate because they are small and are geographically restricted. Exploration in the vastness of Western Australia is a high-risk enterprise and is assisted by the wide range of technical services provided by the Department of Mines.

The impact of exploration varies with the method used and with the degree of care exercised as well as the operating company's awareness of the sensitivity of the environment. The mining and petroleum industry has developed policies to guide the activities of member companies.

Exploration in Western Australia has had a long history and, as a consequence, some of the actions of mineral explorers of the past are still evident and form part of the State's backlog of ground that remains to be rehabilitated.

Exploration is now better organised and regulated than in previous years. Explorers are conscious of their responsibilities to minimise the effects of their field activities. With adequate planning, the long-term impact of exploration can be reduced to a minimum. Appropriate rehabilitation where this is considered to be necessary can effectively remove all traces of costeans, pits and drillholes and seismic lines. However the excessive use of bulldozed grid lines remains a problem in many arid areas as does the illegal use of earth-moving equipment by some gold prospectors.

Exploitation

The degree to which mining physically disturbs the landscape varies and is related to the particular mineral deposit as well as the type of mining operation. Open cut mining and quarrying are used to exploit a wide range of mineral deposits. Generally large quantities of overburden and waste rock must be disposed of. Because of economic constraints these are usually placed in waste dumps adjacent to the pit. While it is technically possible to backfill a worked-out pit it is usually not economically viable. Rehabilitation consists of stabilising and revegetating waste dumps, drainage control and fencing of unsafe areas. Many abandoned pits naturally fill with water and can be used for recreation or as wildlife refuges.

In the case of open cut mining for bauxite, there is virtually no overburden and the mining covers extensive areas to relatively shallow depths. Rehabilitation of the mined-out areas is carried out in a continuous fashion, and revegetation is assisted by using fresh topsoil scraped from areas yet to be mined.

Underground mining commonly causes minimal surface disruption. Rehabilitation usually comprises the removal of surface buildings and equipment and the fencing of collapsed areas and stabilisation of tailing dumps.

Apart from direct effects of mining and waste rock disposal a number of other aspects have environmental consequences. These include townsites, water supplies, power supplies, mine industrial services, ports, conveyors, access roads, railways and refineries.

Minerals and ores are milled, refined or smelted near the resource or are transported to areas of cheap power and easy access to ports.

Further processing of minerals can have a wide range of potential environmental impacts. For example, tailings disposal can result in considerable land disturbance, dust generation and/or water pollution. These activities are subject to control by a range of legislation in addition to the Mining Act.

In general, onshore petroleum production has a much lower environmental impact than the

prior exploration activity. However, offshore petroleum exploration and production which in normal conditions does not pose environmental hazard is a potential cause of environmental damage because of the risk of large oil spills.

Regularly updated contingency plans, preventive procedures and a system of environmental reporting based on the proximity of projects to a series of well-defined environmentally sensitive localities (ESLs) are used to manage offshore petroleum activities (see also Chapter 9).

State Conservation Strategy in relation to mining

Mining is but one of many development-oriented land uses that has to be accommodated in the State Conservation Strategy. The adjustment is made easier in the case of mining because the industry is well accustomed to operating within a multiple land use framework. Increasing consideration has been made over the past two decades to relate exploration and mining activities to the need to protect living resources.

Steps have already been taken to counter anticipated adverse effects on ecosystems and to preserve areas of special environmental quality. Some of the initiatives have constrained mining operations while others have succeeded in integrating conservation with development.

As previously mentioned exploration is a land evaluation tool. The Strategy should make use of this fact. There are some minerals such as coal seams whose absence could be easily demonstrated in a relatively short time if exploration access was allowed. In other words there could be a concerted effort to engage in a programme of "negative" drilling over selected target areas to confirm for all time that such areas do not contain the desired commodity. However, as mentioned earlier, for some resources access has to be on a perpetual basis as changes in exploration techniques or mineral economics may warrant the re-appraisal of previously tested ground.

Conservation

Mineral developers acknowledge the State's obligation to preserve special areas as national parks and nature reserves and to safeguard the cultural heritage of Aboriginal people. However land use allocation has to be made on a rational basis which, in turn, calls for possession of all the facts. A knowledge of the mineral or fossil fuel potential of any given area, as well as its biological or cultural characteristics, is essential for sound decision making. The alienation of land without an appropriate inventory of all of its resources, runs counter to the principles and guidelines of the World Conservation Strategy.

Identification of priority ecosystems has to be an important part of the State's Conservation Strategy. The work of the Conservation Through Reserves Committee (CTRC) laid the foundation for the recommendations which the EPA made for the whole State, as discussed in Chapter 3.

The paucity of basic ecological data in Western Australia is a constraint on wise decision making. It is being partly offset by biological surveys conducted by State departments and private enterprise companies before the start of large development projects.

Mining or petroleum extraction can be a temporary land use because mines, quarries, oil or gas fields have a limited life. Some operations can operate as one of a sequence of land uses. Difficulties arise in undertaking rehabilitation work because of the absence of land use plans for much of the State.

Where conflicts arise between exploitation and preservation, the ultimate choice is made by Government. The requirements of industry and the material demands of the economy have to be reconciled with protection of ecosystems.

Planning

The work of the CTRC and the implementation of the EPA recommendations illustrate the value of planning for conservation on a State-wide basis. Such planning has to be integrated with planning for other land uses in order for it to be effective.

The Geological Survey collects geological data from many regions as part of its work in helping to ensure that land use decisions are made in an integrated manner and that valuable mineral deposits are not overlooked.

Extraction licences for proposed quarries on private land are issued by local authorities under

the provisions of the Local Government Act. Conditions for access and environmental safeguards are set after negotiation between the local authority, landowner and leaseholder. It is intended that, in future, the structural plans of the metropolitan local authorities will organise industrial mineral extraction as part of a sequence of land uses in identified priority areas.

The fragility of the soils and vegetation of the coastal zone is recognised by the companies and departments concerned. Loss of vegetative cover — by cutting for survey lines, tracks and drill pads or introduced dieback — can cause soil degradation and mobilisation of dune sand. Care has also to be taken to protect flora and fauna on offshore islands otherwise interference by humans or the invasion of predators from the mainland can be harmful to the ecology.

Conclusions

In the past people saw land as a relatively limitless resource. In many cases the mining industry paid little or no attention to the question of ongoing land use after mining and consequently no rehabilitation work was carried out. The industry today has started to practise environmental protection measures during exploration and exploitation, and accepts the need to rehabilitate ground disturbed by past and present operations.

To assist industry with the planning of programmes that are compatible with the environment there is a need for the State to compile ecological and resource data. There will be a continuing need for this information to be provided by both industry and government. In addition greater co-operation between government departments is required to make the best use of available data and to avoid duplication of effort. The mining industry is to a large extent assisted in pursuing responsible development (and the State is provided with a sound basis for environmental management) through the Environmental Protection Authority's NoI and ERMP system.

The present Mining and Petroleum Acts establish procedures for mining and exploration on reserved land. But these procedures are based on a classificaton system that does not necessarily represent the conservation value of a given reserve. The conditions applied vary widely depending upon the objectives of the vested authority. The result is a somewhat piecemeal approach and a degree of uncertainty in the minds of the explorers which may act as a disincentive for exploration.

To assist the State in managing land reserved for conservation and to provide guidelines for intending developers there is a need for a single hierarchial classification for conservation reserves that is based on their overall conservation value. It could then be used to define what other activities may be carried out in particular reserves and under what conditions.

In order that the mining industry can plan acceptable rehabilitation programmes — given that mining is a temporary land use — there is a requirement for the State Government to develop regional land use plans. The work has to commence with the Darling Range and the Collie Basin.

In some rare and isolated instances the mining industry may be reluctant to assess the mineral potential of proposed or existing reserves if there is doubt whether mining will be permitted. However lack of knowledge about the mineral potential can delay the reservation process and, because of the lack of management, place at risk the conservation value of the planned reserve.

In such situations it would be desirable for the Department of Mines to conduct limited exploration over the area in order to assist the State authorities in making land use decisions.

Chapter 8

Fisheries

Resources

Western Australia is one of the leading fishing States in Australia. The total gross value of fish, crustaceans and molluscs harvested in 1980-81 was $82.8 million, to which may be added the value of the pearl culture industry bringing the total value to approximately $100 million[1]. In addition, the importance of recreational fishing continues to increase.

The development and management of fish resources within the State is the responsibility of the Department of Fisheries and Wildlife, and of the Department in association with the Commonwealth Department of Primary Industry where major fisheries occur beyond coastal waters. While the major emphasis is upon commercially exploitable species, the Department is becoming increasingly concerned with the management of recreational fishing.

The western rock lobster (*Panulirus cygnus*), fished off the south-west coast between Murchison River and Bunbury, is the most valuable single species fishery in Australia. Most of the catch is exported to the USA as frozen tails. One of the State's four limited entry fisheries, it continues to provide consistent catches for some 2000 fishermen working 800 vessels. This outstanding example of practical fisheries management is based on such measures as limited licences for both boats and pots, escape gaps in pots, the declaration of closed seasons, the proclamation of fishing seasons and zones, minimum size of rock lobsters retained, and the prohibition of taking females carrying eggs.

Important prawn fisheries are established at Shark Bay, Exmouth Gulf and Nickol Bay, and are continuing to develop off the Kimberley coast. There is concern at the condition of the tiger prawn stocks in Shark Bay and Exmouth Gulf. This is the subject of research at the W.A. Marine Research Laboratories.

Pearl and pearl shell fishing has been a valuable if fluctuating industry for many years, the main centre being at Broome. Over the past decade pearl culture has developed steadily, predominantly by Japanese interests operating on the Kimberley coast under licence. The cultured pearl industry within Western Australia is now worth some $15 million in annual production.

A number of feasibility fishing studies supervised by the Department of Fisheries and Wildlife, have been carried out by foreign interests within the 200 mile Australian fishing zone off W.A. The results were generally disappointing and confirmed the earlier view that a rapid expansion of fishing activity within the 200 mile limit was unlikely. One exception is the relatively large stocks of demersal fish on the north-west shelf. Between 1972 and 1978, predominantly Taiwanese fishing vessels took an average annual catch of 53,531 tonnes from these trawling grounds (P.C. Young, personal communication). This is almost as much as the combined catches of all other fin fish throughout Australian waters. Virtually the whole of the catch by foreign vessels is taken directly to the home ports for sale or processing. A problem for Australian interests is that many of the species present on these rich trawling grounds are of little interest to local consumers.

Whale oil and whalebone were among the earliest exports from the colony, but after several periods of activity over the past 150 years, whaling has now ceased. The most recent period of humpback whaling began in 1949 and for a time supported three whaling stations on the W.A. coast. Research by CSIRO warned of overfishing as early as 1954 but only token reductions were made to catch quotas. With the total collapse of humpback whaling in 1963, the International Whaling Commission imposed a total ban on the hunting of humpback whales in the southern hemisphere. One whaling station (near Albany) carried on sperm whaling until 1978 when it closed for economic rather than conservation reasons.

Brown and rainbow trout and English perch have been introduced into the streams of the south-west and these species together with indigenous stocks of freshwater fish (including marron) provide sport for many inland fishermen. In certain areas increasing salinity of streams has diminished the range of certain species (e.g. marron).

1. Department of Fisheries and Wildlife, W.A. State of the Fisheries 1981, p.3.

Conflicts

As recreational fishing continues to grow there are increasing conflicts of interest between professional and recreational fishermen. The areas of particular concern are the major population centres and particularly the estuaries within easy access to these centres. The estuaries are being used increasingly for many forms of recreation including water skiing, boating and amateur fishing, crabbing and prawning. These activities are competing with professional fishing. A number of the professional fishermen have been actively engaged in providing fresh fish for the Perth markets for many years, and planned usages of the estuaries must take their needs into account even though their numbers are small compared with that of the touring and sporting public.

These problems of competing usages of estuaries are superimposed on the vital role which the estuaries play as nursery habitats for the young stages of many species which may be fished elsewhere. Therefore it is essential to retain as much of this valuable estuarine habitat as possible, particularly the vegetation on shallow banks and natural shorelines. These important yet delicate habitats are also subject to pressures of residential and industrial developments. In addition there is a need to safeguard water quality in the estuarine environment (see Chapter 9).

Management

Management of commercial fisheries has become increasingly effective with the development of a broad data base encompassing fisheries statistics as well as biological and ecological information. However, each of the major fish populations which constitute the fisheries of Western Australia is experiencing heavy fishing pressure.

Until recent years fisheries managers have administered fish resources on the general premise that the exploitation rate will not be so high that the parental stock is reduced to a point whereby recruitment in subsequent years is affected. Consequently, management measures adopted have been directed towards rules which provide for industry to obtain an optimum catch.

In some fisheries, especially those having a high product value relative to their cost (e.g. rock lobster and prawns), competition amongst fishermen has led to increasing investment in new technology, including such items as coloured echo sounders, and satellite navigation. The efficiency of catching units has developed to a point that the fishing industry can exploit fish resources at such a high rate that concern is being expressed about the likelihood of recruitment being reduced by heavy fishing pressure. Conservation strategies have to take account of the potential for increasing fishing pressure and its affect on fish populations.

As new technologies become available, a greater responsibility is placed on fisheries managers to control and adjust inputs to allow the fishing industry to remain efficient; otherwise, with the efflux of time, conservation measures aimed at protecting fish stocks could work to the long-term disadvantage of industry.

The western rock lobster fishery is an example of one which is experiencing heavy fishing pressure with an exploitation rate of approximately 70 per cent. In this case recruitment has remained relatively steady but studies are continuing to monitor both the breeding stock and the resultant recruitment.

Prawn fisheries are also being fished very heavily and there are indications that at least for one of the species, tiger prawns, the increasing fishing pressure has reduced recruitment. Studies on this aspect are continuing, and a strategy for reducing fishing pressure is being developed.

In a fishery which is shared nationally as well as with New Zealand and Japan, the southern blue fin tuna has also been fished to the point of jeopardising recruitment. This involves the State in an international problem of resource management.

A greater account also needs to be taken of the effects of fishing on inshore fish stocks and the competing requirements of recreation, tourism and the fishing industry. Strategies need to be developed to protect small, lower valued inshore fish stocks which are experiencing increasing levels of exploitation from recreational fishermen.

Management of fishable resources in estuaries is clearly the responsibility of the Department of Fisheries and Wildlife, but management of habitats and the quality of aquatic environment is less clearly defined. This difficult area is discussed further in Chapter 9 in the section on management of marine and coastal waters.

Increasing population and a continuing growth of tourism in the north-west with resulting increases in commercial and recreational fishing, shell collecting, reclamation, etc., in areas where there are no resident inspectors, is becoming a matter of concern. The one fisheries officer based north of Carnarvon has responsibility for the whole of the north-west coastal and riverine areas, even though his principle duties are in relation to the pearl oyster fishery and pearl culture.

While the Department of Fisheries and Wildlife is clearly the body managing fishable resources, a number of bodies (in addition to Department of Fisheries and Wildlife) are concerned with impacts of other uses on the marine environment as a whole. These are considered in Chapter 9 on Water, and Chapter 11 on the Coastal Zone.

Conclusions

The most serious and difficult problem confronting the fishing industry today (throughout the world as well as in Western Australia), is that advances in the technology of catching have outstripped progress in husbandry. In several important fisheries the fishing power of each unit has reached a point where even with many fewer units operating, the high exploitation rate is endangering the breeding stock upon which future recruitment depends. With very limited alternative resources, few local options remain. In this situation the objective of sustainable utilisation as envisaged in the World Conservation Strategy (see Chapter 1) is threatened. Unless the rate of exploitation can be reduced (even at the cost of some increase in unemployment), there are real risks of collapse of stocks, resulting in even greater and continuing costs to the community.

Within sheltered waters along the coast there are also problems of conflicting uses of resources. These problems are greatest in estuaries and inlets close to Perth, with conflict between professional and amateur fishing, as well as with other users of these waters. Physical alterations (reclamation, clearing, dredging, etc.) and chemical changes from effluent discharges and enrichment causing eutrophication, threaten nursery grounds.

Even on the more distant north-west coast, the growth of development, population and tourism are together increasing problems of conservation of marine resources in areas where there are no resident inspectors.

Chapter 9

Water

Terrestrial Surface and Groundwater

Policies and objectives

Policies governing use and management of inland water resources are many and varied in form. In recent years, the evolution of these policies has reflected a strong awareness of the finite nature of the State's water resources and there has been a developing emphasis on protection of catchments and resources, and on the efficient use of water. In terms of impact on other resource sectors, the protective emphasis is the main source of concern, as protection of water resources is given a high priority in land use decisions. Conversely the water sector has generally been under pressure to widen multiple land use policies in catchments, subject to water management as the primary objective.

The Western Australian Water Resources Council has recently published a set of management objectives to guide the development of water resource management policies in Western Australia. These policies have been endorsed by the Minister for Water Resources and are stated in full below:

> As a general goal, the management of Western Australia's water resources shall be directed to the orderly development of the State and to providing the maximum long term benefits to the people of Western Australia.
>
> This goal of orderly development requires a comprehensive and co-ordinated approach to the conservation, development and utilisation of water, and to related land resources.
>
> The following set of State water resources management objectives has been prepared as a basis to guide the further development of policies for managing the terrestrial waters of Western Australia. Although any consequent strategies adopted for management of these inland waters must give due consideration to effects on estuarine and marine environments, the management of coastal waters is outside the scope of these objectives.
>
> In pursuit of the general goal, the objectives and policies for terrestrial water resources management need to provide for developing and/or managing these resources and/or encouraging appropriate response in other community programmes. Matters to be considered include water quantity and quality, water use, wastewater, flood mitigation, and any other effects of water resources on, or use of water by, the man-made and natural environments.
>
> The principal objectives which have been defined for pursuit of the general goal are listed hereunder.
>
> 1. The provision of a system of management which will ensure the satisfactory co-ordination, on a statewide basis, of all activities related to the water resources of the State.
> 2. The preparation of statewide short term and long range plans or policies which provide for appropriate future development and comprehensive management of the water resources of the State.
> 3. The provision, in the most cost effective manner, of public water supplies, satisfactory in quantity and quality, to meet the reasonable needs of urban communities and of primary and secondary industry.
> 4. The allocation and use of the water resources of the State in a manner which provides for efficient utilisation and which reasonably caters for public and private water supplies and for the environmental and recreational needs of the community.
> 5. The continuing assessment and review of the quantity and quality of the water resources of the State and the extent to which these resources are being used, and are committed for future use, by both man and the environment.
> 6. The development and implementation of policies and practices which protect at the highest practicable level the quality of the water resources of the State.
> 7. The formulation, through continuing research and monitoring, of water supply quality criteria which emphasise public health considerations and which establish other

desirable quality objectives having due regard to how much the community is prepared to pay.

8. The development and implementation of policies and practices, including pricing policies, which discourage the wasteful use of water and where practicable, encourage the re-use of water and use of water of the lowest satisfactory quality.
9. The control and co-ordination of development on flood plains and the implementation of appropriate mitigation measures in order to achieve an acceptable balance between: the benefits of flood plain utilisation; the costs of flood damage and of flood mitigation; and the risk to human lives.
10. The establishment of a programme of community education to promote a proper understanding of the factors affecting the development and use of water resources and the encouragement of an active community interest in the planning and management of water use.

Administration and Management

In Western Australia the rights to the use and control of the water resources of the State, with the exception of certain small riparian entitlements, are vested in the Crown. At present, under several major statutes, the Public Works Department (PWD) and the Metropolitan Water Authority (MWA) are the two principal agencies responsible to the Minister for Water Resources for the control and supervision of the use of water.

However, the decision has recently been made to merge the two State water authorities. A project group is currently developing proposals for the implementation of this decision. Although this will result in a single water authority and a simplification of the present situation, there is likely to be no significant change to the legislation. The principal statutes governing water administration are:

- Rights in Water and Irrigation Act, 1914-81
- Metropolitan Water Supply Sewerage and Drainage Act, 1909-82
- Country Areas Water Supply Act, 1947-82
- Land Drainage Act, 1925-81
- Water Boards Act, 1904-82

Under the various acts some controls, such as over the discharge of effluents, apply to the whole State. Other controls are exercised over large areas of Crown and private land proclaimed for such purposes as catchment area, water reserve, drainage district, groundwater extraction and pollution control areas. In addition, under the Land Act, the Minister for Water Resources has various Crown Reserves which are vested in him.

Water Supply

The State's current major water authorities, the PWD and the Metropolitan Water Supply, Sewerage and Drainage Board (known as the Metropolitan Water Authority) between them supply about two-thirds of the water consumed each year in the State. The MWA supplies water to the Perth Metropolitan Region whose population of about 918,000 is 71 per cent of the State total. The volume of water supplied by the MWA in 1980-1981 was approximately 149 million cubic metres or 18 per cent of total State usage.

Three country towns have a water supply system run by local water boards. These are the South West towns of Bunbury, Busselton and Harvey. In addition, a few mining companies in the Pilbara Region of the North West operate their own supplies for industrial purposes and for towns built by them to accommodate their own workforce. These smaller bodies supplied approximately 20 million cubic metres or 2.5 per cent of the State's total.

The PWD is responsible for all other reticulated water supplies in the State including the Goldfields and Agricultural Water Supply Scheme, the Great Southern Towns Water Supply Scheme and the supply of water to approximately 250 other towns throughout the State. In addition, the PWD operates irrigation schemes in the South West, at Carnarvon in the North West, and in the Kimberley. The PWD supplied 352 million cubic metres in 1980-81 or 42 per cent of the State's total.

In total the two major water authorities, the independent water boards and private companies engaged in mining, distributed 62 per cent of the water used in the State in 1980-81. The remaining 37.5 per cent of water consumed is self supplied — that is to say a little over one-third of total water used in the State is from sources such as bores, wells or small dams which have been developed by users to supply their own houses, farms, parks or industries.

Water resources management

The PWD, in addition to its role of supplying water, is responsible for the investigation, development, protection, flood control, and river management for all waters unless assigned specifically to another body such as the MWA. The latter authority fulfils most responsibilities within the Perth Metropolitan Region.

The responsibility for water resources assessment in Western Australia lies with the PWD for surface water and the Geological Survey Branch of the Mines Department for groundwater. The MWA and PWD as water management authorities also collect a wide range of monitoring information relating to quantity and quality management of surface and underground water resources. The PWD maintains a State Water Resources Data Bank, which contains data from many contributing organisations and makes data available to users on request.

Western Australian Water Resources Council

The Western Australian Water Resources Council is a statutory body constituted to advise the Minister for Water Resources on the development, conservation, management and protection of the terrestrial water resources of the State and to promote awareness and understanding in the conservation, management and protection of resources. This body was established in 1977 by State Cabinet and re-constituted in 1982 by Act of Parliament. It reports directly to the Minister, and has a membership comprising a chairman, the heads of six government agencies and eight private members from outside the government, including farmers, business men and nominees of local government and industry. The Council itself has established a number of committees to deal with such areas as planning and management, rural water supplies, education, conservation of water use and similar issues.

The Western Australian Water Resources Council is required to give broadly based consideration of water resources management issues and the Act specifies that it shall have regard to any factors affecting or likely to affect:

- the quality of any waters
- the equitable distribution or use of any waters
- the loss or wastage of any waters
- the preservation and conservation of any waters
- the health and welfare of the people
- the conservation of flora and fauna, and
- the preservation of the amenity, nature, features and general character of a locality.

In regard to the State Conservation Strategy the Western Australian Water Resources Council is perceived as an important mechanism whereby the conservation aspects of the State Conservation Strategy can be linked with developmental aspects of water management in the comprehensive planning of water resources management.

Other statutory authorities

The major proportion of the water catchments for metropolitan and South West country towns water supplies are within State Forest, and the management of these catchments is conducted by the Forests Department in co-operation with the water authorities. Thus, the Forests Department plays an important role in the conservation of the State's water resources as discussed further in Chapter 4.

Other non-statutory mechanisms

In addition to the major statutory authorities there are numerous committees and groups with specific responsibilities or advisory functions. Important among these is the Purity of Water Committee, an inter-departmental committee which has operated since 1925 to advise the water authorities on any question that might arise with regard to the quality of water and means of improving it.

Resources

Magnitude and distribution

The terrestrial water resources of Western Australia are unevenly distributed both geographically and in relation to the population of the State. Surface runoff, groundwater recharge and the divertible resources in the fresh, marginal, brackish and saline categories for each of the four drainage divisions (Figure 9.1) of the State are given in Table 9.1.

From Table 9.1 it can be seen that of the State's total divertible fresh and marginal surface water resource, 81 per cent are in the sparsely populated Timor Sea Division, 2.3 per cent in the Indian Ocean Division and 16.7 per cent in the South West Coast Division where 89

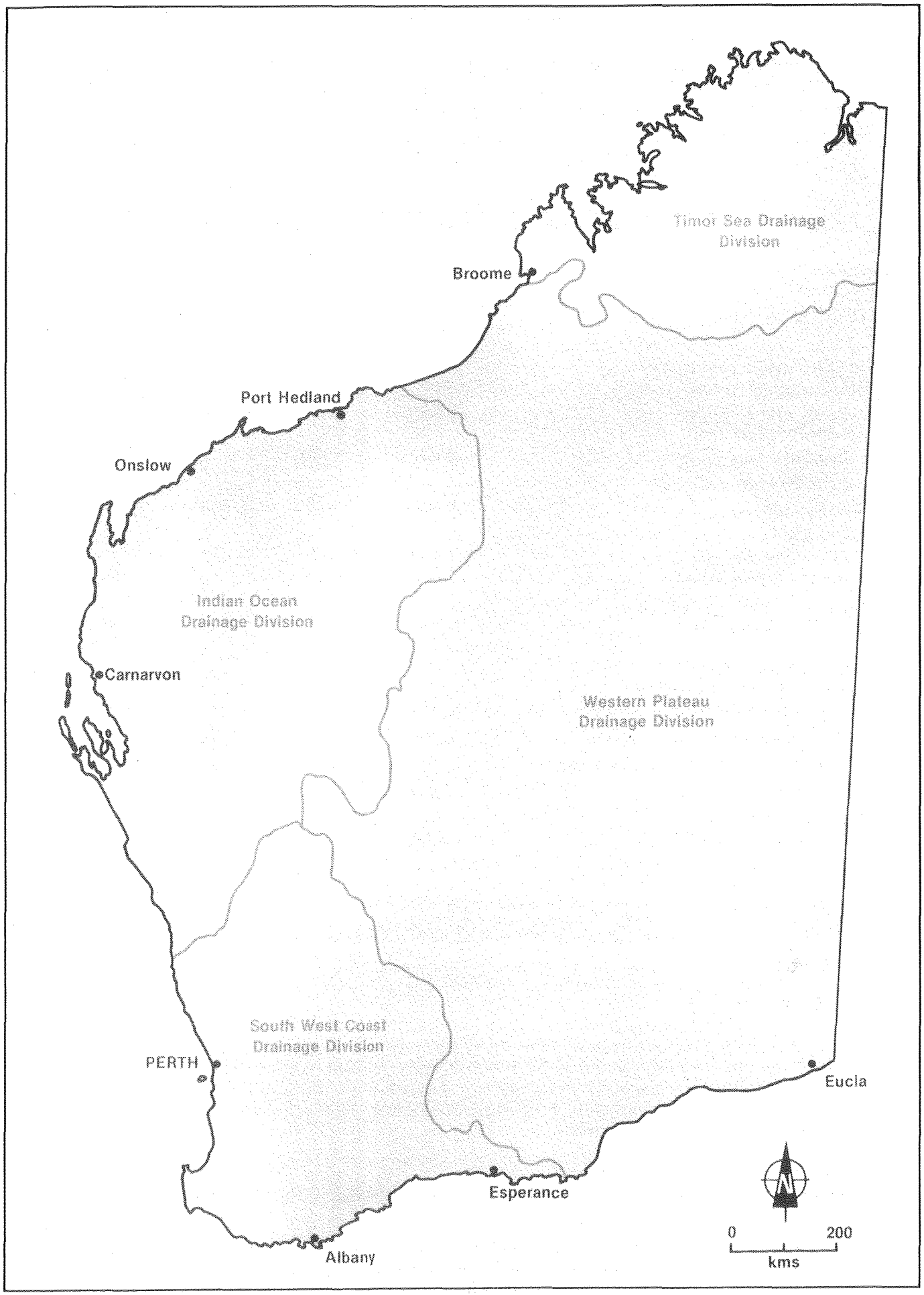

Figure 9.1 — Western Australia's water drainage divisions

per cent of the State's population resides. The surface resource of the Western Plateau Division is negligible.

The groundwater resources of the State are a little more evenly distributed. Most are contained in the sedimentary basins along the west coast and in the eastern deserts, with only limited resources available in the fractured 'hard rocks' underlying the agricultural and pastoral areas.

The divertible resources tabulated in Table 9.1 are not necessarily fixed in quantity or quality. Changes have occurred as a result of past land uses and further changes, adverse or beneficial, are potentially possible as a consequence of future land use management.

Table 9.1: Terrestrial water resources of W.A. and their use

Millions of Cubic Metres Per Annum

Drainage division	South West Coast	Indian Ocean	Timor Sea	Western Plateau
Surface water resources				
Mean annual runoff:				
Fresh and marginal (<1000 mg/l TSS)	4 050	3 475	29 970	N.A.
Brackish and saline (>1000 mg/l TSS)	2 575	470	0	N.A.
Total runoff	6 625	3 945	29 970	N.A.
Divertible*:				
Fresh and marginal	1 803	245	8 760	0
Brackish and saline	1 000	10	0	0
Current (1980—81) use of divertible resources	317	0	92	0
Groundwater resources				
Estimated annual recharge:				
To fresh and marginal aquifers	1 221	368	1 231	383
To brackish and saline aquifers	1 209	778	541	422
Divertible**: fresh and marginal	826	149	240	163
Brackish and saline	292	206	211	125
Current (1980-81) use of divertible resources	280	66	6	1

* Average annual quantity of surface water capable of being diverted on a sustained basis into conventional water supply systems, or to substantial private use, by employing current technology and exploiting potential dam sites identified by investigation or indicated by preliminary reconnaissance.

** Average annual volume of groundwater capable of being extracted on a sustained yield basis employing current technology by a water supply authority on a reasonably large and economic scale or by a practical concentration of private users.

In the 150 years of European settlement the surface water resource in the South West Coast Division and the southern section of the Indian Ocean Drainage Division has been extensively degraded by salinity as discussed in Chapters 2, 4 and 6. With urbanisation and industry concentrated on the coastal sandplain of the south-west coast, there has also been some localised pollution of groundwater resources.

Dryland salinity

Dryland salinity occurring as a result of land clearing has been the dominant resource problem in the South West Drainage Division.

At the present time just under 40 per cent of runoff in the Division is in the brackish and saline categories, i.e. in excess of 1000 mg/L Total Soluble Solids (TSS). This has effectively resulted in a loss of 1000 million cubic metres per annum of potable (fresh and marginal) divertible

water or 36 per cent 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.

Before European settlement all streams in the south-west were probably fresh during the winter flows. The large streams tapping the inland sandplains are likely to have experienced occasional brackish spates, flushing salts from the saline valleys in their headwaters. Such flows would probably have been too small to have affected the quality of the water in their lowest reaches to any great extent. However, after clearing the natural vegetation for agriculture, both the runoff and the salt yields from these areas have increased to such an extent that the flows in some major rivers such as the Swan-Avon, Hay and Moore Rivers are now saline throughout their length, while others such as the Murray, Blackwood and Frankland Rivers are brackish.

Fear of increasing salinisation has led to a ban on the release of further land over a large portion of the south-west and to the imposition of controls on further clearing within the catchment of the Helena, Collie, Warren, Kent and Denmark Rivers to protect the quality of these important sources.

Development of water resources

Development of surface water resources has been mainly by construction of dams forming reservoirs on a number of the major rivers and streams. In the South West, the main developments are on streams draining the western slopes of the Darling Range between Perth and Bunbury. These supply water to the Metropolitan Region, the coastal irrigation districts, the Goldfields and the town and agricultural areas of the wheatbelt.

In the Pilbara, a dam has been built by the Mount Newman Mining Company on the Upper Fortescue River to artificially recharge the aquifier from which water is supplied to the town of Newman. The PWD is currently constructing a dam on the Harding River to supply additional water to a number of North West towns presently supplied with groundwater from the declining Millstream aquifer.

In the Kimberley, the Ord Dam, forming the second largest impoundment in Australia, supplies water to an irrigation district downstream.

Groundwater resources have the very real advantage that they are much more extensive in their occurrence than are exploitable surface water resources, and much more amenable to incremental development. Groundwater therefore is more likely than surface water to be available near to areas of need in quantities suitable for initial water supply development. Consequently supplies for some ninety-seven country towns in Western Australia rely on groundwater. These include the major southern centres of Bunbury, Busselton, Albany, Esperance and Geraldton as well as Karratha, Carnarvon, Port Hedland, Broome, Derby and Kununurra in the north.

Groundwater has also been a popular source for private supplies for such purposes as market gardens, parks and private gardens and is particularly significant in this respect on the Swan Coastal Plain.

Problems

The history of water management in Western Australia illustrates an evolving pattern and priority of resource problems inevitably developing with increasing intensity of land use, increasing utilisation of water resources, changing technology and rising standards of living. The history of development also reflects an adaptive approach with the main centres of water use concentrating in areas of more abundant supply.

In the last two decades, the most significant aspect of this evolution has been associated with the growing level of utilisation of land and water resources in the South West, where intensive settlement has been encouraged by more ready availability of water.

Balance of supply and demand

Increased demand for water is inevitable, although if economic growth continues as at present, demands will expand at a modest rate. The prognosis for the foreseeable future, therefore, is not one of absolute or critical resource deficiencies but one of growing need for resource allocation and growing interaction between conventional water supply usage and other users of water and land resources. Within this general scenario specific problems of heavy local pressure must be expected to occur either due to continual demand growth in presently settled localities or due to demands for new development in areas deficient in water resources.

The response to such supply problems will not solely be the role of the water authorities and water supply technology but will also involve the users themselves. Paramount in such examples would be the need for managing the extraction of water from private bores in areas of intensive private groundwater development.

Growing demand is associated not only with conventional water supply but also with recreation and with recognition of the environmental role of rivers and wetlands. The development of water supply can lead to major changes in natural systems — dams reduce downstream flow, bores lower water tables, and reservoirs inundate areas of land creating new environments. Some recent interesting examples of response to such issues can be identified, such as at Millstream and in the Wanneroo groundwater areas. However, one of the more challenging and important future water resource planning problems, from the viewpoint of a State Conservation Strategy, is the integration of environmental and recreational aspects of water management with traditional water supply planning. The Western Australian Water Resources Council will provide an important forum for this planning activity.

Flood plains

Flood plain management is a problem which is also growing in magnitude with increasing land development. The populated South West 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. The long periods between such floods lead to unwitting clearing and development in areas which are flood-prone. A statutory basis for flood plain management is now in preparation for administration by the PWD.

Salinity

As discussed earlier, the dominating water quality problem in Western Australia at present (and for some time to come) is salinity, a non-point source pollution problem, caused by land clearing.

In recent years, a regional strategy of prevention has been implemented which is heavily dependent on maintenance of indigenous forest in critical areas. Recent research effort has centred on investigating a range of land management techniques that will either avoid or stop the movement of highly saline groundwater to rivers. At this stage the most promising techniques appear to be based on management of the indigenous vegetation but agricultural engineering practices are also being studied. Groundwater movement and tree growth are both relatively slow so it will be some years yet before conclusive results are available.

A range of engineering methods have been considered for dealing with specific salinity problems within the river or water supply systems. These include headwater diversion, reservoir management, alternative source development, blending and desalination. These measures, some of which have been employed and others of which are being planned, are generally expensive and deal with the effects and not the root of the problem, which is clearing the native vegetation.

Pollution

With regard to problems of point source pollution in surface waters, Western Australia is generally in a fortunate situation. This is partly fortuitous as a consequence of settlement patterns and the unsuitability of the intermittent rivers for waste assimilation, but is also due to management. Recent amendments to the Rights in Water and Irrigation Act have provided a uniform State-wide basis for control of effluent discharges affecting streams and aquifers. At present, this is administered by the MWA within the Perth Metropolitan Region. The PWD currently administers the Act over the rest of the State. However, there are some problems.

The control of water pollution by agencies not bound by the Act, and which themselves contribute to pollution by way of their control of sewage treatment plants, drainage systems, etc. has obvious weaknesses. Moreover those few States which continue to exercise water pollution control through water resource agencies face difficulties where waste discharges occur to saline, estuarine or coastal waters. In these cases either a fragmented system of water pollution control results, or there is no effective control of coastal pollution, or as in the case of Western Australia both disadvantages occur.

An area in which the need for management of groundwater pollution is becoming particularly evident is in the section of the unconfined aquifer in the coastal strip from Kwinana to

Cockburn. Here a number of different sources of contamination of the aquifer were identified during the Cockburn Sound Study[1] for example:

- liquid and dissolved petroleum hydrocarbons beneath an oil refinery (estimated total 39 million litres),
- caustic soda, ammonia, chromium, etc. beneath an alumina refinery,
- ammonium sulphate, chlorides and nickel escaped from a nickel refinery,
- phenol, 2,4-D and 2,4,5-T from a herbicide plant,
- ammonia, nitrate and nitrite under a fertiliser works,
- chromium beneath tanneries,
- faecal bacteria near abattoirs and wool scourers.

In the foreseeable future, apart from dryland salinity, the most difficult problem of water pollution appears likely to be associated with controlling groundwater pollution in parts of the Perth Coastal Plain and controlling non-point source pollution as a cause of eutrophication of specific wetlands and estuaries.

Looking to the Future

Traditionally the starting point for most policy decisions on water resources management has been to consider water resources primarily as a means of supplying domestic, industrial and agricultural use. There are, however, other important considerations including effects of water development on living resources, aesthetics and the use of water resources for recreation.

It should be noted that the main water authorities, the PWD and MWA, are primarily responsible for providing water in the sense that they conserve, distribute and allocate what there is. Quality of the water is also their responsibility although they often have limited control over any of those actions which are known to produce an inferior quality of water in terms of salt, silt or other pollutant. The authorities are also responsible for drainage and flood plain management but they have more limited statutory responsibilities and powers in relation to recreation or environment.

The implication is that either the water authorities take a great part in consideration and planning new developments and in changes to land management practices, or that there be rationalisation of responsibility for water pollution control in new comprehensive legislation, combined with its transfer into the environmental portfolio. In either case the presence of the water resource agencies on a diverse range of co-ordinating and planning committees is essential. The task of protecting and developing the water resources of the State should be accorded the highest priority.

A useful recent development in these directions has been the formation of the Western Australian Water Resources Council to advise on the development, conservation, management and protection of water resources of the State. The Western Australian Water Resources Council has the potential to play a useful part in future development of a comprehensive approach to policy making concerned with all beneficial water uses and with conservation of the resource. This would certainly go a long way towards conforming with the principles and objectives of the World Conservation Strategy. The Council, which began as an *ad hoc* committee, is now a statutory body under the Western Australian Water Resources Council Act of 1982. There appears to be an advantage in forming an *ad hoc* committee, testing its usefulness over a period of time and when it becomes clear that the organisation is correctly oriented and functioning usefully, that its membership is adequate, and that it will fill a continuing need in the community, then, and only then, to consider formalising the arrangement.

One of the statutory functions of the new Council is to foster an increasing public and user understanding of issues relating to water management. This will contribute in an area where a high degree of education and extension would seem very necessary. However, Council's principal role will still be that of developing policy advice for the Government in relation to the management of water resources.

Early in 1982 the Federal Government commissioned the Department of National Development and Energy to study and prepare a report "A Perspective on Australia's Water Resources to the Year 2000". The PWD, for the State Government, collected and collated a wide variety

1. Layton Groundwater Consultants (1979). Cockburn Sound Groundwater Survey for Cockburn Sound Study Group. Department of Conservation and Environment, W.A.

of statistical data and other information from its own sources, and from many other Western Australian government departments, and other public and private organisations, in response to requests from consultants working on the national study. It was therefore decided that the PWD would initiate a study in parallel with the Commonwealth and gain a perspective on Western Australia's water resources to the year 2000. The State perspective was subsequently continued under the auspices of the Western Australian Water Resources Council.

The procedure used, of having a State-wide perspective developed under the auspices of an appropriate co-ordinating body to examine present and future policies, has much to recommend it. Such a review is exactly the kind of exercise a conservation strategy would wish to recommend. The study of water resource perspectives to the year 2000 should be regarded as an example of a useful means of examining conservation and development in terms of a particular resource. It seems a model which several other resource-managing organisations might well consider following.

Marine and Coastal Waters

Resources

Marine and coastal waters, including the seabed and offshore islands under the jurisdiction of the Western Australian Government, and estuaries and inland waters in close proximity to the coast, are considered in a general planning and management context in Chapter 11. In this section, these waters and their problems are dealt with in greater detail.

There are three different categories of marine coastal waters, being

(a) waters exposed to high energy disturbance, which include high tidal range waters in the north-west and north of the State, and those open to high wave energy in the micro-tidal zones of the west and south coasts;

(b) low energy ocean embayments, such as Cockburn Sound and Princess Royal Harbour, and also the artificial harbours along the west and south coasts;

(c) enclosed estuaries which on the micro-tidal coasts are extremely well protected from ocean forces and hence dominated by land processes.

Problems

Despite its small population and modest level of industrial development, Western Australia already has localised problems in its coastal waters. These problems are generally located in the sheltered water zones of categories (b) and (c) above, as human coastal settlements have been largely located at those sites. One of the more serious marine environmental problems has been that of water quality in Cockburn Sound and Owen Anchorage. Increasing pressures of effluent discharges from industrial developments over the past twenty-five years caused increasing complaint from other users of the waters and foreshore, until the Government set up the Cockburn Sound Environmental Study in 1976 co-ordinated by the Department of Conservation and Environment (DCE).

Individual discharges into these waters were identified, their composition analysed and rates of discharge recorded, the fate and distribution of pollutants traced in the receiving waters, and their impact on the main parts of the ecosystem and also upon other users of these waters were measured. Proposals for the improvement of water quality were set out[2].

Another area where serious problems in the environment of coastal waters is being encountered is in the Peel-Harvey Estuary[3]. Here the enrichment of these poorly exchanged waters is by fertilisers leaching from adjacent agricultural land, resulting in algal blooms which cause aesthetic problems during the rotting of banks of algae, and also localised reduction of dissolved oxygen in the waters, sometimes to the point of fish mortality. The management of this type of problem is far more difficult than that of direct industrial discharges as in Cockburn Sound.

Immediately north of Bunbury, acid-iron wastes have been discharged for more than a decade. Initially these were discharged into the ocean, but complaints of shore staining led to discharge being diverted into the sand dunes where the limesands aided in the neutralisation of the acid. However, as the capacity of coastal dunes is now being approached, further means of handling this industrial waste are being sought. A favoured option is for pre-treatment of effluent

2. Department of Conservation and Environment, W.A. (1979). Cockburn Sound Environmental Study 1976-1979. Report No. 2.

3. Hodgkin, E.P. *et al.* (1980). The Peel-Harvey Estuarine System Study (1976-1980). Department of Conservation and Environment, W.A. Report No. 9.

to remove much of the iron and solids, then discharge of low-iron waters to the open ocean by a relatively long pipeline.[4]

The State Energy Commission has retained consultants to advise on environmental aspects relating to a major power station proposed at Bunbury. Of particular concern is the large volume of coolant seawater to be discharged into Koombana Bay. Consultants are considering whether the thermal plume might block recruitment of young fish and crustacea to Leschenault Inlet and hence affect the highly valued amateur fishing activity here.

The Hardy Inlet-Blackwood River estuary near Augusta was the subject of a mining company proposal to dredge mineral sands. A multi-disciplinary study of this ecosystem[5] led to the conclusion that there would be considerable environmental impact if the proposed dredging was permitted. In this case the mining company did not proceed with the proposed development.

At Wilson Inlet there have been complaints for many years concerning water quality and management of the bar which is opened annually each year. It is possible that Wilson Inlet is in the early stages of eutrophication due to leaching of agricultural fertilisers in a similar manner to that which is more advanced in the Peel-Harvey Inlet.

A number of urban and industrial discharges are causing localised pollution of Princess Royal Harbour at Albany. Enteric bacteria from several discharges contaminate shellfish in the wharf area. In the north-west sector of the harbour, levels of lead in shellfish have been found to exceed the maximum level permitted in seafoods under the W.A. Food and Drug Regulations. On occasions strongly acidic waste containing high levels of fluoride are discharged into the shallow water of the harbour. Although the affected areas are quite localised, it is clear that marine environmental problems are increasing in these waters.

On the Pilbara coast, it is evident that once the LNG-LPG plant is in operation in Mermaid Sound, and with the further industrial development and urban growth which will follow from this, careful management of the marine environment will be needed to safeguard increasing uses of the Dampier Archipelago.

Several departments (e.g. Mines, Fisheries and Wildlife, Conservation and Environment) are concerned at the potential threat to coastal marine ecosystems by oil spills from marine transport or from petroleum exploration activities. Environmentally sensitive localities are being identified[6] and contingency plans prepared.

The problems outlined above, and also other developments along the coast which are in the planning or discussion stages, highlight the need to carefully manage the discharge of waste into ocean waters, particularly into those sheltered areas which are used for so many other benefits by the community.

Responsibilities

It is clear that responsibility for the condition of our coastal waters is widely dispersed, both in the identification of problems and in the area of action to rectify these problems. Where a particular problem can be identified or anticipated, a scientific multi-disciplinary study may be undertaken as in the case of the Blackwood River, the Peel-Harvey Inlet, Cockburn Sound and Owen Anchorage, and Dampier Archipelago. If a particular development proposed along the coastline is likely to have significant environmental impact, the EPA has the powers necessary to require rectification of the situation.

In June 1979 the EPA set up a Working Group to prepare water quality criteria for marine and estuarine waters in Western Australia. The Working Group completed its report in April 1981.[7] This report provides a basis for developing a State environmental protection policy for marine and estuarine waters. The uses to which our coastal waters might be put have been listed, and for each use, water quality criteria have been proposed for a wide range of parameters. It is envisaged that any authority responsible for the management of a particular body of water would select the beneficial uses to be safeguarded in its waters, and from this

4. Environmental Protection Authority (1983). Evaluation of Disposal Options for Effluent from Laporte Titanium Dioxide Manufacturing Plant. DCE Bull. 137, May 1983.
5. Hodgkin, E.P. (1978). An Environmental Study of the Blackwood River Estuary, Western Australia 1974-75. Department of Conservation and Environment, Report No. 1.
6. Hancock, D.A., Jones, H.E. and Field, R.A. (1979). Oil Spills and the Marine Environment. Department of Conservation and Environment, W.A. Bull No. 71.
7. Department of Conservation and Environment, W.A. (1981). Water Quality Criteria for Marine and Estuarine Waters of Western Australia: Report of the Working Group. DCE Bull. No. 103.

to draw up a single set of water quality objectives, using the water quality criteria as a guide. These objectives for the receiving waters would then be used by the management authority to set effluent standards, and to apply the necessary licensing, monitoring and inspecting of all discharges.

One of the difficulties in the implementation of such a policy is that it is not at all clear who would be responsible for putting it into effect. Following the report of the Cockburn Sound Environmental Study, the then Premier stated that the responsibility for the management of water quality in Cockburn Sound rested with the Fremantle Port Authority (FPA), with DCE playing a liaison role. However, there is considerable doubt whether the FPA has powers under its Act to manage water quality and effluent discharges. Nevertheless, the FPA Regulations, 1971, do include provisions regarding water pollution control, but these really need revision to be effective. Experience since the Cockburn Sound Study suggests that the FPA has limited experience in water quality management and does not propose to develop into this field. Other port authorities have even less resources for the management of pollution in their waters. In many instances the Agreements Acts which regulate the operation of industrial developments restrict the management options available to the authorities with general water quality management responsibilities.

The Harbours and Rivers Branch of PWD is normally asked to solve problems of erosion and siltation along the foreshore. It is also able to advise on the impact of structures and works on coastal waters and shores.

The Department of Marine and Harbours has the statutory responsibility for structures in the coastal and navigable waters of Western Australia, but is not responsible for water quality at sites other than where it exercises the responsibilities of a port authority.

Certain of our estuaries are under the jurisdiction of the Waterways Commission. However, the management role of the Waterways Commission applies only to those estuaries which are declared Management Areas. To date three such areas have been declared and a Management Authority set up for each, viz. the Swan River Management Authority, the Peel Inlet Management Authority, and the Leschenault Inlet Management Authority. Elsewhere there are as yet no formal arrangements for co-ordinated management or the formulation of policies and guidelines for estuaries. The Waterways Conservation Act[8] does however allow the declaration of additional Management Areas, and both Hardy and Wilson Inlets are under consideration. This need not lead to an unworkable number of management authorities, as it is possible for existing bodies such as local authorities to be delegated the authority for management by the Waterways Commission.

As outlined in Chapter 8, the Department of Fisheries and Wildlife has some responsibility for maintaining suitable habitats for the safeguard of fish stocks. In addition the Department of Fisheries and Wildlife has made considerable input in an inter-departmental formulation of environmentally sensitive localities around the Western Australian coast in the preparation of an oil spill management plan. However, in the event of an oil spill, that department plays only an advisory role in the subsequent clean up or other management procedures. As discussed in Chapters 3 and 11, there is not clear responsibility for the selection and management of marine reserves in Western Australia. Under the Fisheries Act as revised in 1974, the Department of Fisheries and Wildlife has some powers to set up marine reserves but very little progress has been made owing to lack of resources, problems of defining State and Commonwealth waters, and uncertainty as to management responsibilities.

Needs

While the State has increased its capability for the scientific study of the quality of coastal and oceanic waters in the past decade, it has not yet addressed the problems of management in a co-ordinated way. Management is fragmented and does not cover all waters: the Waterways Conservation Act covers some inlets; individual port authorities administer specific embayments; while there is no agency responsible for most of the coastal waters. In addition, none of the bodies mentioned has been given the resources to rectify problems of unwise past development or to expertly administer pollution control. This would be facilitated if there were a single agency responsible for co-ordinating the control of effluents, and setting of standards, and which could provide appropriate technical expertise.

8. Western Australia, Parliament, Waterways Conservation Act, 1976-1982.

Chapter 10

Air

Introduction

Our air is a vital life support system which is intricately linked with most essential ecological processes, and therefore should be guarded carefully against any deterioration in quality.

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.

Air pollution may be defined as substances present in the atmosphere in concentrations great enough to interfere directly or indirectly with comfort, safety or health or to have an adverse affect on the environment.

While combustion is the most important source of man-made pollution, other sources include smelting and heating processes, mining and quarrying, cooking and chemical processes. Air pollutants may be further classified into two groups: primary emissions from identifiable sources, and secondary products formed in the air by interaction between two or more primary contaminants or by reaction with normal atmospheric constituents, with or without photochemical activation.

Air Pollution in Western Australia

Air quality is at times impaired in Western Australia because of particular local circumstances. Perth, as seen from a distance, is sometimes enveloped in a brown haze. Dust and smoke are nuisances which can be acute in some areas at certain times. Major industries contaminate the air over Kwinana. Aerial crop spraying is blamed for the death of trees bordering croplands in some parts of the wheatbelt and the south-west.

Burning off in summer months sometimes causes nuisance if it coincides with a period of inversion. Under these conditions, hot gases containing particulate matter which would normally escape into the upper atmosphere become trapped under the inversion layer and so become concentrated. Forest burning off is restricted under these conditions, but private burning, not prohibited by fire regulations, can occur, and may ultimately require controlling.

The principal air pollutant in large cities with climatic conditions such as occur in Australia is photochemical smog. This is caused by a reaction between hydrocarbon vapour and oxides of nitrogen in the presence of sunlight. The largest single source of these precursor gases is motor vehicle exhaust emissions. The products of the reaction include oxidants which have a damaging effect on vegetation and some materials such as rubber and also contain small traces of carcinogenic gases. Because the reaction occurs slowly, levels of photochemical oxidants build up during the course of the day when air conditions are still or stable inversions persist.

Perth, which is noted for its high winds, is fortunate in that although it relies heavily on motor vehicles and has abundant sunlight, the prolonged inversions which allow high levels of photochemical oxidants in cities like Sydney and Melbourne rarely occur. In any case, the problem has been alleviated in recent years with the advent of motor vehicle emissions controls.

The brown haze which occurs over Perth, particularly under inversion conditions, is believed to be a combination of smoke and dust rather than due to photochemical smog.

Dust is innate in much of Western Australia and a natural product of dry, but windy conditions in summer. In agricultural areas, grazing land may become denuded. This is especially the case in stock-holding paddocks where vegetation is so completely removed by the concentration of animals, that dust nuisance poses real problems. These are now controlled under the Clean Air Act, 1964-1981. The control of nuisance from dust due to industrial processes such as sand blasting, has been greatly improved in recent years.

Sulphur dioxide is a pollutant which causes air quality problems in localised areas of Western

Australia. A major study (with modelling) of air pollution at Kwinana has been undertaken by the Department of Conservation and Environment in conjunction with the Department of Public Health and a number of other agencies[1]. This has identified a situation in which levels rise significantly to the north-east of the industrial strip in and around Wattleup, but for relatively short periods generally of less than three hours. This is a unique feature of the sea breeze situation which occurs along the west coast and is quite different to industrial pollution elsewhere which is categorised by steady state conditions. As a result, air quality criteria based on long-term averages are inappropriate at Kwinana. While the relatively short high peaks of sulphur dioxide do not pose health problems, they can undoubtedly create odour which is aesthetically unattractive to those affected, and may cause stress in vegetation. This situation is expected to improve when natural gas is available to replace fuel oil in 1984.

A similar problem occurs at Kalgoorlie where gold roasters have been used for many years to concentrate sulphide ores. Here the roasters have historically been sited close to residential areas and the height of stacks is limited by the flight paths of the Kalgoorlie Airport. In certain climatic conditions the emissions from the roasters fall on built-up areas causing nuisance, although again health problems are not believed to occur.

Another pollutant which has given rise to localised problems is fluoride, a byproduct of clay firing during the manufacture of brick and pipes. The conflict has centred on the Swan Valley where clays suitable for brick making exist alongside the loams which are the basis of this important wine growing area. Vines are particularly sensitive to fluoride and some damage has occurred in spite of dry scrubbers on the kilns. Since both industries are important and neither can be readily relocated, stringent emission control appears to be the only solution, and has been implemented in some instances. The MRPA has set up the Swan Valley Project and one of its detailed objectives is to establish standards for industry in the area on various matters including air pollution.

The main air quality problems therefore include smoke due to fires and burning off, dust caused by erosion of paddocks and land which has been cleared of natural vegetation, dust from slime and tailings dumps and ore stockpiles and dust from certain industries such as cement manufacture and sand blasting. Localised pollution also results from burning of fossil fuels containing sulphur and from smelter operations. However, Western Australia's isolation and climate conditions have spared it from many of the air quality problems of other states both in Europe and North America and on the eastern seaboard.

Management

Air pollution is controlled under the Clean Air Act which is administered by the Minister for Health. The Act establishes an Air Pollution Control Council, chaired by the Commissioner for Health, which has, subject to the Minister, responsibility for its practical administration. The Air Pollution Control Council is advised by a Scientific Advisory Council and both are serviced by the Clean Air Section of the Public Health Department.

The legislation is aimed at industrial sources of pollution and is designed to protect human health rather than to maintain overall environmental quality. Consequently the major effort has been directed towards the alleviation of air pollution that has demonstrated potential for adverse health effects.

However, the impacts of air pollution are by no means confined to problems of human health. Many plants are susceptible to pollutants at concentrations far below those which affect human health. Elsewhere in the world, other problems from air pollution include "acid rain" corrosion of metals and building materials and the accelerated perishing of rubber, at concentrations in the atmosphere not necessarily affecting human health.

Conclusion

With continuing industrial growth likely to include the large-scale smelting of minerals, the accent of air pollution problems will increasingly fall on environmental impact rather than be confined to human health. Western Australia is the only State where responsibility for air pollution control still resides in the health portfolio. However, human health is rarely threatened by the air pollution levels reached in Australia, and in other States its control, monitoring and research are undertaken by organisations concerned with environmental protection as a whole.

1. Department of Conservation and Environment, W.A. (1982). The Kwinana Air Modelling Study. Report No. 10

Chapter 11

Regional Land Use Planning

Introduction

The World Conservation Strategy proposes that a balance be struck between conservation and development through environmental planning and rational land use allocation. Such planning involves detailed analysis of the natural and man-made systems and through an evaluative process devises an equitable distribution of land uses.

The strategy being developed for Western Australia deals with several land use components at a broad scale. Mining, agriculture, forestry and pastoral activities cover vast tracts of land and it is in the growth and development of these components that land use conflicts emerge. The intrusion of agriculture into forests and the exploitation of mineral resources in forest areas are examples of conflicts which come to mind.

Such broad-scale land use problems highlight the need for joint physical and economic planning. A State-wide Regional Land Use Plan for Western Australia would help to resolve broad-scale land use conflicts and would strike a balance between economic efficiency and environmental amenity. Regional planners are not merely 'land accountants' or purely conservationists, but are arbitrators of conflicting pressures and demands upon land and other resources. They are concerned with establishing and working towards long-term objectives, ensuring continued growth with progressive improvements.

Regional planning in Western Australia

At present the broadest scale of planning which has been attempted in Western Australia is a plan for the Perth Metropolitan Region and as such deals mainly with urban issues. Similarly, a plan for the Bunbury Region deals with the alternatives for the urban expansion of Bunbury City. The remainder of Western Australia is subject to incremental and *ad hoc* planning. The reason for this is quite understandable. The land area of the State is vast and has a relatively minute population. There has been little or no need in the past to consider regional or inter-regional planning as most of the urban and regional problems that afflict more densely populated countries have not existed.

Now, with Perth approaching a population of one million and with a more intensive approach towards mineral and resource utilisation, some problems are beginning to emerge. Diseconomies of scale in Perth are beginning to be felt. The high cost of commuting from outlying suburbs, increasing land values as a result of high demands, the provision of services on a large scale and pollution are beginning to detract from the otherwise high quality of life and are beginning to degrade the environment.

Some of the broader-scale State-wide concerns are as follows:

(a) the polarisation of economic and physical development in Perth and the corresponding stagnation of rural areas;

(b) the depopulation of rural areas and the increasing discrepancy between urban and rural standards of living;

(c) deforestation.

Recent proposals such as 'Bunbury 2000' and previous attempts at decentralisation such as the Assistance to Decentralised Industry Act, 1974 (which was later repealed) indicate that the Government is becoming concerned with broad-scale inter-regional planning issues.

A State-wide Physical Development Plan

A comprehensive State-wide Physical Development Plan could analyse the natural systems and utilisation of resources at the broadest scale. After setting a goal and objectives for the overall long-term operation of the entire system it is possible to identify opportunities and constraints. Policies are then drawn up to resolve conflicts, physical plans are prepared and priorities are identified. The planning methodology may best be shown in a flow diagram (Figure 11.1).

Through planning, areas which have conservation potential can be set aside and protected

from expanding land use components. Such areas may be set aside totally and preserved or may be utilised for selected forms of recreation or research under a scientifically based management plan. Management plays an important role in areas of development as well. Where land use and development changes take place management proposals and strategies can help reduce the harmful effect on the environment.

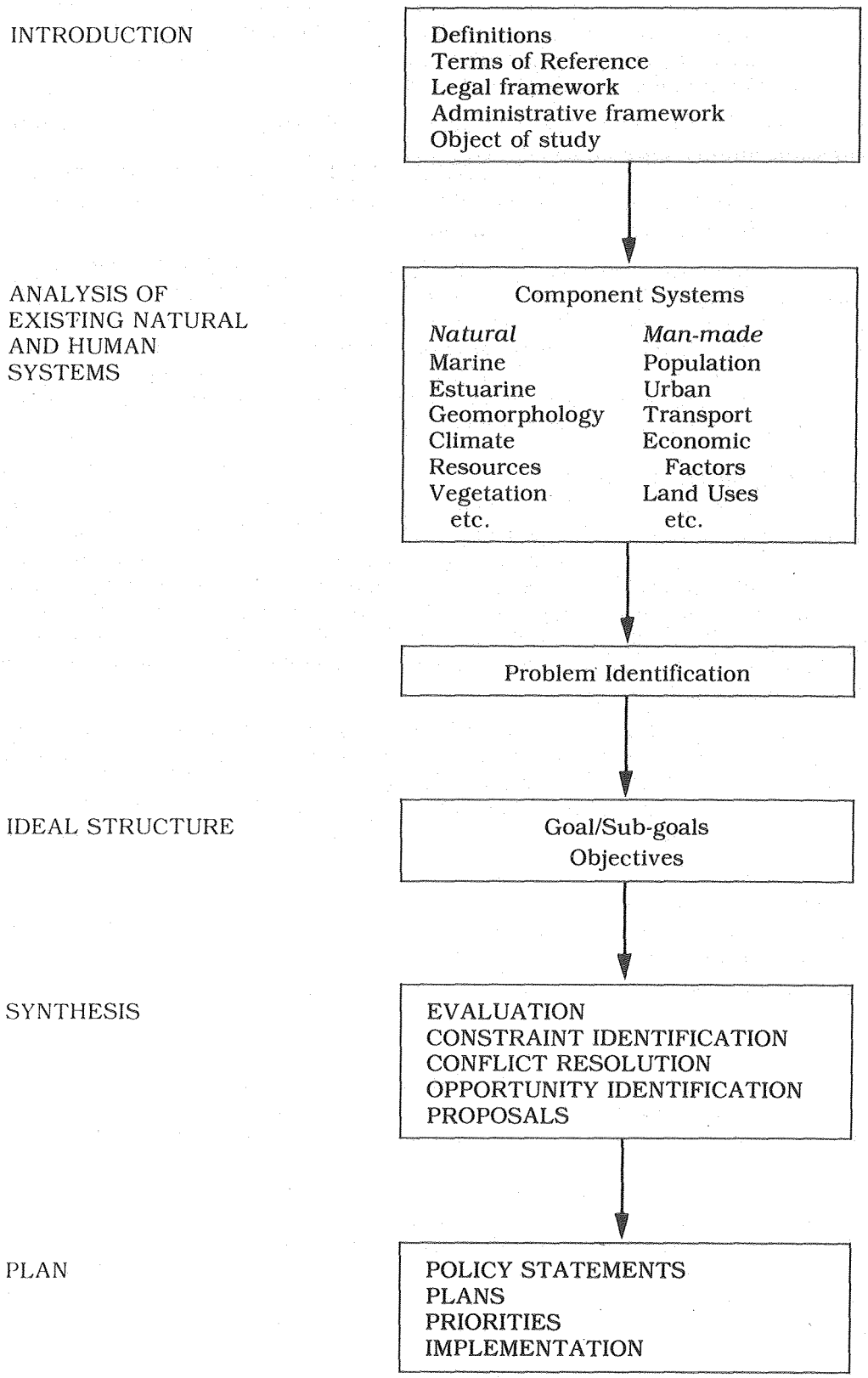

Figure 11.1 — A systems approach to planning and management

The coastal region as a case study

At present, one of the most intensive land use conflict areas in the State is the coastal region. The coast is not a land use component in the same context as forests, agriculture, mining and pastoral activities but is a zone within which most land uses interact. Eighty-five per cent of the Australian population live within three kilometres of the coast and a high percentage of urban and regional land use conflicts take place along the coast. To further complicate matters the coastal region is a sensitive environmental entity subject to a range of processes which frequently cause instability.

For this reason the planning and management of the coastal region will be considered as an example of an attempt to resolve regional land use planning problems.

Western Australia has by far the longest coastline of any State, some 12,500 kilometres compared to Queensland with the second longest of around 6,500 kilometres. While much of the coast is isolated and uninhabited, it is unique in Australia, having a wide range of marine biogeographic zones present, from tropical in the north through warm/temperate on the west coast to a temperate south coast.

Although much of the Western Australian coast experiences less intense user pressure than, for example, the coasts of New South Wales and Victoria, a high proportion is subject to significant human impact. In several areas, especially the south-west of the State, the potential for conflict between competing uses of the coast is equal to that found anywhere in Australia. This results from the hot, dry climate and lack of substantial inland rivers and lakes. Coastal recreation in this situation is therefore of great importance.

A coastal area is more than the narrow strip where land and ocean meet. Here it is taken to contain the following elements:

- coastal waters, the seabed and offshore islands under the jurisdiction of the Western Australian Government,
- the mobile beach zone and frontal dune systems,
- estuaries, their foreshores and margins, and
- those areas of land (including inland waters) in close proximity to the coastline or estuaries whose use or development could substantially affect the above elements.

Coastal resources

The coastal region exhibits great variety in geology, landforms and vegetation, and thus contains an immense range of resources available for society's use and enjoyment. There will always be differences of opinion as to which uses of these resources should take priority and to the manner in which some areas should be managed. These perceptions may also change with time.

Sound management of coastal resources is clearly of vital importance to the State's economy. It is also evident that the valued resources of the coastal zone are not confined to those things that we can "dig up and take away". The natural environment is also a major economic asset, notably as a source of fish and clean water, and as an attraction for tourists.

Pressures and problems

Management problems along the coast arise from the inherent fragility and sensitivity of some coastal environments; from use pressures and conflicts; and from simple mistreatment or ill-advised development.

About two-thirds of the Western Australian coast consists of sand and muds deposited during the last few thousand years. Less than a quarter is rock. The sandy coasts in particular are in a constant state of change as dunes are first built and then attacked by the action of waves and wind, and large quantities of sediment are moved on and off shore, and along the coast. Most of the State's population live adjacent to a fragile, sandy coast on the Swan Coastal Plain, and erosion problems such as those experienced at Mandurah, Floreat and Quinns Rocks attest to the need to respect natural processes and in particular the destructive power of the sea on an exposed coastline.

Not only sand dunes are sensitive. The estuaries of the south-west, for example, whose rivers usually flow only in winter and which often experience little tidal exchange with the ocean, are extremely vulnerable to pollution. In the north, the mangroves which fringe much of the

coast and which provide vital protection against storm surge, are also easily damaged.

Table 11.1 summarises current uses of coastal lands. Grazing is clearly the major use, and a substantial (though far from excessive) area lies within conservation reserves. Recreation areas, urban-industrial development and mining at present occupy only a small percentage of available land. Much of the coast presently classed as "unused" is serving a valuable role as a protective buffer to important shallow water habitats which are nursery grounds for valued fish resources.

Table 11.1: Use of coastal lands*

TYPE OF USE	AREA (km^2)	PERCENTAGE
Conservation Reserves	6,006	14.8
Other Reserves	6,594	16.1
Agriculture	243	0.6
Grazing	9,186	22.5
Forestry	111	0.3
Recreation	102	0.3
Urban-Industrial Areas	363	0.9
Mining (includes salt)	150	0.4
Unused, Water Bodies	17,961	44.1

* Coastal lands are defined as extending inland from the shoreline for 3 km, or as far as the inner boundary of Holocene estuarine and eolian coastal sediments, whichever distance is the greater. The figures in this table are estimates based on a sample survey.

Source: CSIRO Division of Land Use Research.

However, pressures for use of the coastal zone are intensifying rapidly as demands grow for residential and recreational areas, hobby farms, industrial sites (including power stations) and commercial, fishing and recreational port facilities. Conflicts between alternative uses are inevitable, either because of the sheer weight of user pressure, as in the Perth Metropolitan Region, or because the particular resource for which users are competing is scarce.

In the Pilbara, for instance, the number of suitable locations for ports and industrial development is limited, and the available sites tend to be found in areas which also contain important recreational and environmental resources. The result is potentially intense competition between user groups at a few points along an otherwise largely undeveloped coast.

With careful planning and management, many of the problems which arise from the fragility and sensitivity of the coast, and from use pressures and conflicts, can be overcome successfully. Unfortunately, the problems with which coastal managers are presently confronted have all too often resulted from lack of care and foresight — buildings unwisely located on frontal dunes, poorly designed and located roads, mangroves unnecessarily cut off from tidal water, indiscriminate use of off-road vehicles and so on. Development and a whole range of human activities can be accommodated successfully within the coastal zone, but it would seem that increased awareness of the special characteristics of the coast is urgently required. In addition, the planning and management system must incorporate sufficient checks and balances to avoid inadvertent damage.

It remains to be seen how much longer Western Australia can avoid the levels of expenditure which have become commonplace in the Eastern States. Current indications suggest that without a more concerted coastal management effort, and especially a fuller appreciation of the inter-relationships between different elements of the coastal environment, the day of reckoning may not be far off. The huge sum involved in preventing further pollution of Cockburn Sound is one obvious example. Similarly, erosion along the coast between Geographe Bay and Moore River has already cost State and local government millions of dollars.

Coastal planning and management

Ideally, coastal planning and management would draw together all those functions of govern-

ment which regulate the use of coastal resources. Those resources are extremely diverse, including cooling water for industry, minerals, fisheries, tourist attractions, recreation opportunities, areas of scientific or educational value, and many others. The number of organisations which might become involved in a 'comprehensive' coastal management system is correspondingly very great, and there are practical limits to the degree of co-ordination which can be achieved.

Current planning and management arrangements for the coastal zone are not adequate to ensure that problems are avoided, and that the best possible use is made of coastal resources. The aim must be to minimise costs and maximise benefits by considering the full implications in the long term of development and expenditure decisions on the coast.

The goal of coastal planning and management should be to ensure full recognition of the special significance of coastal resources to Western Australia, and to provide for the use and conservation of those resources in such a way as to achieve a balance between the economic and social needs of the community and maintenance of the environmental quality, stability and resource values of the coast itself.

Current planning and management arrangements
There are a very large number of activities and organisations which form part of the overall pattern of coastal planning and management in Western Australia. At least twenty-five State government organisations and forty-three coastal local authorities are directly or indirectly involved.

The key question is whether the complex web of management which emerges is sufficiently efficient and effective. A recent review of coastal management in Western Australia identified eleven main areas of administration:

- coastal planning in general
- land subdivision and development control
- management of coastal waters and estuaries
- reservation and management of Crown land
- coastal engineering and ports
- soil conservation
- provision of access
- mining and industrial development
- tourism and recreation
- project funding, and
- information and research.

The overall conclusion was that the major obstacle to more efficient and effective coastal management in Western Australia is an excessive fragmentation of responsibility, coupled with a lack of mechanisms to co-ordinate the planning and management system as a whole. It was recognised however that significant growth in planning and management activity had occurred in the last decade to fill some major gaps and that this provided opportunities for further development.

Coastal management initiatives
Whilst recognising the roles and responsibilities of the many organisations involved in the coastal zone, the Western Australian Environmental Protection Authority has for some time been working towards a more effective system of coastal management.

A significant stage was reached in June 1977, when the EPA circulated its Working Draft "Guidelines for an Environmental Protection Policy on the Coastal Zone in Western Australia". This reflected the Authority's longstanding concern about the need to secure an appropriate balance between development and conservation in the coastal zone.

The Guidelines were intended to lead to the preparation and implementation of a statutory Environmental Protection Policy, under the provisions of Sections 35-41 of the Environmental Protection Act. Such a policy would have the force of law as if it were part of the Act, which takes precedence over most other State legislation, and was seen by the Authority as providing for "an overall approach to coastal management to allow for creative planning, recognising the importance and sensitivity of all facets of the coastal zone" (EPA Annual Report 1973-74, p.15).

Given the potentially far-reaching consequences of these proposals, it is not surprising that they aroused considerable interest and concern, and in some quarters outright opposition. In March 1978, the situation was reviewed by the Conservation and Environment Council, which is established to advise the Authority and the Minister for Conservation and Environment. The Council recommended the formation of an interim Steering Committee to work with a Coastal Planning and Management Adviser to carry out a wide-ranging examination of the current status of coastal planning and management in Western Australia. In summary the major findings were:

(a) Sound management of coastal resources is of vital importance to the State's economic and social well-being.

(b) Coastal environments are often very fragile and sensitive to mistreatment. Many of the problems currently being experienced along the Western Australian coast are the result of ill-conceived use or development, and lack of regard for coastal processes.

(c) Increased awareness of the need for special care when using or developing coastal lands and waters, is essential.

(d) Pressures for use and development of the coastal zone are mounting rapidly, and intensified conflicts between user groups seem certain to occur.

(e) Expenditure on coastal planning and management in Western Australia is significantly less than in other, comparable States. Shortages of funds and manpower are evident throughout.

(f) In the short term, the most appropriate form of coastal policy for Western Australia would be a broad statement of the State Government's attitudes and intentions in relation to objectives and organisations for planning and management.

At an early stage of the Committee's review, it became apparent that many coastal management issues in Western Australia reflect wider concerns, especially the need to strike a balance between economic development and conservation of the natural environment.

But implementation of improved coastal planning and management *processes* need not be delayed simply because there may be differences of opinion as to desirable *outcomes*. More effective and efficient decision- and policy-making procedures can be to the benefit of all those concerned with the coastal zone, irrespective of their philosophical viewpoint.

The Government's response to these findings announced by the Premier on 14 September 1982 was to form a co-ordinating committee of senior government officers and continue the position of Coastal Planning and Management Adviser as Executive Officer. The functions of the committee are to overview planning to co-ordinate departmental activities and to give advice to the Government.

Coastal management plans

A prime co-ordinating mechanism will be through the preparation of non-statutory coastal management plans. The concept of a coastal management plan is that of a document which can guide the application of a variety of different management tools — subdivision and development control; reservation of Crown land for various purposes; coastal protection works programmes; construction of roads; regulation of off-road vehicles; declaration of Soil Conservation Districts; creation of aquatic reserves and so on. To perform this role, a coastal management plan must go further than a conventional regional land use plan or town planning scheme: rather than simply establishing a broad pattern of land use and development, the coastal management plan must also make specific recommendations concerning management programmes and priorities necessary to achieve agreed objectives for the utilisation, conservation, protection or restoration of coastal resources. Furthermore, it must cover at regional and local levels both land *and* waters, in order to ensure that the plans reflect wider community and State interests. However, it would be essential to work in close consultation with local councils and opportunities should be provided for public input.

A coastal resource inventory

A resource inventory should be prepared, at least at the level of an overview of coastal resources of State significance, with a view to identifying major problems or conflicts and to delineating those sections of coastline which require more detailed study.

Resources which could be considered to be of State significance would include existing and potential ports; sites for major industries dependent on a coastal location (including power

stations); major fishing grounds and breeding/nursery areas; key locations for tourism development and recreational use; land and water areas of outstanding natural beauty or scientific interest; mineral deposits, etc. Periodic review would be essential.

Coastal zone priorities
There are a number of actions which should be given high priority if coastal zone management is to be effective.

1. Co-ordination of funding is essential for efficient use of limited resources, and could be carried out by the Coastal Management Co-ordinating Committee. It would administer a programme of funding to subsidise multi-purpose projects proposed by local government councils.
2. Coastal resource inventory should be compiled, including living and non-living resources, as a basis for planning.
3. Each development should not be considered in isolation, but in terms of all additional pressures being made on the coastal ecosystem.
4. Pollution problems inevitably arise with industrial and other development. While air pollution control is presently a responsibility of the Public Health Authorities, water pollution control is fragmented and no agency has overall responsibility for coastal waters (see Chapter 9).
5. Aquatic Reserves need to be provided for within the planning framework (see also Chapters 3 and 9).

Summary of coastal region planning and management
Wide-ranging action is clearly necessary to develop more efficient and effective coastal planning and management. Formation of the Coastal Management Co-ordinating Committee is only a first step towards an improved system.

In particular the success or otherwise of the Co-ordinating Committee should be reviewed after two years, and action in the matter of aquatic reserves and control of marine and estuarine water quality should be undertaken as a matter of urgency.

Overall, the action of the Government in moving towards more effective management of the coastal zone is to be commended. However, it must be recognised that this is a dynamic area not only in a physical sense but administratively and organisationally as well and must be kept under active review.

Coastal planning and management in W.A. should aim to ensure that the following objectives are met:

(a) maximum economic and social benefits are gained from the use of coastal resources, and sufficient resources are conserved for future generations;
(b) conflicts between users of coastal resources are thoroughly analysed to permit them to be resolved satisfactorily;
(c) the stability and environmental quality of the coast are maintained, or where necessary restored; and
(d) State and local government expenditure can be minimised by ensuring that beneficiaries provide monies for monitoring and restoration as well as for the initial development.

Conclusion

A State-wide Physical Development Plan would be of assistance to a Western Australian Conservation Strategy in attaining its objectives. The plan would provide a structural framework within which spatial aspects of decision making could be guided. Although Western Australia has had little need to prepare a broad-scale plan until recently, urban and regional pressures are beginning to indicate that such planning is required. Conservation strategies would benefit directly in terms of allocation of land for conservation and management. Land use conflicts could also be reduced by means of drawing up relevant policies.

The coast is an example of a region which has been considered as a priority for planning and management. Coastal planning problems and strategies have been discussed and the administrative framework outlined. Much of the planning in the coastal region has been on a local scale and it is only recently that a decision was taken to become involved in broad-scale coastal planning.

Chapter 12

Major Elements of the Strategy

The preceding chapters raise a large number of issues affecting the integration of conservation and development, and consequently the State's policies with respect to almost all forms of land use. The main conclusions and proposals arising from them are brought together here in summary form.

Conservation and production

Conservation of flora and fauna

A most important way of maintaining genetic diversity of plants and animals is through the provision of an adequate and representative system of parks and reserves, where a primary purpose is the conservation of nature. The area already set aside in Western Australia is likely to increase as Environmental Protection Authority (EPA) and Conservation Through Reserves Committee (CTRC) and System 6 Studies are accepted and implemented. As further knowledge of the natural ecosystems becomes available, the need for additional reserves may become apparent, particularly in the marine environment which has so far received insufficient attention.

Periodic reviews of the adequacy of the parks and reserves system for the conservation of flora and fauna, with emphasis upon the maintenance of genetic diversity are required. There is a particular urgency in the case of marine reserves.

There is steady but slow progress in the mapping of the biological resources of the State, on which the selection and location of reserves is based. Their adequacy for the representation of important ecosystems cannot be assessed in the absence of proper inventory.

Biological surveys to complete an inventory of the whole State (land and waters) are necessary to ensure the establishment of an adequate and representative system of parks and reserves.

While biological surveys provide information on the range of ecosystems which should be represented within the system of reserves, they are seldom an adequate basis for management. For management it is necessary to understand how the ecosystems function, and in particular the role of the fauna which has so far received little attention.

Research on ecosystem functions is required primarily as the basis for development of management policies and techniques for both terrestrial and aquatic reserves.

This report and numerous other reports have pointed out that existing parks and reserves are in danger of deterioration because the managing agencies have insufficient resources for their management and protection.

There seems little doubt that additional management and planning staff resources are required, and that the requirements will increase as new parks and reserves are created.

During the last decade, the system of parks and reserves has been enlarged as a result of EPA recommendations to the government based on studies by expert committees, a process which is still continuing. The System 6 Study advised that in some cases publicly owned and available land suitable and recommended for reservation should be protected and managed as a park or nature reserve for a limited term, pending evaluation of its potential for other conflicting uses, particularly mining and water supply. If such limited-term reservation is to be effective, there is a need for inventory of land, mineral and water resources, so that decisions between competing uses may be made without undue delay.

The State should take the responsibility for assessing the water and mineral potential of areas proposed as parks and nature reserves so that decisions on reservation are not deferred indefinitely. The policy of the Mines Department may need to be modified to facilitate this.

At present, parks and reserves are classified according to designated uses, and security of tenure and purpose. These classifications 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. This leads to uncertainty in the mining and other industries which demand access for exploration and exploitation, opposition to the establishment of new parks and reserves, reluctance to explore in existing and proposed reserves, and difficulty in designating appropriate managing agencies for those that are established.

A revision of the system of classification of parks and reserves established under the Land Act is required. The new classification should:

(a) reflect the value of the reserved land for the conservation of nature;

(b) take account of the desirable balance between conservation and other uses including public access and enjoyment;

(c) enable the indentification of the most appropriate managing agency.

Conservation outside reserves

Given the extent of the land already cleared, and the need to devote land resources to production in support of the community's expected living standards, it seems unlikely that any system of parks and reserves can be fully representative of the range of natural ecosystems. Consequently, the contribution of land outside reserves assumes great importance. That is to say, the farming areas, the pastoral lands, State Forest and open country in whatever tenure, have a part to play in the Conservation Strategy.

In the farming areas little opportunity for reservation of natural areas now remains, due to the extensive alienation of land from the Crown for agricultural development. This is also true of urban, residential and industrial areas. Besides the direct loss of natural areas, there is the further impact, through hydrologic change and salinisation, on lakes, wetlands and drainage systems. In some parts of the pastoral areas, degradation and change in composition of plant communities has significantly altered natural habitats.

Consequently, protection of remaining natural areas which do not comprise part of existing reserves has an important contribution to make in a conservation strategy.

Consideration of natural areas outside reserves should include:

(a) acquisition of data on the extent, composition and current status of remnant natural areas on farms and other freehold land;

(b) the completion of the resource inventory and condition surveys of the State's pastoral lands;

(c) the provision of an effective extension service to provide occupiers with expert advice on the management of natural areas, with particular emphasis on regeneration in the longer term;

(d) consideration by the Government of financial or other incentives and assistance to defray costs of maintaining important remant areas, especially wetlands;

(e) the use of planning legislation and financial incentives to protect the natural areas on private land.

Pastoral land

Pastoral leaseholders are in effect the managing agents for a large proportion of the land area of the State where they use a fragile natural vegetation for domestic stock. This area is thereby effectively restricted to one form of land use, to the possible exclusion of alternative or innovative uses of the renewable resources such as recreation or tourism.

Policies on allocation and management of pastoral lands should recognise that there may be other valid uses of the renewable resources.

Pastoral land has a considerable potential for the retention of natural habitats, although some areas are badly degraded. In others, grazing by stock has modified the original condition, and exotic plants have been introduced and even encouraged for their grazing value, as provided

for in the 1980 Amendments to the Land Act[1]. The 1982 Amendments to the Soil Conservation Act[2] provide an important means of protecting the production potential of the leases, and their rehabilitation where necessary. This does not necessarily involve the maintenance of the natural or pristine condition, which may conflict with the primary purpose of pastoral production. Nevertheless, the important contribution which the pastoral areas have the capacity to make to the conservation of natural flora and fauna on about 38 per cent of the land area of the State should be formally recognised. At least one member of the Pastoral Board should have the relevant expertise.

The conservation value of pastoral lands should be an important consideration in determining the policies under which they are administered.

While sustainable and perhaps even elevated production is in the best long-term interest of the pastoral leaseholders, it does not necessarily follow that this is compatible with conservation objectives. Maintenance of natural conditions and species' habitats may be at the cost of some production foregone.

Overgrazing of pastoral areas is common in or near the fringes of deserts here as in many countries. It results in a steady decline of the resource to a point where it cannot be regenerated.

Part of the reason for degradation is that some land leased for pastoral purposes is not capable of supporting production from grazing the natural vegetation at economically viable levels. Such measures as drought relief may be a means of encouraging the continued grazing of climatically unsuitable areas.

The Land Act provides for review of pastoral leases before 1995, and their renewal in 2015.

The capability of pastoral land to sustain production at an economic level should be a prime consideration when leasehold conditions are reviewed.

Management of pastoral lands should take account of the need to protect conservation values. For this the provision of incentives and possibly subsidies to pastoralists should be kept under review.

Vacant Crown land

Vacant Crown land accounts for almost half of the land area of the State, most of it in the arid centre. In the more intensively settled areas, vacant Crown land with other publicly owned land forms scattered and generally small parcels which offer opportunities for dedication to conservation as parks or nature reserves. For these purposes its value is extremely high, especially in those areas of the State where clearing is extensive, yet it is often seen as cheap land for such developments as rubbish tips, abattoirs or trotting tracks.

In view of its contribution to conservation and its scarcity, publicly owned land in developed areas, including vacant Crown land, should not be regarded as cheap and readily available for further development.

The problems of managing the State's vacant Crown land are obviously immense, particularly in the more remote areas. The Department of Lands and Surveys' role is essentially custodial and administrative, as it continues to hold the land against future use.

Vast areas of the centre are too arid for any form of pastoralism, yet the country is subject to such activities as mineral exploration and the occasional passage of recreational travellers, usually in off-road vehicles. Although the traffic may be infrequent, the fragile, natural ecosystems are easily damaged and take a long time to recover.

The extensive vacant Crown land in the arid interior (and tropical north) of the State is a valuable but fragile conservation resource which requires effective measures for its protection.

Biological and other surveys of vacant Crown land to determine potential uses, including dedication to parks and reserves, should be expedited.

1. Western Australia, Parliament, Land Act, 1933-1980.
2. Western Australia, Parliament, Soil and Land Conservation Act, 1945-1982.

State Forest

There are already areas set aside primarily for the conservation of nature within State forests. The conservation Management Priority Areas (MPAs) are particularly valuable because they are surrounded by country which is managed to ensure that their purpose is not endangered. State Forest is managed according to Working Plans which are regularly revised and published every five years. In effect, the whole forest is zoned by management objectives accorded specified priorities for each zone. The plans have been determined after extensive consultation with other government agencies and with industry, particularly bauxite and coal mining and timber production interests. It can be argued that the views of the general public and community interests are also considered during the revision which takes place during the five-year period between each Working Plan. Thus the Forests Department's activities are controlled by a long-term plan, which is publicly available, and periodically revised and approved by the Government. Its approaches and policies are further elaborated in well-produced publications like "Forest Focus".

Nevertheless the arrangements by which the concerns of other agencies, industry, community groups and individuals are taken into account in policy formation are to a large degree informal and *ad hoc*, the final responsibility remaining with the Conservator of Forests. This may well account for the degree of concern expressed by the public over such issues as conservation of flora in the jarrah and karri forest, the level of sustainable cut in native hardwoods, provision for public access for recreation, and the extent of replacement of native forest by pine plantations.

In view of the wide range of uses which the forest must provide, it would be appropriate for policy development to involve public and private interests to a greater degree through some formal arrangement.

The State Forest is the most important remaining opportunity for conservation in South Western Australia, and the MPAs for conservation of flora, fauna and landscape within it have been designated for this reason. They have been selected as the best available by Forests Department officers with an intimate knowledge of the forest types and their condition. Their tenure as State Forest is secure, equivalent to that of Class A reserves, but they are not secure against conflicting uses such as open cut mining or construction of reservoirs which destroy their conservation value.

A means by which the State may establish the security of purpose of conservation MPAs is urgently needed, after proper consideration of competing uses.

The conservation MPAs have been chosen for representation of the natural ecosystems on the basis of their soils, landforms and vegetation, which are readily observed. Data on fauna, particularly invertebrates, is sparse. The Western Australian Wildlife Authority does not regard study of the MPAs or State Forest in general as its responsibility, while in the past the Forests Department's traditional activity tended to be more concerned with the effects of forest operations, such as extraction of wood products and controlled burning, on the fauna, rather than with using ecological relationships as a basis for conservative management.

Studies of the fauna of native forest, and in particular of the conservation MPAs, primarily to ensure adequate management, are needed.

The cumulative effects of public and other utilities such as roads, railways, conveyor belts, pipelines and powerlines, and also dams and reservoirs, make serious and, to a degree, uncoordinated inroads into the forest resource. They destroy significant areas of forest and can spread dieback disease.

State Forest and other publicly owned land should not be seen as readily and cheaply available for public and other utilities, but as a valuable limited and unique resource.

Intensification of forest production, as well as such activities as open cut mining have the potential to interfere with ecological processes such as nutrient cycling which are essential for the maintenance of biological productivity of forest growing on mineral-deficient soils. Monitor-

ing programmes at present concentrate on effects on water quality, and so far the effects are minimal. The impact of extraction on the sustainability of forest production, and the adequacy of post-mining rehabilitation for other purposes should also be monitored, according to predetermined end uses.

Monitoring of the ecological effects, particularly on biological productivity, of potentially damaging developments in the forest is necessary.

Effectiveness of rehabilitation procedures in achieving defined objectives also needs monitoring and revision where necessary.

Forest on privately owned land

Throughout the south-west there are significant areas of native forest in private ownership, mostly on farms. They form a valuable resource for conservation, amenity, shelter for stock, protection of local water supplies and for wood products such as posts or fuel. They require management for their maintenance and regeneration.

Some research may be needed on forest management, including regeneration, at the farm scale. The results should be disseminated through an advisory service to landowners comparable to that provided by the Department of Agriculture for farming activities.

Mechanisms giving positive incentives not to clear all privately owned native forests should be encouraged as a matter of priority.

Agriculture

Agriculture is one of the State's most important forms of primary production, and earns a substantial share of Australia's export income. The expansion of farming areas culminating in the late 1960s was based on a system of ley farming with nitrogen inputs and soil stability against erosion provided by the subterranean clover-based pasture. The main environmental effect in addition to the widespread loss of native vegetation was salinisation. Shallow-rooting pasture plants in particular allow soil water to pass beyond the root zone, a major factor in the salinisation of soils and streams lower down in the system.

The situation has now changed, due to a combination of factors including market considerations which favour cropping rather than pasture-based production, greater use of nitrogenous fertilisers, advances in technology which permit weed control by chemical sprays instead of mechanical cultivation, and early planting and new crop varieties to give higher yields. Loss of good soils by salinisation has become less acceptable to farmers due to increases in land value and capability for production, and the community generally is finding deterioration in water resources due to salinisation or eutrophication less acceptable. The result is change in farming practices, which have the potential for both beneficial and adverse effects.

These are:

- an increased crop yield potential;
- intensification of cropping and higher levels of production which will increase soil water use, though perhaps not sufficiently to prevent or control salinisation;
- intensification of cropping, particularly on sandy soils and in dry years, may aggravate the problem of soil erosion unless carefully managed;
- the use of herbicides for weed control in crops will minimise the erosion risk but if inefficiently used may result in damage to individuals or the natural environment;
- poor sandy soils in higher rainfall areas are unable to retain applied phosphate, which is leached and causes eutrophication of water bodies into which they drain;
- acidity of soils and subsoils, inhibiting root development and production.

There is an urgent need to:

(a) develop agricultural systems which take advantage of new technology and new crop and pasture plants to minimise adverse effects on the environment, particularly living resources, while permitting increased levels of production;

(b) develop long-term strategies through effective planning of land use;

(c) develop new farming systems, including agroforestry;

(d) fund local governments for drainage and other works required for the general benefit;
(e) provide financial and other incentives to encourage changes in farm practices;
(f) promote local interest and initiatives through Soil Conservation Districts.

New land releases for agriculture

The release of Crown land for new farming developments has already proceeded into areas for which long-term rainfall records do not exist and for which there is only superficial assessment of the land resources. Failure of development schemes in such areas could lead to pressure for rescue operations at public expense. Even in districts where development has proceeded for some years, it appears that some land, unsuitable because of the wind erosion risk, has been cleared and, of course, salinisation of soils in certain identifiable situations is inevitable as clearing takes place.

The development of new farming areas ideally should only take place where all the factors which influence the development of sustainable, economically viable agricultural production are known to be satisfactory.

Consideration could be given to the possibility of preparing Environmental Review and Management Programmes for larger areas proposed for release, and making them available for public comment.

Mining and conservation

Ever since the turn of the century when the discovery of gold accelerated the pace of development, the State has seen the need to encourage mineral exploration and mining. The pioneering days are now past, and mining, with its demands on the land not only for extraction, but also for the disposal of wastes, has to accommodate increasingly to other uses and community aspirations.

It is important to distinguish between mineral exploration on the one hand, and mining on the other. Exploration may affect wide areas, and while it has the potential to damage the natural environment, ways and means of reducing this to tolerable levels can often be found. Mining itself on the other hand can have drastic and, at times, totally destructive effects on natural ecosystems, generally confined rather than extensive. However, the mining of some ores which are widely dispersed such as bauxite, can have effects on whole regions.

The Mining Act of 1978[3]provides that the consent of both Houses of Parliament is required before a mining lease may be granted in the South West Land Division or the Shires of Esperance or Ravensthorpe on any Class A reserve or national park. Throughout the State, the consent of both Houses of Parliament is required to change the purpose of Class A reserves, including those of national park or nature reserve, and this, if strictly interpreted, could result in the exclusion of activities incompatible with the declared purpose. In general, there is provision for the effect of any mining proposal on other land uses to be considered by the Warden's Court.

The very fact of protective measures for parks and reserves means that mining interests tend to oppose the creation of new ones. Some of the proposals already made (see page 77) regarding the establishment and classification of parks and reserves could help with this situation. Given a suitable classification of parks and reserves which reflected their conservation value, then the State could define conditions for each area, ranging from the situation where mining is not permitted to one where large-scale surface mining is allowed, provided it is followed by a suitable form of rehabilitation. A similar approach could be taken with mineral exploration. In the meantime, limited-term dedication of such new areas to conservation has possibilities, and would permit their protection while the information on mineral or other potential was sought. However, if it is not sought, then firm reservation may be delayed indefinitely, and there will be a risk of deterioration. Private enterprise may be reluctant to invest in the assessment of mineral potential if there is a strong possibility that mining may not be eventually permitted.

It would be desirable for the Department of Mines to examine the mineral potential of proposed new parks and reserves, giving priority to those of highest conservation value.

3. Western Australia, Parliament, Mining Act, 1978-1981 (and Regulations).

Once the mineral potential of a proposed reserve has been determined and the conservation value assessed, a value judgement can be made as to which should assume priority. A mechanism is required by which a decision can be reached in the interests of the community as a whole. This should take account not only of the value of the mineral resource, but also its scarcity and relative importance to the community, the ease with which it can be exploited without major degradation of conservation values, and the period over which mining would be likely to occur.

A suitable means should be established for judging the relative value of each mineral resource where its exploitation would conflict with the conservation value of a proposed reserve.

Fisheries

Each of the major fish populations within the commercial fishery of Western Australia is now experiencing heavy fishing pressure.

Until recent years fisheries managers operated on the general premise that the exploitation rate would not be high enough to reduce the parental stock to a point whereby recruitment in subsequent years would be affected. Consequently, management measures adopted have been directed towards rules which provide for industry to obtain optimum catches. Measures such as legal minimum size, time closures and area closures have been used to reduce mortality on juveniles, and protect nursery areas or spawning animals. However these by themselves cannot control the level of fishing intensity. Hence it has been necessary to limit the number of fishing units.

In some fisheries, especially those having a high product value relative to their cost (e.g. rock lobster and prawns), competition amongst fishermen has led to increasing investment in new technology, including such items as coloured echo sounders and satellite navigation. In several important fisheries the fishing power of each unit has reached a point where even with many fewer units operating, the high exploitation rate is endangering the breeding stock upon which future recruitment depends. With very limited alternative resources, few local options remain. In this situation the objective of sustainable utilisation as envisaged in the World Conservation Strategy (see Chapter 1) is threatened. Unless the rate of exploitation can be reduced (even at the cost of some increase in unemployment), there are real risks of collapse of stocks, resulting in even greater and continuing costs to the community.

The monitoring of the breeding stock and of recruitment in commercial fisheries should be accelerated. Where high exploitation threatens recruitment, action to reduce fishing pressure should not be delayed. The failure of a strategy of sustainable yield will be of even greater cost to the community.

Further attention also needs to be given to the effects of fishing on inshore fish stocks where there is competition between recreation, tourism, the fishing industry and developments causing pollution and eutrophication. Although inshore stocks may be of relatively low commercial yield, their indirect value to coastal centres in terms of tourism and recreation can be very significant.

Strategies are needed to protect those stocks which are exposed to increasing levels of exploitation from recreational fishing.

Conservation measures are required to protect vulnerable habitats in estuaries and coastal waters.

Protection of life support systems

Soil

Soil is a renewable resource, although renewal is very slow if it is left to nature, and costly if not. Without fertiliser, the soil's capacity to support production from living resources is limited by the ability of the mineral substrate to supply nutrients, which, in general, diminishes as the soil parent material ages. This is an important factor in Western Australia, with its poor soils. The natural ecosystems are adapted to these conditions so that they can accumulate and retain scarce nutrients within the biological system.

An understanding of the processes involved in maintenance of the biological productivity of natural ecosystems is essential, particularly for land uses like pastoralism and forestry (and water uses such as fisheries) which depend on sustained production from natural vegetation.

In addition to low levels of natural fertility, there are other problems. These are mainly associated with the great extent of sandy, coarse-textured soils which have a low moisture-holding capacity and are prone to wind erosion. Accessions of air-borne soluble salts give rise to problems of salinisation and structural deterioration when natural vegetation adapted to these conditions is cleared. Due in part to generally gentler slopes, water erosion is not as prevalent in the farming areas as elsewhere in Australia, but is a concern in the arid zone where even light and infrequent traffic leaves long-lasting surface damage which can become catastrophic under the occasional heavy rains.

The deeper sandy soils present the greatest problems in the farming areas. In some of them there is a serious risk of wind erosion, little capacity to retain applied nutrients, and acid subsoils and compacted layers which tend to inhibit root development and plant growth. Clearly, some soils have been cleared which are not capable of sustaining agricultural production under present systems.

Secondary salinisation of soils and streams is an inevitable consequence of clearing throughout almost all the farming areas. This will not change until new systems are developed capable of using more soil water and consequently creating a potential for increased production. Structural deterioration of the heavier soils, and the dense and impermeable nature of many subsoils also contribute to increased runoff and waterlogging.

Despite these difficulties it has to be said that, in general, the productive capacity of the soils of the farming areas has been raised. This has been achieved by fertilisation and the use of legume-based pastures. Sound farming practices involve the exploitation of the soil's enhanced productivity, necessarily fluctuating, above a lower limit determined by the level from which recovery is possible, technically and economically.

Effective soil conservation requires:

(a) adaptation of farming systems to environmental factors, particularly soil and climate;

(b) exclusion of unsuitable soils from clearing;

(c) land use planning which ensures that agricultural development does not extend into areas where erosion risk is high. This has implications for the release of new farmland.

In the pastoral areas the difficulties may be more economic than technical. Degradation has occurred in the form of severe gullying, sheet erosion, and scalding on susceptible soils, and on landscapes which are prone to erosive influences. Techniques for reclamation are available, but are costly and may be beyond the resources of some pastoralists.

There is a growing community realisation of the need to prevent soil erosion and salinisation, and to restore damaged soils in the pastoral, farming and coastal zones. Damage due to erosion or salinisation may affect not one but several properties, such that action on one is required to benefit others. The rating provision in the Soil and Land Conservation Act could be used to distribute costs fairly. At times a district project may provide general benefits, e.g. improvement to a water supply. In any event, we are dealing with a natural resource, the degradation of which may not have resulted from decisions of the present owners or occupiers. For these reasons there are good arguments for some external funding either at local, State or Federal government level.

The District Soil Conservation Committees provided for under the Soil and Land Conservation Act 1945-1982, must play an important role in:

(a) promoting the identification of district and regional problems and an awareness of them among land users;

(b) developing programmes for the solution of district problems. For this they must have professional and technical support and advice from the Soil Conservation Service and other agencies.

Projects should be capable of cost benefit analysis so that costs can be fairly distributed.

Schemes which have a community significance beyond the benefits to the individual landholder should qualify for external funding from local, State or Federal government sources.

Water

While water is not a living resource, it is a renewable one, and an essential part of the earth's life support systems. Any degradation affects the potential for both conservation and development. Further, movement of water and solutes in the landscape means that changes to the system may have effects far removed from the original site of impact.

Protection and management of water resources requires controls on other land uses with a potential to cause pollution and adverse hydrologic change.

Maintenance and protection of water resources in general is highly compatible with reservation and environmental protection. But development of water supplies can, in some cases, have undesirable effects such as major diversions from river systems, lowering of groundwater levels, inundation of valleys suitable for reservoirs — a scarce recreation and conservation resource in south Western Australia — and establishment of large new water bodies may have serious ecological consequences. In tropical areas there may be effects on the transmission of disease. Further, generous supplies at low cost increase use, and hence increase volumes of effluent for disposal, whether from domestic, industrial or irrigation sources.

There is a need for comprehensive planning of water supply development which takes proper account of environmental effects of supply and distribution of water, and of the disposal of waste effluents.

There is an increasing awareness of this as the State moves from a pioneering phase of development in which it seems possible to tolerate some adverse effects, to one where multiple use of the land and water resources requires integrated planning for their protection and optimum use.

Degradation of water resources in Western Australia — terrestrial, coastal and marine — has already taken place as a consequence of salinisation, eutrophication and industrial pollution.

Non-point sources of water pollution such as salinisation and eutrophication due to clearing or fertiliser use on unsuitable soils are most likely to be brought under control through a combination of land use planning which locates uses on suitable sites, and modification of harmful practices. However, beyond the Metropolitan Region there is no statutory regional planning machinery to enable the siting of industrial and other developments according to land capability and suitability.

Single point source pollution arising from industrial, sewage, drainage and other effluents may be minimised in its effect by suitable location, again a matter for planning. But is also requires the setting of standards to which effluents must conform, and an effective machinery for monitoring, inspection and penalties to ensure conformity.

For terrestrial waters in Western Australia there are two main authorities, the Public Works Department and the Metropolitan Water Authority, responsible for pollution control. They do so under the provisions of the Metropolitan Water Supply, Sewerage and Drainage Act[4] and the Rights in Water and Irrigation Act[5]. By Statute they are responsible for development of supplies, maintenance of water quality, distribution and allocation, and also for sewage disposal. Their formal responsibilities are thus more concerned with protection of existing and potential water supply areas than protection of the water resources as a whole. As a result, other beneficial uses such as recreation or effects on the natural environment have in the past tended to receive insufficient attention. With their responsibility for sewage disposal, the authorities are both potential polluters as well as responsible for control. In any case the legislation under the Rights in Water and Irrigation Act does not bind the Crown, so that government agencies are exempt.

A merger of these two authorities is to take place by June 1985 and a consideration in this integration will be a broadended charter for the new authority which gives more direct responsibility for addressing comprehensive objectives of terrestrial water resources management.

4. Western Australia, Parliament, Metropolitan Water Supply Sewerage and Drainage Act, 1909-1982.
5. Western Australia, Parliament, Rights in Water and Irrigation Act, 1914-1981.

For coastal and marine waters, responsibilities are distributed among several agencies, including the Waterways Commission, the management authorities set up under it, and the Fremantle and other port authorities. While these bodies may have the necessary powers for regulation, they lack the technical expertise to use them effectively. Moreover, discharges to many coastal waters are not subject to any control at all.

An urgent requirement in Western Australia is to achieve greater co-ordination of the control of effluents, the setting of water quality guidelines or standards and the provision of appropriate technical and management expertise, similar to that in most other states.

The resolution of this problem is now inevitably linked in part with the structure and charter being developed for the merged State Water Authority. Alternative approaches to standard setting and control need to be discussed between the Department of Conservation and Environment and the State water authorities, with the aim of achieving an early solution. For terrestrial water there are arguments for integrating quantity and quality management. Further action must address better co-ordination of estuarine and marine water quality control. There are also arguments for integrating water quality control in surface and ground waters on land, with estuarine and marine waters, as discharges to the former soon affect the latter.

Despite the current deficiencies in legislation and administrative arrangements, the water authorities in practice are moving in a responsible manner through their forward planning, to take account of the broader issues of environmental protection and provision for other beneficial uses of the water resource in addition to supply. They do so in concert with other agencies, taking account of interactions with other land uses. The Western Australian Water Resources Council, established in 1977 and a statutory body since early 1983, responsible for advice to the Government on matters concerning water policies, has exhibited the potential to play a large part in this process, bringing together the responsible government agencies and certain community interests. It has taken an initiative in proposing the development of clearing control legislation in water catchments to deal with salinisation, and is studying the problems of recreational use of catchments, reservoirs and streams. Other matters, such as the salinisation of inland drainage systems and wetlands or the eutrophication of estuaries and coastal embayments are at the boundary of the terms of reference and beyond the range of interests represented on the Council and therefore pose particular problems of co-ordination which need further consideration.

There is a need to develop a comprehensive approach to policy making concerned with all beneficial water uses including recreation, and the conservation of the resource. This question will need further examination in merging the water authorities but it is apparent that a body such as the present Western Australian Water Resources Council could take a leading role.

If a Water Resources Council is to be effective in the areas of conservation and recreation its membership and terms of reference should ensure a proper balance between these interests as well as those of supply and development.

Air

Air quality in Western Australia is on the whole excellent due to the natural advantages of isolation, weather patterns, and the low level and localised nature of industrial development.

The main problems are smoke from fires and burning off, dust from stock-holding paddocks and tailings dumps, and localised pollution from burning fossil fuels and smelter operations. These effects tend to be of short duration. Photochemical smog due to the action of sunlight on vehicle exhaust emissions occurs occasionally in Perth, but the atmospheric temperature inversions do not persist long enough for the problem to become severe.

Control of emissions is through the Clean Air Act[6] administered by the Public Health Department. The legislation is aimed primarily at industrial sources of pollution and is designed to protect human health rather than to maintain overall environmental quality. However, natural vegetation tends to be adversely affected by pollution levels far below those which threaten human health. Recognising this, the Department of Conservation and Environment has promoted studies of air quality, and the factors affecting it. The development of models to predict

6. Western Australia. Parliament. Clean Air Act. 1964-1981.

levels of air pollution from existing or proposed sources has been a major advance in recent years. This information is invaluable in planning the siting of industry and residential and other developments so as to avoid undesirable impacts.

It is understood that the Government has under review all arrangements for pollution control in the State and that some rationalisation may result. The existing legislation on air pollution control is now somewhat dated in its approach compared with that introduced more recently in some other States. In these States, air pollution research, monitoring and management are undertaken by organisations concerned with environmental protection as a whole rather than the single aspect of human health. The latter is rarely threatened by air pollution levels reached in Australia.

Air quality management would be considerably improved if government efforts were concentrated in one responsible authority with wider terms of reference than are available at present under the Clean Air Act.

Planning for conservation and development

Introduction

The World Conservation Strategy proposes the integration of conservation and development through environmental planning and rational use allocation. It involves the evaluation of the living resources, assessment of the effects of development on them and, based on the evaluation and assessment, a procedure for allocating the resources to the range of uses required.

The concept is not new. It is an essential component of land use planning. What is new is the emphasis on sustainable production. In Western Australia, the need for this in the long term is increasingly recognised as the State develops, as shown by a number of recent reports concerned with the allocation of the land resources to conservation of flora and fauna as one among several competing uses.

Among them the reports of the CTRC were important pioneering studies which identified areas suitable and available for new parks and reserves throughout the State, and many of their recommendations were supported by the EPA, and accepted by the Government. Implementation has been in progress since 1976. The hinterland of Perth, known as System 6, has been the subject of a more intensive study which attempted to reconcile requirements for an adequate system of parks and reserves with the numerous demands on the land for other uses. Nevertheless, all these studies were limited in that they had a single objective, namely, the allocation of land to parks and reserves, with only incidental consideration of alternative uses. They have, however, clearly demonstrated an important point basic to a conservation strategy.

To be effective, planning for conservation of nature needs to be integrated with planning for other uses.

Land use planning

Formal land use planning is limited in Western Australia. Local authorities are, of course, active throughout the whole of the State, but their activities tend to be concerned with their own districts rather than with the broader-scale regional planning called for if conservation and development are to be integrated in an overall State Strategy. Planning activity at the regional level is, naturally, most advanced where the need is greatest. Thus, the Metropolitan Region Planning Authority (MRPA) co-ordinates the allocation of land to use in the Perth Metropolitan Region through statutory planning schemes.

One of the ways in which conservation of nature and public recreation and amenity are provided for by the MRPA is the designation of regional open space. In addition, some local authorities, in the more intensively used areas of the south-west, have collaborated in the production of non-statutory regional plans. Within State Forest, the Forests Department has defined zones for each of which a combination of uses including conservation is given in priority order. The water supply authorities have requirements for controls on land use provided for under a number of Acts, the most recent being concerned with clearing controls in water supply catchments, only two of which, those of the Helena and Collie Rivers, are harnessed at present.

Beyond the Metropolitan Region, major developments are essentially planned by their proponent, whether they are government agencies or private developers. The Department of

Resources Development co-ordinates and promotes the process for industry, guiding private developers in their negotiations with government agencies.

Formal regional planning with some standing in a legal or statutory sense, which takes some account of the interactions between all potential and community needs should not be confined to the Metropolitan Region and the State Forest, and is urgently needed in the rapidly developing regions of South Western Australia and in the Pilbara.

The Environmental Review and Management Programme process required for major developments under the Environmental Protection Act[7] enables a consideration of impacts on other uses competing for the land resources as well as direct environmental effects. Only at this stage is there generally provision for public information and comment, and by then the proponent, with official encouragement, may have made a substantial commitment to the development, including its location.

An important purpose of planning is to give an indication of future developments which are permissible or likely, as indicated by land capability and predicted impacts, so that corporate planners and private individuals have some framework within which to conduct their affairs, and the general community interest in environmental and other matters is protected.

The development of public procedures for regional planning throughout the State, more especially where use and development is intensifying, is an urgent necessity.

Improvement of planning mechanisms

The necessity for improved planning mechanisms is already recognised. For some years, the development of a policy for management of coastal areas has been a concern of both the Environmental Protection Authority and Conservation and Environment Council;[8] and land use in the Darling Range has been the subject of a special study commissioned by the Government in 1979.[9] Both studies have produced recommendations for their specific areas, some of which have application to land use planning in general.

The following guidelines for integration of conservation and development in a land use planning framework are derived mainly from these studies.

Land use policies are required to establish the general principles on which planning is based, taking into account the following considerations:

(a) the capability of the land to support a range of uses;

(b) restoration of capability after destructive uses;

(c) alternative sites for particular uses;

(d) equity, that is, the claim of all elements in the community to a share of the resource use;

(e) community views in the determining of priorities.

To maintain environmental quality, resolve conflicts between users, and to achieve maximum economic and social benefits, the following are required:

(a) an inventory of land and aquatic resources and existing uses as a basis for planning;

(b) co-ordination of planning and management;

(c) provision for parks and reserves; terrestrial, aquatic and marine; and

(d) identification of an agency responsible for setting standards for, and implementation of, pollution control.

Closing comments

To a large extent, much of our present day-to-day contribution to conservation for sustainable development is reactive, that is, responding to development proposals with the aim of guiding these along avenues which minimise environmental impact. This is somewhat akin to the actions of the back seat driver. In the long term, there is a need to become more involved in

7. Western Australia, Parliament, Environmental Protection Act, 1971-1980.
8. Coastal Planning Steering Committee (1981). Coastal Planning and Management in Western Australia. A Report to the Conservation and Environment Council.
9. Darling Range Study Group (1982). Land Use in the Darling Range, Western Australia. A Report to the Premier of Western Australia.

the planning of development, in selecting forms of development which are more likely to be sustainable, and in considering whether we should continue to aim for ever increasing material standards of living or should give more emphasis to more enjoyable life styles.

The elements of a conservation strategy outlined above represent a synthesis of viewpoints at one instant in time rather than a rigid format to be regarded as a fixed course. As stressed in the opening chapter, the process of formulating and applying a conservation strategy should be seen as a long-term and continuing process, developing and strengthening the already established trend towards making environmental considerations an integral part of every decision involving the use of, or affecting, the living resources of Western Australia.

The Symbol

The circle symbolizes the biosphere—the thin covering of the planet that contains and sustains life. The three interlocking, overlapping arrows symbolize the three objectives of conservation:

- maintenance of essential ecological processes and life-support systems;
- preservation of genetic diversity;
- sustainable utilization of species and ecosystems.