USE WITH CARE

MANAGING AUSTRALIA'S NATURAL RESOURCES IN THE 21ST CENTURY

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There is no end to the writing of books.

Ecclesiastes

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ABBREVIATIONS

ABS Australian Bureau of Statistics

ACF Australian Conservation Foundation

AEAM Adaptive Environmental Assessment and Management

AFZ Australian Fishing Zone

AGPS Australian Government Publishing Service

AIDA Analysis of Inter-connected Decision Areas

ARIS Australian Resources Information System

AUSLIG Australian Surveying and Land Information Group

BTKM billion tonne km

CSIRO Commonwealth Scientific and Industrial Research Organisation

EIA Environmental impact assessment

EIS Environmental impact statement

ENSO El Nino-Southern Oscillation (perturbation)

GATT General Agreement on Tariffs and Trade

GDP Gross Domestic Product

ICOMOS International Council on Monuments and Sites

LGA Local Government Area

M-DB Murray-Darling Basin

MFP Multi-Function Polis

NFF National Farmers' Federation

NSW New South Wales

OECD Organisation for Economic Co-operation and Development

SA South Australia

UNESCO United Nations Educational, Scientific and Cultural Organisation

WA Western Australia

PREFACE

All my working life, I have been paid well to enjoy myself studying the natural resources of Australia. My first jobs were as an agricultural advisory officer and then as a commercial agricultural consultant in western Victoria. After some years overseas, I returned to the CSIRO Division of Land Research at the time when they were just winding down their massive program for mapping the natural resources of sparsely settled Australia. It was my job to evaluate the economic prospects for commercial cropping revealed by the Division's research programs in the Kimberleys and the Northern Territory. From that blooding I developed a lasting interest in land use policy and land use planning which has since led me to places as far apart as the Great Barrier Reef Marine Park and north-west Tasmania.
My attitudes to land and its use have changed since I went forth thirty years ago to carry the good news about potash to a breathlessly expectant farming community. Certainly I loved being in the bushland of the Otway Ranges but I never blinked as thousands of acres of native forest fell to the chains and dozers to create the Heytesbury closer settlement scheme. I was more concerned about how to make clover grow in that newly naked landscape.

I still appreciate well-managed farmland today but my heart bleeds a drop when I see a more or less natural area being drained or felled or burnt or levelled to let two blades of grass grow where none grew before. `Surely true wealth lies in being able to let it be, in not being forced to use resources intensively?' I now ask. Like all our natural systems, areas which remain undeveloped are still going to have to change and adapt to powerful new forces even if no one touches them. At very least, they will have to adapt to alien plants and invading animals brought here by Europeans. They may have to adapt to major climatic changes.

Nowadays I work in the CSIRO Division of Wildlife and Ecology. It is an environment where one is constantly aware of resource utilisation battles between ecological conservatives and economic conservatives. The Division itself tries to stay neutral and provide disinterested information which, at least, will allow extreme positions on either side to be challenged. I too am neutral; not because I do not care, but because I can appreciate the values promoted by both the greenies and the brownies. My colour is olive.

Central to this book is my belief that it is still possible to have an Australia where the values of all but the most extreme materialists and extreme environmentalists can be satisfied. Acts of desperation are not yet necessary. This is not to say that I am optimistic that this scenario can be or is likely to be achieved. A scenario is a description of a plausible future; if I think that the idea of Australia as a good place to live can survive well into the next century, it is up to me to argue how this might believably come about. It will be inch by inch, step by step, not in one miraculous leap. I will still be sad for things that we have unnecessarily lost---great Huon pines and Karris, Tasmanian tigers, Sherbrooke lyrebirds, Aboriginal languages, Barmah forest (almost), Lake Pedder, coastline access ...

I have chosen to direct this book at the next hundred years because that is intellectually liberating. If we look ten or twenty years ahead, common sense screams out that significant changes in values are not possible, that the States and the Commonwealth will still be smiting away at each other in territorial battles and that the juggernaut of short-sighted market-driven change will be rolling on regardless. All things are possible in a hundred years though, aren't they? No one can pretend to see that far ahead and one can be certain that any medium-to-long-term scenario will be massively wrong. It does not matter; I am really trying to look at problems and possibilities which will spring fairly directly from today's Australia over the next several decades but without the shades of common sense to restrict my vision.

What I have to offer in the `struggle for perspective' is some accumulated technical knowledge, a little controlled passion and a handful of variously acquired insights on some of the reigning issues in the resource use-resource management debate. It is not much. But I once asked Professor Geoff Leeper, doyen and scourge of several generations of Melbourne University agricultural science students, what I could do to change the world. `The best you can do is tell people how you see things' he said.

A comment on language

Encountering words like **proactive** which are somewhat new and not found in basic English frequently rouses otherwise intelligent and sensible people to a fury. English has a large and dynamic vocabulary for succinctly and accurately expressing an evolving multitude of ideas. I ask the reader to accept that every word I use has been chosen because I think it is the best word. I have tried to use a minimal number of specialist scientific terms but, apart from that, if a word is unfamiliar, it does not mean that I am being pretentious, it means that you should look it up.

I have mostly avoided using Latin names for plant and animal species in favour of standard common names, not that these are all that standard. My attempt to avoid the repeated use of `his or her' is `hir'.

Acknowledgements

Jenny Clark is an expert in the natural resource-environmental literature and she has not only found the books and references I wanted, but suggested others which turned out to be extremely useful. I am grateful to Brian Walker, Chief of the Division of Wildlife and Ecology, for his willing acceptance of the idea that I devote time to completing this book. Ninon Geier has imposed a neat uniform style on a diverse suite of maps, some of which were originally computed by Nina Wood. Julia Tanguy and Venetia Nelson from New South Wales University Press have managed to be both warmly supportive and coolly professional during all the rites of passage a manuscript must undergo. Several colleagues have given time to read and comment on portions of the manuscript: John Patrick `Bottom line' Makeham who tried hard to rein in my appetency for polysyllabic prosification; Mike Young, who reminded me to think like an economist---when absolutely necessary. Finally, I want to thank Doug Cocks for doing all the typing.

Canberra

October 1990

1. LEARNING THE HARD WAY

Australia is the flattest, harshest, ugliest land in the world.

Eric Willmott
Boyer Lectures,
1986

Natural factors affecting land use

Australia's outstanding natural attributes

Apart from size (the sixth largest country in the world) and location (isolated in the southern oceans), Australia's outstanding natural attributes are a dry climate and a geologically ancient land surface. Taken together, these factors have produced a resource complement which, by global standards, is noteworthy in at least the following ways

* a climate characterised by low variable rainfall, strong climatic gradients between coast and inland, droughts and floods

* generally unproductive soils---infertile, shallow, stony and salt-prone

* limited occurrences of perennial surface water and snowfields

* a long diverse coastline

* a featureless landscape with little mountainous terrain

* a rich and unique complement of native plants and animals

* limited areas of (a) natural grassland and (b) relatively unproductive forests.
Some of the land use implications of this situation have been

* intensive settlement has only been possible over a modest fraction of the country

* large forestry activities have not been possible

* intensive agriculture has only been possible in the wetter fringes of the country

* methods of adapting European agricultural systems to the Australian environment have had to be developed *de novo*

* the coastline and inland waters have become the foci for recreation activities

* ground transport systems have been slow to develop over the country's long distances and have been of poor quality

* production of minerals for export has been and continues to be an important economic activity

Some spectacular historical misjudgments

Because European settlers had to learn to understand the Australian environment from scratch, it is

inevitable that they should have made misjudgments about the consequences of various land management practices. Among the more spectacular of these have been misjudgments about

* long-term livestock-carrying capacity and crop yields in inland areas

* the impact of introducing feral animals (particularly rabbits and foxes) on pasture and range productivity

* the effects of introducing exotic plants destined to become weeds, e.g prickly pear

* the unforeseen consequences of excessive clearing of timber, e.g. salinisation, erosion, woody regrowth

* the effects of uncontrolled irrigation, e.g. salinisation of soil and water

* the susceptibility of bare soil to water and wind erosion

* the risks and consequences of floods and fires.

Such technical misjudgments have been an important factor in explaining Australia's changing land use patterns since white settlement. While many individuals have paid dearly for their own misjudgments, the social costs of individual mistakes have dwarfed the private costs in many cases; salinisation of the Murray Basin is a national disaster as well as a disaster for farmers forced off their land.

Social and institutional factors affecting land use

Rigid social attitudes to land

In addition to `technical misjudgments' about land affecting the land-use pattern, there are a number of hard-line social attitudes towards land and its use which have also played a part. Old established examples include

* landowners have the right to use their land as they wish

* a productive (i.e. commodity-producing) land use is always better than a non-productive or consumptive use

* Australia has more than enough land for all purposes

* all land is much the same, apart from its location

* left alone, degraded land rehabilitates itself

* when resources run out, you move on.

More recent attitudes which can be widely detected include

* any extension of the area devoted to productive uses is wrong

* land development of any type, industrial or primary, should be regulated to the point where the side effects on third parties are undetectable.

Costs and prices

Turning from attitudes and perceptions to more direct economic considerations, Australian land use, especially primary production, has always been in the throes of adjusting to one or other fluctuation in export prices. Wool, meat, dairy products, and minerals all offer good examples. For example, a weighted price index over all main export commodities rose over 70% between mid-1986 and 1989; eventually it will fall

Public or Crown land, which comprises some 90% of the country, is largely managed in disjoint tracts by various special-purpose State resource agencies such as those with responsibility for forestry, national parks, vacant Crown land, the coastal zone and catchment areas.

In Victoria the allocation of public land between agencies is handled by the Land Conservation Council, but the other States lack comparable bodies, and allocation by interdepartmental committees is the norm.

In all States, there is an increasing requirement for public land to be managed according to the dictates of formally prepared management plans. The content of these is variable but they usually identify zones to be used for different purposes, development works to be undertaken and the policies which will guide management decisions.

The other main institutional device affecting both public and private land is the use of environmental impact assessment procedures. Under both Federal and State legislation, designated major development proposals may be required to demonstrate acceptable predicted impact on the bio-physical and, increasingly, the socioeconomic environment before being approved.

Land-use problems and prospects

In the foreword to the 1939 edition of their classic text *Land utilisation in Australia*, Wadham and Wood say that land utilisation is usefully viewed as a matter of balance between uses, a balance which can be tipped one way or another by technological advances, prices, attitudes, etc.[1]
Fifty years later this is still a perceptive way to view land-use change, but a qualification is required, namely that with every year there are greater pressures to tip the land-use pattern in ever more directions even while the remaining possibilities for such changes are diminishing. Briefly, there is an increasing scarcity of land for most main categories of land use in Australia, and the causes and effects of this scarcity are at the heart of our land-use problems.

Confluence of increasing demand and falling supply

As one expression of Australia's growing national wealth, there have been increasing marketplace demands for land for both established uses and new uses (such as hobby farms). Simultaneously, there have been increasing political or non-market demands for land to be made available for consumptive uses such as recreation and conservation (Map 1.1).

Map 1.1 Competing land uses

Adapted from Australian Surveying and Land Information Group, 1989. In most parts of Australia, new land uses have to displace or coexist with existing land uses.

Demand is one side of the scarcity equation; supply is the other. At any time there is a maximum area of reasonably suitable land which could be made available for any particular land use, i.e. made available through purchase or statutory dedication. This maximum can be increased or decreased by changes in factors such as

* transport costs

* available technology

* input and output prices

* the area of land either too developed for the use (e.g., cleared areas can no longer be used for forestry) or degraded to the point where it is no longer suitable for the use

* the area subject to performance standards or zoning restrictions on that use

Community perceptions of major land-use issues

The above `scarcity' diagnosis of Australia's land-use problems emerged from an analysis of the results of a CSIRO survey in 1979 of people's perceptions of major land-use issues.[2] About 350 people in government, business, interest groups and academia nominated what they thought would be the major land-use issues of the 1980s and 1990s.
The 2000 or so nominated issues fell into one and sometimes both of two categories. The first category could be labelled **Issues concerning the location and management of such major land uses as urbanisation, agriculture, mining, recreation, forestry, parks and physical infrastructure.** The second could be labelled **Issues concerning the management and use to be made of critical regions and resources such as coastal lands, arid lands, alpine areas, water-resource areas, forests, minerals and soils.**

The most widely shared perception among respondents was that the main metropolitan fringe areas (within a half-day's drive, say) would be the setting for conflict, competition and controversy in the 1980s and 1990s. Rising demands for accessible sites for diverse uses would be bumping against a fixed supply of land in the metropolitan environs.

One much-noted aspect was the displacement of agriculture by urban subdivisions, thus reducing the food-producing potential of the metropolitan fringe. Other contending peri-urban uses are active recreation, base minerals extraction, water catchments, hobby farms and landscape appreciation.

Agriculture came second to urbanisation as an issue generator and generally appeared as a land use under threat from subdivision and hobby farms as noted but also from uncertain markets, costs, erosion, salinity and mining. On the other hand, respondents were concerned at intensive practices used in agriculture, particularly the use of fertilisers and chemicals and factory farming. Expansion in the production of fuel crops was seen as a potential opportunity although this raised the issue of where they were to be grown.

In contrast to agriculture, mining (notably of uranium, bauxite, coal and beach sands) emerged as a strongly competitive land use with significant impacts on Aboriginal lands, farmlands, recreation and conservation areas, scenic landscapes, water catchments, forests and fisheries. The other side of the mining issue appeared as a concern for the `sterilisation' of valuable deposits in national parks, heritage areas, catchments and built-up areas.

Dipping now into the second category of issues, concern was most commonly expressed for the future of strongly demanded resources in relatively short supply. Coasts and native forests are good examples, both being extensively quoted.

Australia is a relatively unforested continent and clearing for grazing, mining and settlement and clear-felling (woodchipping) were seen as contentious activities, as was reafforestation with exotic species. Respondents saw the heart of the forests issue in the reconciliation of increasing demands for access to the forest resource---recreation, national parks, water supply and timber.

Australia has 30 000 km of coastline, but most of this is not where the people are. Residential and recreation demands are high along much of the Gladstone--Adelaide rim but spotty elsewhere. The essence of the coastal issue is seen as the impact of these demands on a resource which is essentially fragile in its scenery, landforms, waterbodies and vegetation.

Finally, straddling both the land-use and the key-resource categories, there was a set of nominations which we can conveniently tag as **Maintenance of environmental quality and conservation of the resource base**. Attention here was directed towards how land-using activities are to be carried out (in contrast to what and where) and the implications for air and water quality, flora and fauna, soil resources, water supplies and mineral and energy resources.

Processes frequently mentioned included erosion, mining, desertification, waste disposal, pollution and dereliction of unused lands. Practices associated with these processes included grazing in the arid zone, irrigation methods, crop rotations, recreation in off-road vehicles and open-cast/strip mining.

Many respondents, rather than identifying land-use and environmental issues directly, noted the changes in social, economic, international, technological and demographic processes which they foresaw as having land-use and environmental implications. Changing social values and perceptions of Australia considered to be especially significant were environmental awareness levels and acceptance of the search for alternative lifestyles.

The opportunity to explore alternative lifestyles was seen as flowing from a changing economy, which included higher unemployment, increasing affluence and shorter working hours. The changing structure of the Australian economy was the other economic agent identified, notably shifts from labour- to capital-intensive industries (especially mining) and from primary to secondary to tertiary industry.

Rising energy costs were seen to be significant through their impacts on, mainly, the siting of rural settlement and impacts on transport systems and land-use patterns within cities.

Internationally, our position as a sparsely populated, food-exporting, mineral- and energy-rich country was seen as having considerable implications, notably in overseas demands for access to our resources and a say in how they are to be used.

Technological change was seen as having special implications for certain activities,

using interests and values find themselves confronted by new, vocal and (often) financially strong demands for a share of the resources cake or a say in sweeping up the crumbs.

Alternatively, it is the amenity levels of established interests which are threatened by the intrusions of newcomers. Perhaps issues cannot be seen in tight geographic terms but what we can say is that issues are more likely to arise where population pressures are high, where scarce, accessible, versatile, fragile or particularly attractive resources are involved and around industries experiencing changing economic fortunes.

So much for diagnosis and prognosis. What about treatment? Survey respondents suggested a range of opportunities, strategies, approaches and prerequisites for community preparedness for coping with tomorrow's land-use problems. Reduced to their bare bones, these suggestions amounted to three injunctions on the Australian community:

1. to learn more about the extent and nature of our natural resources and the techniques by which they might be used and conserved

2. to develop appropriate attitudes (ethics, Values and policies) towards resources and their use

3. to develop appropriate controls, both allocation and management, over resources and their use.

National resource-management goals

My own way of starting to make sense of this plethora of issues has been to develop a statement of **goals for a national land-use, natural environment and natural resources policy**. These goals, **(natural) resource-management goals** for short, are general perceptions of what needs to be achieved if issues of most concern to the community are to be transformed or deflected from becoming crises. One never has time to consider all possible issues of course. **It is both natural and efficient to concentrate on identifying what needs to be achieved in relation to those issues considered to be highly divisive or having major repercussions for good or ill, depending on how they are approached.**
Goals also must `belong to someone', and I am bestowing these goals on government, because it is governments, I believe, which have the chief role to play in resolving resource-management issues, notably in establishing a level playing field for the struggle between the Market Interests team and the Public Interests team (and perhaps buying guernseys for the latter).

Government funds and resources will be used in appropriate amounts in programs to support the achieving of

Five conservation goals
1. maintenance of the productive capability of the nation's soil resources;

2. maintenance of the supply and quality of the nation's :air and water resources;

3. maintenance of the diversity and distribution of the nation's plant and animal resources;

4. preservation of historic and prehistoric sites of national cultural significance;

5. creation of a high-quality system of national parks and other conservation reserves;

Three primary production goals
6. continued availability of the nation's prime mineral, forestry, farmland and fishing resources for primary production;

7. implementation of socially beneficial natural resource developments;

Even a white racist is unlikely to reject the goal of satisfying legitimate demands for land from Aborigines---it all depends what you mean by legitimate will be hir response; and that is a correct response. It is short-sighted to dismiss goals as `motherhood' statements. Agreeing on goals at least gets the debate into the right coliseum---without backing any particular gladiator.
Goals are themselves means to meta-goals or broader goals. The meta-goal common to all of the above is to implement the right of every Australian to a place where s/he can live a long, healthy life, where daily life is a pleasant and satisfying experience.

Maintaining options and increasing richness of choice are fundamental to such goal-seeking. The nominated 15 goals identify aspects of resource management in Australia where a variety of people feel that important options are under threat or where choices could be significantly and effectively expanded. Achieving conservation goals, for example, is a step towards the goal of preserving options such as walking through a tropical rainforest today or borrowing useful genes from some desert marsupial tomorrow. Primary production goals are guidelines for creating wealth which in turn creates options for personal and community development. Community-management goals reflect both the satisfying of direct personal needs and the establishment of low-cost operating environments for resource-based enterprises.

We could continue pushing goals back further and further in the hope of finding the meaning of life! But, at some stage, goals have to be accepted as irreducible primitives whose values it is unrewarding to tease out further. Goals have done their job when they have stimulated ideas for reaching them.

Not quite. Besides being a crucible within which to develop strategic proactive plans, a set of goals has immediate practical value as a check list against which to react comprehensively to resource development and management proposals. When projects like a spaceport or a very fast train are proposed, they can and should be promptly tested to see how they will promote or frustrate each of those 15 goals. Goals not only remind us where we are going but also warn if we are taking a wrong turning.

We turn now to the first of the injunctions coming from that 1979 issues survey: the demand to get the facts, to increase our knowledge of Australia's resources and environments. Chapter 2 reviews what we know about the resources we have.

2. TAKING STOCK: THE NATURAL ASSETS OF A SMALL CONTINENT

The simplest definition of **resources** is that they are **assets**, `things you would rather have more of than less of'. One very fundamental attribute of natural (Nature-given) resources (soils, plants, animals, climates, landscapes, ecosystems etc.---there are hundreds of categories) is that they either cannot be moved (e.g. Sydney Harbour) or cannot be moved without losing their natural character (e.g. logged trees). *Where* natural resources occur is extremely important because this influences how they evolve, how they get used, whether they get conserved etc. So before selectively describing the country's natural assets we need a `mud map' of folk regions for giving them a general, widely known location, preferably something finer than the eight States and Territories but not as detailed as Local Government Areas (LGAs) of which there are 8--900.

Map 2.1 is adapted from Nancy and Andrew Learmonth's *Regional landscapes of Australia* and will do nicely. Every Australian child would benefit for life from being taught to draw such a picture. In practice, everyone eventually develops their own `mental map' of folk regions. All will differ somewhat and most will have fuzzy overlapping boundaries between regions.

Map 2.1 Folk regions of Australia

Adapted from Learmonth and Learmonth, 1971.

Another basic property of natural resources is whether they are irreplaceable (non-renewable) stocks or self-replacing (renewable) flows. Soils, mineral deposits and natural landscapes are effectively irreplaceable once they are used up. Surface water, native plants and animals and the assimilative capacities of the atmosphere and the oceans are commonly regarded as available for continuing use provided the rate at which they are used does not exceed `threshold level'. Above threshold level, processes are set in train which markedly change the nature of the flow being delivered, e.g. the size of the fish being caught gets smaller each year.

Do we know what we have?

The question of what natural resources we have can only be answered in relation to some purpose. Land suitable for growing opium poppies is a resource if you are trying to corner the world heroin trade, otherwise not. Our less dramatic purpose is to consider Australia's prospects for reaching 15 national resource-management goals and so our attention must be on the resources singled out in the wording of those goals.

A tranquil tectonic plate

Australia began to drift away from the ancient southern continent of Gondwanaland about 125 million years ago.[3] The Australian continent is essentially a tectonically tranquil broad platform with a long low `mountain range' along the eastern margin. It is both the lowest (average height of 330 m) and flattest of the continents; to travel hundreds of kilometres without significant change in landform is common (Map 2.2).

Map 2.2 A minimally drained continent

Adapted from Mabbutt, J.A., and Sullivan, M.E. (1970). Less than a third of the continent drains directly to the sea.

Because there has been little uplift of the land surface to rejuvenate streams so that they actively erode the landscape (streams run faster in steeper country), ancient terrains from Tertiary times (between one and 70 million years ago) remain, though deeply leached of the soluble minerals needed for plant growth. Earthquakes are few (less than 1000 detectable seismic events a year), probably because Australia (unlike New Zealand and Papua New Guinea) is sitting safely in the middle of the Indo-Australian plate as it grinds north towards Asia and the Pacific plate (Map 2.3).[4] Australia has been fortunate to have competent geomorphologists like Joe Jennings, Jack Mabbutt, Ernst Loëffler and Brian Ruxton to trace, map and explain the surface shape of Australia in broad terms (Map 2.4) but we still lack detailed knowledge of land height above sea level at the scales we need---every 100 m or so across the country.[5] The Federal Government's Land Information Group, AUSLIG, is working on producing a digital elevation model, as it is called, which will eventually make such information available via

computer terminal. Such information is necessary, for example, for predicting frost incidence in areas where there are no meteorological stations.

Map 2.3 The Australian plate

Adapted from *Plate tectonics* in Bureau of Mineral Resources, Geology and Geophysics, 1979. Exercise: locate New Zealand and Papua New Guinea.

Map 2.4 Physiographic provinces of Australia

Adapted from Jennings and Mabbutt, 1977. In their original map they divide the 23 provinces shown into 227 regions.

A thin skin of soils

Sitting on the physiographic surface of the continent is a thin skin of soils, the most basic of all natural resources. They have been formed from bedrock by a variety of wind, water and `deep weathering' processes well summarised by Cliff Ollier.[6]
While there are no classes of soils unique to Australia, certain soil types do occur much more commonly here than in northern hemisphere continents. This results from the long period of geological stability of the Australian continent, the small extent of recent glacial activity, the flat terrain and the dry climate. These include unconsolidated sands (about a third of the continent), saline (chloride-affected) and sodic (sodium-affected) soils, hard-setting soils, soils low in nutrients and organic matter, cracking clay soils and soils with abrupt changes in texture with depth.[7]

We are not making a lot of progress in learning more about what soils are where. **Australia is one of the few first world countries without a national soil-mapping agency.** Pedology, the soil mapper's science, is unfashionable and pedologists are retiring faster than they are being trained. The main soil map of Australia is still Keith Northcote's compilation for the *Atlas of Australian Soils (1960-8)*.[8] It is drawn at a scale of 1:2 million which is enough to substantiate the observation

in Chapter 1 that Australian soils are indeed infertile, shallow, stony and salt-prone. For example, most Australian soils can store very little water, a serious weakness where plants are so vitally dependent on soil-water reserves to carry them through from one chancy downpour to the next.

Map 2.5 Intrinsically productive soils

Adapted and interpreted from Northcote and others, 1960--68.

Map 2.5 interprets the Northcote map in another way. It is an experienced soil scientist's evaluation of which are the more and which are the less (potentially) productive soils across the country. Less than 10% of the country has reasonably productive soils and lots of this area lies in climatically unfavourable areas, i.e. unfavourable for agriculture. There are large areas where, in spite of deep soils and good rainfall, tree growth is poor because of nutrient deficiencies, e.g. the low scrubs of much of Cape York Peninsula (870--2100 mm rainfall) or the scrubs of the Henty peneplain in south-west Tasmania (2500 mm rainfall). Northcote and Skene estimate 5.3% of Australia to be saline and 32.9% to be both saline and sodic. Sodic soils are often highly erodible.[9]

The amounts of phosphorus available for growing plants are pitifully low in most Australian soils other than those developed on younger basalts or basalt-derived alluvium. It is not surprising that superphosphate has twice been a decisive material in Australian agricultural history. It was applied to wheat in the early years of the century after yields had fallen dramatically, even in the fertile Victorian Wimmera, and was soon used universally. Thirty years later it was introduced as top-dressing on

pastures of European clovers and high-grade grasses, imported into southern Australia to replace the native grasses that were adapted to poverty. Adding to the problems of Australian soils, at least in arid areas, available nutrients are concentrated in the upper few centimetres and hence, if these are eroded, plant production is reduced drastically.[10]

Difficult climates

Map 2.6 is based on the work of a maverick Argentinian scientist named Papadakis.[11] It shows Australia divided up into **agro-climatic zones** according to the range of crops which could be grown within each zone. To re-emphasise the point that the way we view resources depends on our purpose, contrast Map 2.6 with Map 2.7. While Map 2.6 is of little interest to the Australian Tourist Commission intent on identifying tourist promotion areas, Map 2.7 shows Australia divided up into **human comfort zones**.[12] These summarise the amount of artificial heating and cooling required for people to stay comfortable, with all that that implies for the tourist trade. So, two climate maps, two resource sets.

Map 2.6 Agro-climatic zones

Simplified from Papadakis, 1970. Papadakis was an unrecognised pioneer in systematically relating plant production to climatic conditions (ideas have changed somewhat since 1970).

Map 2.7 Human comfort zones

From Auliciems and Kalma, 1979. The shadings represent estimates of the total heating (e.g from exercise) and cooling (e.g from sweating) energy in Watts per square metre of body suface required to keep an upright naked man at a comfortable daytime body temperature throughout the year.

We have enough regional-scale climatic knowledge, accumulated from about 1000 weather-recording stations around the country, to draw such interpretive maps although our ability to interpolate (fill in) what goes on in the gaps between stations is still somewhat limited. It will be ironic if our ability to interpolate climate between stations matures just as we enter a period of rapid climatic change when historical records cease to be a guide to what to expect.

Temperatures

Mean summer maximum temperatures vary from 13°C to 33°C across the continent. The highest maximum on record is 53°C at Cloncurry (western Queensland). Minimum temperatures are more important for determining limits to plant growth. Coastal areas and the wet tropics are frost free. Inland, however, sub-zero temperatures are recorded even in the tropics, especially at higher altitudes, and the severity of frosts increases towards the south, especially in the east. The lowest minimum on record is -22°C near Mt Kosciusko. We can produce reasonably accurate maps showing average number of frost-free days a year and the timing and intensity of frosts.

Wind patterns

Jetse Kalma has recently mapped and **modelled** the continent's broad wind patterns for the first time.[13] His maps help to explain why some areas, even though well inland, get high deposits of sea salt each year. They also help to explain how significant areas of soil in eastern Australia have been formed from particles of soil carried from the west on the prevailing winds over centuries.[14] Map 2.8 shows both the average erosive power of the winds and their resultant (average) direction.

Modelling is the term used by scientists to describe the process of representing the main features of some phenomenon (e.g. wind patterns) by a simplified analogy of some sort, mathematical or physical, i.e. by something which behaves in much the same way as the phenomenon being modelled. A good model can be used to predict how the phenomenon being modelled will change over time.

Map 2.8 Winds of Australia

Simplified from Kalma and others, 1988. Shadings indicate capacity of wind to blow sand and hence to cause wind erosion.

Winds in the form of cyclones are an aspect of the climate warranting extreme respect. About 13 severe tropical cyclones a year form off Australia. A zone of tropical cyclone hazard extends from Geraldton in the west to Brisbane-Gold Coast in the east. Cyclones have however been recorded as far south as Perth in the west and Coffs harbour in the east (Map 2.9). In central and northern Queensland and the Gulf of Carpentaria tropical cyclones are the major cause of flooding, whereas in New South Wales flooding is the result of an interplay between tropical pressure systems and a southern-westerly circulation which creates systems producing heavy rain. On average, about one cyclone per year crosses the coast in each 5x5° grid cell.

Map 2.9 Cyclone hazard regions

Adapted from a map (n.d.) produced by the Natural Disasters Organisation from Bureau of Meteorology data. Based on total known crossings per 100 km of coast between July 1909 and June 1975.

Rainfall and runoff

Rainfall over the continent is related mainly to latitude which correlates with the paths of low-pressure systems (Map 2.10). The northern part of the continent experiences a predominantly summer rainfall sucked in by low pressure associated with heating of the tropical part of the continent. In the south rain is largely associated with low-pressure cells striking the continent from the west in winter.

Most Australians would bet that this country receives the lowest average precipitation over its land surface of all the continents; the correct answer is Antarctica. Still, one third of the continent is arid on any assessment---traditionally meaning average rainfall of less than 250 mm a year in the south and

350--380 mm in the north. Rainfall here does not exceed evaporation in any month of the year. Extremely arid country does not support perennial vegetation; only plants with a life cycle short enough to be completed on a single fall of rain can persist there. There is no generally accepted functional (plant-growth) criterion for distinguishing arid from semi-arid country.

Another third must be regarded as semi-arid, meaning `not arid but receiving insufficient rainfall to grow rain-fed crops'. The potential evaporation rate of water at any place is determined by available solar energy and thus by latitude. Plants die by cooking if they cannot get sufficient soil-water to satisfy evaporative demands on their leaves and keep cool. Because of regional differences in potential evaporation rates (2.8 m a year in Alice Springs, 0.5 m in Tasmania), rain-fed crops require more than

*250 mm mean annual rainfall in the south

*375 mm in most of New South Wales

*500 mm in northern New South Wales and south-eastern Queensland

*625 mm in north-eastern Queensland

*750 mm in north-western Queensland, the Top End of the Northern Territory and the Kimberleys.

A substantial review of Australian water resources, *Water 2000*, was published in 1983 confirming much of what was already generally known

but also adding useful detail. As well as having large areas of low rainfall, Australia's precipitation is also extremely variable from year to year by world standards.[15] If average variability of rainfall is expressed as a percentage of mean annual rainfall, it is only the Top End and the south-east and south-west coastal rims which have less than 20% variability; most of the arid zone has greater than 30% variability and the Pilbara over 40% (Map 2.10).[16]

Map 2.10 (a) Mean annual rainfall

Map 2.10 (b) Variability of mean annual rainfall

Adapted from Hanley and Cooper, 1982. Variability is measured by taking a typical or standard deviation from the mean or average and expressing it as a percentage of that mean.

Low rainfall means that many streams carry little water considering the area they drain. The Murray-Darling system, for example has about 1.5% of the runoff per unit area of China's Yangtze-Kiang River. Because Australia is the flattest continent, rivers are slow-flowing (the Darling falls at 5.6 cm---just a thumb's length---per km over its 2000 km length) and much of the continent drains inland rather than to the sea; the Lake Eyre Basin internally drains about a sixth of Australia. Long stretches of river have no tributaries; from the Queensland border to where it joins the Murray at Wentworth the Darling has no tributary worth mentioning and if it were not that the river runs in a clay channel it would probably be lost in the sands of a desert as are some rivers in central Australia.

Australian rivers deliver fairly small quantities of water and sediment to the coast but carry high loads of dissolved salts. Why? Water quality in rivers is highly dependent on water quantity; high flows come from surface runoff (rather than from groundwater) which has the dual effect of mobilising sediment (creating turbidity) and diluting salty groundwater baseflows. Groundwaters tend to be salty because they are commonly stored in marine sediments laid down in former oceans.

About 65% of all surface runoff occurs on the 21% of the land surface around the northern edge of the continent from Brisbane to the Kimberleys (the fraction of rainfall running off is closely related to total rainfall). Runoff varies markedly with season over most of Australia, the ratio of peak season flow to trough season flow commonly being hundreds of times the same value for typical European and North American rivers. The difficulty in using this northern runoff is that it occurs intermittently following high-intensity storms.

When they flood, Australia's inland rivers can rise quickly in response to intense tropical rainstorms despite their large flat catchments. At other times, especially in the lower parts of the Murray-Darling system or round Lake Eyre, impending floods can take several weeks to arrive. Inland floods disperse much more slowly (over many weeks sometimes) than those in the small steep catchments of coastal rivers. Again, flood flows in Australian rivers are a much higher multiple of average flows than are flood flows elsewhere.

Wetlands

Wetlands are areas of shallow standing or flowing water, salt or fresh (e.g. swamps, billabongs, shallow lakes, marshes), and are under the same broad climatic controls as rivers (Map 2.11). In northern Australian wetlands plant and animal life must cope with great changes in water supply between seasons. In response to lower and less regular rainfall, inland wetlands are smaller and even more seasonal and are often brackish in the dry season. In the arid interior, wetlands may be dry for years on end, but in the rare wet year such as 1989 lakes and swamps are abundant and full and become important habitats for waterfowl. In the better-watered south-east and Tasmania, permanent wetlands are more common, especially on floodplains and at the margins of high ground. There is also a distinctive set of wetlands in the coastal zone, where seepage from sand dunes can maintain permanent wetlands even in rather dry areas, e.g. around Perth. Along muddy coasts with a large tidal range, as in northern Australia, there are extensive tidal wetlands that usually support mangrove forests. In

* Murray River floodplains in the Murray Mallee

* Murrumbidgee--Lachlan confluence

*Interdune swamps in the lower Murray region

* East Gippsland coastal lakes and swamps.

About 80% of the almost two million migratory shorebirds that visit Australia each year occur in three main regions: the north-west coast between Broome and Port Hedland; the coast of north-eastern Arnhem Land and the Gulf of Carpentaria; and the south-eastern coasts and lakes between Eyre Peninsula and Corner Inlet, Victoria.[20]

Map 2.11 Major concentrations of wetlands

From Paijmans *et al.,* 1985.

In Victoria, it is recognised that about a third of the State's wetlands have been lost in the last 200 years and a Wetlands Conservation Program has been established with policies covering wetland purchase, water-level maintenance, minimal further drainage and selective restoration.[21]

Table 2.1 Three per cent of Australia is wetlands

	sq km
Perennial lakes	9 650
Intermittent lakes	12 730
Dry and episodic lakes	120 750
Swamps	90 460
Reservoirs	6 340
	239 940

Source: Australian Resources Information System

Fossil water

The paucity of permanent surface water serves to emphasise the major role played by (under) groundwater in sustaining agriculture, mining and settlement in Australia. Groundwater occurs in near-surface aquifers (porous layers) covering about a quarter of Australia as well as in deeper sedimentary basins covering two-thirds of the continent and provides about 14% of all water used for human activities. In area terms, human activity in about 60% of the country is almost totally dependent on groundwater and elsewhere it is used to supplement surface-water supplies.[22]

Map 2.12 Groundwater resources of Australia

Adapted from Department of Resources and Energy, 1983. The shadings give an estimate of average yield per sq km in each of 12 drainage divisions and circles give estimates of the quality of that groundwater.

There are large untapped groundwater resources in Northern Australia and Tasmania where recharge from rainfall is at present occurring. In the low-rainfall parts of Australia groundwater is largely a fossil (non-renewable) resource, albeit a very large one. However, despite massive reserves, pressures which drive artesian water to the surface are declining in large areas, particularly in the Great Artesian Basin (covering much of inland New South Wales and Queensland) where, commonly, water has to be pumped up another half-metre each year. Increasing pumping costs are forcing graziers to substitute polythene pipes for wasteful open bore-drains as a way of distributing water to stock. One day the technology might exist to move fossil groundwater around the country in underground rivers, turning it into a renewable resource limited by recharge rates (which themselves can be artificially lifted in many situations).

Tom Chapman has calculated that the water stored in various places has an average depth across Australia as follows[23]

Precipitable water in the atmosphere	18 cm
Surface water	5 cm
Groundwater	1524 cm

Groundwater pollution is a problem in many countries, usually caused by leaching (dissolution and through-drainage) of fertilisers or animal wastes in recharge zones. This could become a short-term problem where groundwater moves quickly through highly porous aquifers (e.g. Perth, south-east South Australia) but a long term problem only in inland basins where turnover rates are low and recharge areas are not farmed intensively.

Wattles and gums

Of the world's 411 families of flowering plants, 221 occur in Australia. Most of those that do not occur in Australia have few members and are confined to the Americas. The number of species in the continent (around 13 000) represents only 4.3% of the world's species and might be regarded as low given that Australia occupies about five per cent of the world's land surface.[24] About 85% of vascular (stemmed) plant species found here are unique to Australia.
Ask any botanist to name the outstanding feature of the Australian flora and you will get the same answer. It is dominated by two genera, *Acacia* and *Eucalyptus*---wattles and gums to John Citizen. Both are widely distributed and both are rich in species, collectively over 1000. All are evergreen and the same leaves have to withstand both winter storms and the `sprites of flame and drouth'. Almost as characteristically Australian are the `hummock grasses' of the genera *Triodia* (spinifex) and *Plectrachne*, particularly in arid areas.

Rainforests are closed-over forests dominated by neither acacias nor eucalypts and although only occurring in small residual pockets along the east coast, across the North and in Tasmania, are extremely rich in both plant and animal species. Australian rainforests comprise only 0.2% of the world total, but this small area contains about five per cent of total global rainforest species, including the greatest concentration of primitive flowering plants in the world. Many rainforest species are likely to have

recording all of the country's plant and animal species. Their *Australian Biological Resources Study* supports the ongoing publication of the *Flora of Australia*, the *Fauna of Australia* and the *Zoological Catalogue of Australia*. Herbarium and museum records provide patchy but still valuable information about the distribution of individual plant and animal species.

A unique fauna

The Australian fauna has been derived from three main sources: the original fauna present on the continental plate when it broke away from the supercontinent Gondwanaland in Cretaceous times (70--120 million years ago), immigrants from South America in late Cretaceous times and immigrants from south-eastern Asia which began to arrive in the Middle Tertiary era when Australia collided with Asia.[27] Marsupials (pouched mammals) and monotremes (see below) make up the typically Australian mammals. The other native furred animals, placental mammals, are relatively recent arrivals and, in species terms, outnumber the marsupials. From an ancestral kangaroo-like creature there developed the big Red Kangaroos that live on the inland plains and the forest-dwelling Grey Kangaroos. Heavy-footed kangaroos, the rock wallabies, also evolved, as well as a variety of small swift things that haunt tussock and undergrowth. Two kangaroos, in tropical Cape York, have climbed back into the trees and eat fruit and leaves. Wallaby, Wallaroo, Tungoo, Paddymelon, Potoroo: these are all kangaroos springing from one or perhaps two kinds of ancestors. Ancestral possums evolved into the nest-building ringtails, and bushytails and others that live in hollow trees. Some possums developed membranes down their sides. These enable the so-called `flying squirrels' to glide almost noiselessly from tree to tree. The same story of isolation, evolution and radiation through a big and varied continent can be told of other stocks---the marsupial `cats', mice and wombats and many more.

Even more archaic than the marsupials are the monotremes, found only in Australia. These, the Platypus and two species of spiny anteater, although true mammals with fur and milk glands, nevertheless lay tortoise-like eggs and retain various internal features that show their fairly close relationship to reptiles.

The `recent' arrivals include the bats, the ancestors of which were able to fly here. Then there are the true rats and mice, the forebears of which probably drifted here on floating debris. The small Asiatic wolf, the Dingo, almost certainly arrived here recently (within a few thousand years), brought by the nomadic Aborigines perhaps, and so it did not, and now probably never will, differentiate into more than one kind.[28]

Further illustrating the high diversity and endemicity (meaning `occurring nowhere else') of the Australian fauna, we have

* about 850 species of birds, 70% of which are endemic

* about 700 species of reptiles, 88% of which are endemic.

Geographic distributions of many Australian vertebrate (back-boned) animals are still imprecisely known. Nevertheless, approximate range maps are now available for birds, mammals, reptiles and amphibians.[29]

Australian invertebrates are largely unknown. We have about 300 000 insect species, most of which have not yet been described. For example, in a recent collection of 630 species of spiders and beetles on a 20 ha site at Wog Wog, New South Wales, 530 had not been described before.

Sea and shore

The natural resources of the Australian coastline have been documented comprehensively by Bob Galloway and others.[30] In a massive exercise in air photo interpretation they recorded, largely in computer-readable form, geology, landform, vegetation and land use for each of 3027 10 x 3 km sections of coastal lands. Other more specialised inventory exercises have concentrated on describing the resources of estuaries (about 750) and beaches.

South of latitude 25° (Shark Bay to Fraser Island) the coast receives high energy swell from the Southern Ocean and, except for the tropical north-west, tidal ranges are low to moderate by world standards.

Australia has four main types of coastlines, the most `low-lying' of which are the **tidal flat** coasts laid down in areas where wave energy is low, e.g. where the continental shelf is wide. Included here are the mudflat coasts of northern, north-western and southern Australia which, among other important aspects, support a large proportion of the world's wading birds for at least part of the year.[31] Broad intertidal zones have developed around the low-energy shores of gulfs and estuaries in northern Australia where the tidal range is large. Wide tracts of mangrove swamp are backed by saline flats which flood during exceptionally high tides.

Barrier coasts have lagoons or estuaries, often filled in, behind their beaches. These occupy most of the east coast between Melbourne and Cape York and most of the Gulf of Carpentaria and the Top End of the Northern Territory. The coastal flood plains of the east coast streams have to be regarded as the most flood-prone areas of Australia. Storm tides, by delaying runoff, commonly contribute significantly to flood height and duration.[32]

Rocky coasts, commonly with cliffs and with some sort of shore platform, occupy big sections of Tasmania, the Great Australian Bight, the South-West and the Kimberleys; **mainland beach coasts** make up the `non-rocky' sections of these regions.

The Royal Australian Navy Hydrographic Service acts as the national hydrographic authority. It runs a small but active bathymetric charting program. At the Australian Oceanographic Data Centre it operates several computer-based information systems built around a combined meteorological-oceanographic database. Charting for general navigation purposes is adequate throughout the 200 mile Australian Fishing Zone. There are 150 tide gauges installed around Australia but many are antiquated. An upgraded system is vital for such tasks as measuring the Greenhouse effect on sealevel.[33]

Estuaries and their associated tidelands and wetlands are the biologically richest ecosystems of the coastal zone. Most of the species that make up the nation's seafood catch depend on coastal estuaries and tidal marshes during some or all of their life cycle. The principal classes of coastal ecosystems focus around mangroves, seagrassbeds and kelp beds and coral reefs. Most of Australia's 12 000 sq km of mangroves occur in the tropics, as do coral reefs. The Great Barrier Reef includes around 2900 individual reefs. Sea-grass beds occur in a variety of situations around the coast and, while thought to be important primary producers in Australian marine ecosystems, they have been poorly studied.[34] The biological resources around Australia, out to the continental shelf and beyond to the 200 nautical mile Fishing Zone are certainly not spectacular by world standards.

Australia are relatively poor in nutrients and thus do not support large populations of photosynthesising organisms. The nutrients in question are the same ones that farmers put on crops to enhance yields. Elsewhere in the world, such as the coasts of Africa, Peru and North America, there is large-scale upwelling. This is a process which recycles nutrients from the deep ocean waters to the surface where, in the presence of sunlight, the microscopic plants of the ocean can utilise them and produce organic compounds which are the start of the marine food chain. Upwelling can be thought of as analogous to deep ploughing the land to bring nutrients to the surface. This process occurs only in restricted areas and sporadically around the Australian coast.[35] Under a different process, even small changes in the sea-surface temperature of the main currents flowing southwards off the east and west coasts of Australia can affect fishing catches and, interestingly, on-shore rainfall.

While our marine plants and animals show many similarities to those of nearby oceans and shores, our long diverse coastline supports a great number of species. It is the species of the southern coast which tend to be unique to Australia.

The Great Barrier Reef follows the east coast south from Torres Strait for about 2000 km. Apart from coral reefs, it contains about 250 continental islands and 300 sand cays. The outer reefs are about 50 km offshore and extensive coral zones occur between the outer reefs and the coast. The Reef's inhabitants are amazingly diverse, including about 400 species of hard and soft corals, over 1500 species of fish and thousands of species of molluscs, sponges and echinoderms.

Apart from oil and gas fields, little is known about the potential for marine minerals. On the continental shelf there is some exploration for tin and gold. By 1992 there is likely to be some exploration for phosphatic minerals on the slopes of the continental shelf and manganese, nickel, cobalt, and copper nodules and polymetallic sulphides on the abyssal plains.[36]

Minerals galore

Why is Australia mineral-rich?

Geologically speaking, Australia is made up of the Australian Shield occupying the western two-thirds of the continent and regions associated with the Tasman Geosyncline (trough) occupying the eastern third. The Australian Shield comprises extremely ancient rocks and is highly mineralised; it has provided the greater part of Australia's total production of gold, lead, zinc and uranium. Also, the long history and relative stability of the Shield have provided unequalled opportunities for the weathering and leaching processes which form iron ore, bauxite and nickel ores. The building of the eastern third of the continent involved the fillng in of the Tasman Geosyncline. Regions associated with the Tasman Geosyncline are markedly different with respect to mineralisation processes and have failed to produce the major ore deposits of the Shield. They are much younger and have been subject to uplift and deposition processes, particularly in New South Wales, Victoria and Tasmania. In Queensland a relative lack of uplift activity has permitted the extensive deposition in the Great Artesian Basin which we recognise today as massive coal deposits.

Map 2.14 shows the country's 13 major mineral bearing regions, termed **metalliferous provinces**. Areas outside these are the 20 or so sedimentary basins which can also be mineral-rich but rather in the `organic' minerals such as oil and gas and the chemical precipitates such as limestones and phosphate rocks. The sedimentary basins extend considerable distances beyond the continental land mass in places, creating the promise of offshore oil.

Map 2.14 Mineral-bearing regions

From *Atlas of Australian resources*, 2nd series and an unpublished map from Esso Australia. Australia can be divided into sedimentary basins with better or worse prospects for yielding energy minerals (but not metallic ores) and metalliferous provinces where metallic ores (but not energy minerals) are most likely to be found.

Extent of mineral resources

The bigger the map (i.e. the larger the scale), the more information you need to complete it without leaving lots of blank spaces or using great sweeps of colour. For most of our natural resources we can probably depict much of what we know of their distributions on a map of Australia which, at most, would cover the living-room wall (a scale of around 1:2 million). We normally cannot draw resource maps at the sorts of scales needed for assisting on-site resource-management decisions without having to go out and specially acquire the required information at first hand. Such large-scale maps (1:10 000-1:50 000) exist for numerous small areas where particular management decisions have required such information to be collected at some time but these probably amount to little more than a wash of fly specks on our living room map. Several attempts, including one by my own colleagues, have been made to collate lists of these studies to assist decision-makers going into an area for the first time.[38] The recently established National Resource Information Centre, operated jointly by the Bureau of Mineral Resourcesand the Bureau of Rural Resources, has plans to produce such compendia in detail.

Yes, but how much?

Knowing that a species or an ecosystem or other resource occurs somewhere, even knowing accurately, is only a first achievement. It does not tell us how much; log volumes in a mountain ash forest? Koala numbers on the north coast of New South Wales? megalitres of water in the Murray? etc. We have reasonable ideas on how to estimate numbers of stationary things like trees but find it expensive and difficult to estimate animal numbers, both onshore and offshore. Minerals too; great costs are incurred in going from recognising a mineral province to `proving up' the estimates of tonnages in an ore body.

Better inventories

Large companies, particularly mining companies, carry out exploration and inventory work where they foresee this as being profitable. But what is the role of government? Mining company submissions to a recent review of the Bureau of Mineral Resources wanted the Bureau to concentrate more on `basic mapping' of geology and resources and less on basic research into geological processes. And yet, as the history of Australian mining has shown a number of times (e.g. finding the Roxby Downs deposits), having models of geological processes can dramatically lift the payoff from exploration expenditures.

Similarly with biological resources; models of the type at present being built in the CSIRO Division of Wildlife and Ecology can produce reasonably reliable estimates of the presence of species, communities and ecosystems without having to tramp every metre of the forest (Fig. 2.1). Such models run on information provided by existing maps and by remote sensing exercises (including interpretation of satellite imagery and air photography) calibrated from limited ground survey. They also use `synthetic' climate data interpolated to areas of interest from nearby meteorological stations. **Government work on resource inventory needs to be balanced between `doing' inventories and learning how to do inventories more efficiently.** Research into

inventory-taking methods is paying high dividends in the form of improved efficiency, and the hope of researchers in this field is that governments will be perceptive enough to recognise and support this.

Fig. 2.1 Occurrence of silver top ash in relation to altitude and rainfall in the forests of south-east Australia

Source: M. Austin, personal communication. This is what its creators call a `fried egg' diagram. The boundaries of the `white' enwrap all combinations of mean annual temperature and mean annual rainfall found in the forests of southern NSW and eastern Victoria. The inner `yolk' contains combinations of temperature and rainfall where there is a high probability (greater than 60%) of finding silver top ash (*E. sieberi*).

The starting point for learning to do better inventories is having a clear purpose. Inventory-taking is expensive and we cannot afford to pour money into data collection exercises without rigorous assessment of potential applications and links to existing data bases. That is the Iron Law of Data Collection, regularly forgotten by even experienced scientists. In the 1960s the Australian Representative Basins Program spent millions collecting data for relating rainfall to runoff, but there is very little to show for the money today.

If we had such a thing as a national strategy for natural resource inventory (and we should), it would need to be a `mixed strategy', balancing efforts at different scales---from continental to local. Not that one can ever get it right of course. Basinski's Law states that, whenever you complete an inventory exercise, someone will come along and tells you how useful it would have been if only it had been done at slightly larger scale. If you do work at larger scale, available resources ensure that you will cover a smaller area, and someone then tells you that their area of interest is just off your map!

Another basic principle for any sort of `background' inventory-taking should be to design it as though planning to describe the whole continent, even though this may never be fully implemented. A major flaw in the generally excellent work done by the CSIRO Division of Land Research in mapping the soils and vegetation of vast areas of Australia was that because each survey was `one-off' the maps they produced did not `match at the edges' when survey areas began joining up.

What is happening now is that funding bodies and agencies are reluctant to support basic inventory work. We are constantly trying to wring something more out of past inventories, but no one wants to pay to get better inventory data unless they absolutely have to---and then it gets done in an ad hoc way. For a number of ubiquitous natural resources (e.g. soils, vegetation, landform) we should be prepared, as the next step, to spend the money to produce continent-wide maps at a target scale of 1:1 million. For resources which we have spent little time investigating, we have to make a start, e.g. offshore resources and environments.

Finally, it is important that inventory data be routinely stored in **computer-based geographic information systems.** This way, its usefulness is enhanced many times over; data from different sources can be co-ordinated; the same raw data can be interpreted in numerous ways and the output mapped in hours rather than weeks.

Making our mark

Beyond knowing the whereabouts and quantities of current resources comes the greater challenge of knowing what they were like and what they might be like if past trends continue or if emerging forces change these trends. Again, we do not have precise knowledge by any means, but we can identify the grosser changes which have occurred since European settlement in resources which are the focus of current conservation concerns: plants, animals, soils and water bodies.

The great extermination

In 1966 Jock Marshall, an awe-inspiring one-armed zoology professor, edited *The great extermination: A guide to Anglo-Australian cupidity, wickedness and waste.*[39] In it he had a group of his biologist mates document the exploitation, displacement and subsequent

Native plants at risk

CSIRO botanists have produced a list of about 2000 plant species (over 10% of the total flora) which they consider to be in some danger of extinction, depending on how widespread the species is and whether it is growing in areas where it is likely to be disturbed.[41] Nine recorded species are believed to be extinct as they have not been collected in recent years (how many unrecorded?). A total of 221 species is endangered, the category of greatest risk. In Western Australia alone, 1024 species out of the State's 7000 or so native vascular plants are listed as rare or threatened; most are in the south-west in areas cleared for farming.

For example, 23 000 sq km of native grasslands once existed west of Melbourne; now they and many of their component species remain only as tiny preserves on roadsides and railway lines and in cemeteries. The New South Wales tablelands, northern and southern, yield a similar story.

Mammals too

We have no real idea of how common the Australian mammals were when the European settlers came. Historical records do show however that the range over which many species could once be found has diminished spectacularly. Figure 2.2 gives some examples. Australia has the worst recent record for extinctions of native mammals of any continent---18 since European settlement which represents seven per cent of our mammal fauna. It also represents two-thirds of the world's total extinctions over that period. Some 30 more species are endangered. The situation is even worse when it is realised that most of the animals that have been lost were marsupials, the pouched mammals which set Australia apart from the world.

Fig. 2.2 Past and present distributions of some Australian mammals

From Newsome (1971) and Strahan (1983). Of the five species shown, the Crescent Nailtail Wallaby (probably) and the Pig-footed Bandicoot (definitely) are extinct. The Bridled Nailtail Wallaby was rediscovered some years ago after having been thought extinct.

Map 2.15 Species density of rare and endangered mammals

(After Woinarski and Braithwaite, 1990). Based on the particular species list used, the wet tropics is the paramount area for the preservation of rare Australian mammals, with other important areas in the Top End, Kimberley, south-west WA and coastal south-eastern Australia (including Tasmania). Two of these, Top End and south-west WA are also areas of high mammal diversity.

The problem is most critical in arid and semi-arid Australia. The inland contains (or contained) two-thirds of the species that are at risk or have disappeared. One reason why the arid zone has suffered such severe losses is that in poor seasons many native animals are forced to retreat to isolated and relatively small pockets of dependable country, where they are highly vulnerable to any added disturbance.

The first such disturbances triggered by Europeans were from large mobs of sheep, cattle, horses, donkeys and goats. In harsh seasons these animals inevitably fell back to the same pockets of dependable country that the native species occupied. They changed the habitat and the native animals were progressively exterminated. Then came the rabbit which out-competed the burrowing native animals. Next came the fox and the cat, which cleaned up many remnant colonies of bandicoots, small wallabies etc. in a way which the Dingo never achieved (perhaps because it could never stray too far from drinking water).

The final straw in the sandy spinifex country seems to have been the altered fire pattern resulting from the departure of Aboriginal people from their

Box 2.1 Causes of extinction of arid-zone mammals

* Foxes

lands. Originally these people burnt small patches, but now the spinifex is consumed in fires that rob animals of their preferred habitats over huge areas. As a consequence of these changes, extinctions swept across inland Australia and will continue to do so. Many species are endangered and some have declined to only one or two communities. **It is likely that another bout of extinctions will take place when the next extensive drought occurs.**[42]

The loss of Aboriginal `firestick farming' after 1788 has probably been an important factor in extinctions elsewhere too. When firestick farming stopped in the Sydney area, species that depended on the open parkland conditions that it maintained (such as the White-footed Rabbit-rat and Tasmanian Bettong) disappeared forever.[43]

Among the mammals, it is the medium-sized marsupials which are most under threat---the smaller wallabies, some bandicoots, Numbats (termite eaters) and species reduced, like the Rock-wallaby, to a few remnant colonies. Recent scientific evidence shows that these meal-sized marsupials are highly vulnerable. Predation from the European Fox has been undergoing a re-evaluation and can no longer be ignored. The best evidence is from Western Australia where populations of three species living in woodland remnants in the widely cleared wheatlands continue to shrink. Numbat numbers there continued to fall until foxes were controlled. As a result, Numbats increased by 50% in 18 months. In New South Wales foxes killed an entire release of 47 rare Parma Wallabies. And so on. **The adage that you can protect a species by protecting its habitat is no longer sufficient.** There is no alternative to controlling foxes and cats---the introduced predators---if extinctions are to be avoided. Reserves have to be actively managed (see Chapter 5).

Birds

The bird fauna has fared better than mammals, with only one species, the Paradise Parrot, definitely regarded as having gone extinct. Some though

have only been rarely sighted in recent years, e.g. the Night Parrot. Birds have the apparent advantage of mobility when times get tough, although many species never move more than a kilometre in a lifetime. For them, there is no escaping the implications of permanently reduced feeding areas or nesting sites. In southern Australia the current distribution of rare and endangered birds coincides substantially with that of the lost mammals. Ornithologist colleagues have commented that it is only a matter of time before bird species start going the same way as the mammals. One grasswren, for example, lives in the saltbush stands which are an early victim of overgrazing. Again, rabbits remove all tree seedlings from vast areas and, as sparse old trees die, the numerous bird species which depend on them must also go. Foxes are decimating the young of the ground-dwelling Mallee Fowl and there is almost no recruitment to the breeding population.

And insects

An area that carries only a few score bird species or a dozen mammals may be home to 2000 insect species. Like other animals, they are in danger of extinction when their habitats are endangered. Species particularly at risk are those completely restricted to narrowly distributed habitats:

> However, there is no conclusive evidence of extinction of any mainland Australian insect as yet, and few indisputable cases of a species being seriously threatened with extinction, in spite of great reductions in range ... If we wish to conserve the characteristic insect fauna, we need a program to reserve samples of all Australian ecosystems.[44]

Outlook for the extinction industry

One lesson of this sad chronicle is the rapidity with which an abundant species can disappear. Localised species occurring over only limited areas are in particular danger, as are species occupying specialised habitats. Today, threats to wildlife are indirect rather than direct. The basic threat is destruction of habitat. We know that the geographic range of many species is decreasing as their habitats are developed or destroyed. It is true that the massive land clearing for agriculture of the 1950s and 1960s is over. Nevertheless,

* small-scale clearing of patches of native vegetation will continue at a reduced rate in temperate Australia

* woodchipping threatens large areas of forest habitat in New South Wales and Tasmania

* there may yet be a sizeable expansion of cropping in central Queensland

* there are some significant areas which could still be opened up to pastoralism, notably in Western Australia

* chemical thinning of very large areas of Poplar Box woodlands in Queensland and northern New South Wales remains a possibility

* droughts will continue

* predators are still spreading

* most importantly, species conservation efforts are insufficient actively and significantly to throw the odds back in favour of threatened plants and animals.

Key Point

There is no reason to suppose that the rate of species extinction in Australia will fall.

Changing the rules

Following extensive aerial surveys, numbers of the three most abundant kangaroo species were estimated in 1981. The total of c.19 million comprised c. eight million Red Kangaroos, c. two million Western Greys and c. nine million Eastern Greys. These numbers could have decreased by about 40% in the 1982--83 drought, but no doubt numbers are breeding up rapidly following bountiful rains in 1989. These particular species appear to be in no danger of extinction, despite extensive commercial harvesting. The Greenpeace organisation, which I admire, has got this one wrong. It can in fact be argued that commercial harvesting of the abundant species helps to protect rarer species. The argument is that poisoning by farmers would replace shooting if commercial harvesting were stopped and poisoning does not discriminate between rare and abundant species. It can also be argued that creating conditions favourable for kangaroos would probably benefit other native animals. It is important that the search for more humane control methods should continue.

Broad-scale aerial surveys of waterfowl distribution and numbers (14 species of ducks and five of geese etc.) are carried out each year throughout eastern mainland Australia. The intention is to assess the effects of hunting pressure and loss of wetland habitat on waterfowl populations. Unlike coastal areas, there appears to be little loss of the inland wetlands so vital to waterfowl breeding. Despite the hunters, survey returns to date do not suggest that waterfowl are in danger of extinction.[46]

Other baseline exercises which could be the start of monitoring programs include a recent Koala survey and the production of an all-species bird atlas by the Royal Australasian Ornithologists Union. A successful bird-banding scheme administered by the Australian National Parks and Wildlife Service might also be included here.[47]

What can be concluded? Despite all these efforts described, our knowledge of most species is too poor to know whether population sizes and geographic ranges have stabilised within identifiable limits. Monitoring is very expensive and will remain so even though techniques are improving. **Since choices have to be made, it is the recovering populations (like seals and whales) and the highly endangered species (like the Hairy-nosed Wombat) which have priority for being monitored.**

The great invasion

The special vulnerability to disruption of island ecosystems is well known to biologists and Australia is the supreme example of a large, formerly isolated, island ecosystem.[48] At the same time as European man was clearing the land and killing the wildlife for profit, he was also, usually unwittingly, bringing in plants and animals which would in many instances turn out to be strong and, eventually, uncontrolled agents in the destruction of Australian ecosystems, including both natural and agricultural ecosystems. Compared with other places for which data is available (Britain, New Zealand, United States), exotics do not form a particularly high proportion of the total number of species of resident mammals, birds and some plant families.[49] However, it is the competitiveness of exotics, not the total number of species, which is important.

In establishing themselves, exotic plants have been greatly assisted by the major disturbances of the landscape accompanying the expansion of settlement; stable, diverse ecosystems are harder to invade. Soil disturbance (e.g. along road verges, ploughed fire breaks) is of particular importance in the spread of exotic species. Disturbances such as agriculture, pastoralism, increased bushfires, mining, infrastructure development and urbanisation created conditions more familiar to the invaders than the locals.
In the south of the continent there are a large number of successful introductions and invaders from the Mediterranean region (e.g. skeleton weed) and, to a lesser extent, the corresponding climate zones in the western USA (e.g. mesquite) and southern Africa (e.g. bitou bush). Few of the successful plant introductions are trees---willows and poplars are the exceptions.

Some examples. Mesquite, a thorny-stemmed bush, is choking large areas of pasture around Tibooburra in western New South Wales and `has the potential to eliminate the pastoral industry from Bourke to the Victorian border' according to Doug Pearson, former Western Lands Commissioner. It is well established in Western Australia. The prickly South American shrub *Mimosa pigra* has formed dense stands across 30 000 ha of the Adelaide River floodplains. It represents a

significant conservation problem for other areas of wetland, including Kakadu National Park which now employs six people to patrol the park seeking and eradicating infestations. Annual seed production is up to 9500 seeds per sq m. While chemical control is possible at a price, biological control efforts to date have not been encouraging.

Rubber vine from Madagascar is choking out the riverine fringe communities of the Gulf of Carpentaria and the dry rainforests of north Queensland. Somewhere along the path of its westerly advance it will meet *Mimosa pigra* advancing east. Throw in the cane toad and you have a recipe for ecological disaster, somewhere round Arnhem Land! Stella Humphries, who has just completed a review of the subject, judges rubber vine to be Australia's worst weed of natural systems (cf. agricultural systems).[50]

Bitou bush. Coastal dunes in eastern Australia which are under stress from human disturbance or storm erosion are vulnerable to bitou bush invasion. It is now widespread from Sydney to southern Queensland. The plant is much less invasive in undisturbed permanent vegetation. It was a recommended species for dune stabilisation for about 30 years till 1971 when the recommendation was withdrawn. While it competes very successfully with native vegetation, it is less successful than these same natives at resisting erosive forces, and dunes dominated by bitou bush are more susceptible to blowouts and hummock formation. Thus, while its ability to reduce sand drift is significant, its control is now being sought to protect native coastal plant species.[51]

The list could be lengthy: lantana, blackberries, bracken ... Whole conferences are run on weeds, with speaker after speaker detailing hir battle with some scourge. A changing perspective at such conferences is that they nowadays consider plants which are a threat to native vegetation as well as to agricultural operations. For comfort, several of our limited number of successful forays into biological control might be recalled here

* Prickly pear, a cactus, took 260 000 sq km out of agricultural production in the 1920s in Queensland and New South Wales. It was comprehensively eaten out by *Cactoblastis* beetles specially imported for that purpose.

* *Salvinia molesta* is a free-floating South American fern which, over a period of 30 years choked large numbers of water bodies in eastern Australia. It has recently been brought under almost total control through the release of a Salvinia-relishing weevil.

The fact is ...

While we might notch up an occasional win against a bad weed, the fact is that most of the aggressive weeds in Australia are out of control and we do not have the resources or technology to effectively combat them. One thing we can learn from history is that most of today's bad weeds sat around for years, for decades often, before erupting as major problems. The lesson is that further such `sleepers' are almost certainly out there and that research might allow us to learn to identify them in advance. Their physiological and ecological weaknesses could then be sought and pre-emptive action taken.

Another belated lesson from history might be that we should ban the import of species of ornamental plants new to this country.

Not all well-established introductions are regarded as weeds of course. Mediterranean species (e.g.subterranean clover, rye grass) have changed the face of the pastoral landscape in southern Australia, and tropical and subtropical introductions from north Africa (e.g. buffel grass) and South America (e.g. *Stylosanthes* species) are on the way to playing a similar role in the northern half of the continent. The point being made is not that there are `good' and `bad' introductions but that endemic plant species have been displaced from large areas of Australia since European settlement by introduced species.

In a few parts of the world Australian plants have managed to `counter-attack'. A *Leptospermum* is choking and drying out large parts of Florida's wetlands; a number of Australian trees and shrubs (not grasses) have successfully invaded southern Africa.[52]

Animals

Turning to animal invaders (they have been more commonly sponsored immigrants!), every schoolboy knows it is the European rabbit which has been the most destructive of all. Spreading from the south since its introduction in about 1859, it may finally have reached its northern limit of colonisation around the Tropic of Capricorn where feed supplies during the spring to autumn breeding season become too unreliable.[53] Apart from baring the soil to erosive forces, the great, and as yet unrealised, threat of the rabbit is in preventing tree and shrub regeneration. There may never be another generation of saltbush in massive areas of southern Australia. Because saltbush, bluebush, mulga, myall etc. are long-lived, the loss of their palatable seedlings to rabbits goes unnoticed.

Fewer people are aware of the enormous populations of feral camels, brumbies(horses), donkeys and goats which roam the drier inland of Australia, destroying the delicate, nutrient-rich surface crusts of the soils there, exposing them to erosion.[54] Most feral livestock only seem to become serious pests to pastoralists though in certain drier seasons when they make waterholes unusable by domestic animals. Donkeys, and probably brumbies, are now being shot out (commonly for pet food) faster than they can reproduce. As populations of feral livestock are reduced, movements to conserve them (`Save the brumby'), because they are the stuff of folklore, are arising.

The installation of water bores which have allowed sheep and cattle to graze much of the semi-arid rangelands have also permitted the explosion of kangaroo and feral animal numbers. A socially acceptable way of reducing numbers of these species, assuming they are not to be `ranched' in some way, would be a technology which excluded all but domestic species from artificial watering points. First, artesian water would have to be distributed in polythene pipes instead of accessible earthen bore-drains. Second, troughs at the end of pipes would have to be designed to exclude unwanted species. Ian Burnet, a Victorian farmer, has made some interesting suggestions about how this might be done.[55]

In the monsoonal north, buffalo `highways' have initiated saltwater intrusion into large parts of the diverse and beautiful coastal wetlands (swampy grasslands and lagoons) and this has significantly reduced numbers of many species of waterbirds there.

Pigs, foxes and cats are serious threats to native birds and mammals in wetter areas. Pigs can be enormously destructive of crops and pastures as well as being disease carriers. The role of foxes as predators on lambs is probably overrated; they function usefully in fact as predators on rabbits. They would however be a reservoir for rabies if that disease ever became established here. Cats may not so much threaten the creatures they prey on as they do the small native hunters they compete with. Marsupial native cats, for example, are now extinct throughout much of their former range.

Feral dogs (like Dingoes) kill large numbers of sheep on occasions but they are also recognised as a threat to the purity of Dingo stock through interbreeding.

Among the more chilling `animal criminals' is the cane toad (*Bufo marinus*). It was introduced into Queensland (by scientists) during the 1930s, supposedly to control two species of cane beetles that were damaging sugarcane crops. No adequate studies were conducted before its release to ensure that an ecological disaster would not follow, but Murphy intervened and it did. The Cane Toad is now effectively unstoppable. It is dispersing west and south out of Queensland at an alarming rate with what *appear* to be extremely damaging consequences for the native fauna which are its food (proper studies have not been done). Nonetheless, the Cane Toad provides an interesting example of how local fauna will eventually adapt to and check the most aggressive of invaders; several birds have already learned to turn toads over and eviscerate them, thus avoiding their highly poisonous skins.[56]

Sheep and cattle are invaders too. As these species were introduced into the rangelands, the large kangaroos prospered, basically because of improved watering facilities, but many species of small marsupials have died out or become rare.[57] **If we want to preserve little-known species like the Rabbit-eared Bandicoot or the Desert Hare-wallaby, more national parks are needed.**

Insects

Sirex wood wasp, oriental fruit fly, spotted aphids are some of the commercially more important insect pests which have made it to Australia. The sheep blowfly from South

duction from its victims. The related screw-worm fly would be an even bigger disaster if it became established.

Map 2.16 Forest and woodland significantly modified since European settlement

From a map produced by Kim Wells, Nina Wood and Paul Walker, CSIRO Division of Water and Land Resources from an assessment of Landsat imagery by Peter Laut and others, 1980.

It is ironic that commercial beekeepers who have always regarded themselves as environmentally aware, and who have fought against logging and woodchipping in the forests, should now find themselves regarded by conservationists in a similarly unfavourable light. Through the very efficiency of their nectar-collecting activities, European honeybees are suspected of having a significant impact on native bird numbers and native bees and plant pollination. The research to establish the extent of such impacts has not been done though and the limited resources of the conservation movement would be more usefully directed at other targets.

Control principles

Exotic pests, weeds and diseases have two main costs:

> The first is the loss of, or decrease in, a rich indigenous fauna and flora in many areas. This loss is aesthetic, scientific and perhaps also spiritual, but it is not total, by any means, and was inevitable given colonisation of such a land by Europeans ... The second cost is more serious. The deliberate and accidental introduction of pests, weeds and diseases from overseas has significantly reduced the productivity of the land in many ways, but above all through a reduction in plant cover and in accelerated soil erosion.[58]

The various approaches to weed and pest control fall into one of three main categories

* measures aimed directly at the animal or plant

* measures aimed at the animal or plant through some predator or parasite

* measures designed to operate through changes in the environment of the target species.

Direct measures usually have only a temporary effect and it follows that poisoning, trapping etc. must be cheap enough with respect to the crop or product to allow repeated use, e.g. 1080 (sodium fluoracetate) rabbit poison.

The use of predators and parasites has had some notable successes but has perhaps been overglamorised. Usually a self-adjusting balance is set up between host and enemy, resulting in only a partial reduction in the host population, e.g. myxomatosis.

The use of habitat manipulation requires ecological studies to determine and exploit potential weak points in the pest's life cycle, e.g. the establishment of vigorous pasture to crowd out weeds.

The modern concept of **integrated pest management** recognises the need to make use of all available approaches.

If it doesn't move ...

In 1788 forests covered less than 10% of the country and woodlands, where trees are more widely spaced and often smaller, covered 23%. Australia's total forest area has changed *relatively* little in recent decades. The rate of clearing has slowed radically for a variety of reasons

* planting and replanting of native forest species and plantations of exotic softwoods is

in the pipeline (up to 14) and the advent of efficient new tree-killing chemicals or arboricides (e.g. Graslan).

New pulp mills will demand large timber supplies from both private and public lands. Selling timber to pulp mills will provide farmers in high rainfall regions with a profitable way of clearing land which would otherwise remain uncleared.

Arboricides are expensive but, if the economics support it, there will be great pressure to allow their use to increase short-run carrying capacity of thousands of square kilometres of woodlands in semi-arid Queensland and New South Wales.[59] *Day of the Triffids*

In large areas of the semi-arid woodlands of Queensland and elsewhere in the rangelands, regrowth of woody species after clearing, trees as well as shrubs, is a major problem for pastoralists. Woody weeds as they are known inhibit the growth of native grasses, even after good rains, and make stock mustering difficult. In the case of one of the most troublesome species, poplar box (*Eucalyptus populnea*), over 1000 regrowing stems per hectare is common, more than before clearing.[60]

Accelerated erosion et cetera

Degraded land is land which has *unintentionally* lost part of its value for one or more purposes because of man-induced changes to its bio-physical character. Thus tree clearing on land intended for cropping or improved pasture does not per se constitute degradation even where this reduces the land's

Table 2.2 Trying to establish the current rate of forest clearing

Australia-wide, this is a frustrating exercise. It would be useful and not expensive to monitor clearing of both forest and woodland. The following figures are taken from various issues of *Australian Forest Resources* (Australian Bureau of Agricultural and Resource Economics, Canberra). If the 1977--87 absolute overall rate of clearing were to continue, the last forest would disappear in 2164.

Native forest areas: by forest type and ownership

	'000 sq km 1977	'000 sq km 1987
Rainforest	19.0	20.5
Class 1 Eucalypt forest	31.0	25.6
Class 2 Eucalypt forest	141.0	136.5
Class 3 Eucalypt forest	124.0	117.6
Tropical Eucalypt forest	65.0	65.3
Cypress pine	44.0	42.9
	---	---
	431.0	408.4
Public land	341.0	299.4
Private land	90.0	109.0

value for (say) forestry; degradation arrives with the subsequent unintended accelerated erosion and declining yields due to decreased water and nutrient availability. Box 2.2 lists the forms of land degradation currently recognised by the Standing Committee on Soil Conservation.

While degradation can take many forms, from weediness to the presence of pesticide residues, it is widely recognised that soil acidification in crop-pasture systems and soil erosion and salinisation of agricultural and pastoral land following devegetation of some sort (e.g. overgrazing, tree clearing) are this country's paramount land degradation problems.

Table 2.3, based on the only national survey of land degradation which has been completed (15 years old now), shows over half of our agricultural and pastoral lands in need of remedial treatment for some sort of degradation. This is, without a doubt, the most widely quoted environmental indicator ever produced in Australia. It should not be regarded as particularly accurate and it says nothing about current rates or levels of degradation, but it is a useful hook on which to hang an argument.

More recent estimates for one State are contained in a report prepared by the New South Wales Soil Conservation Service (Table 2.4)[61]

Table 2.3(a) Forms of degradation in non-arid areas of Australia, 1975 {tc "**Table 2.3(a) Forms of degradation in non-arid areas of Australia, 1975** " \f t}

	Area '000 km^2	%
Area in use	1 804	
Area not req. treatment	987	55
Water erosion	577	32
Wind erosion	57	3
Wind plus water erosion	55	3
Vegetation degradation	92	5
Dryland salinity		
(+/-water erosion)	10	<1
Irrigation area salinity	9	<1
Other	14	<1
Total area req. treatment	815	45

Table 2.3(b) Forms of degradation in arid areas of Australia, 1975{tc "**Table 2.3(b) Forms of degradation in arid areas of Australia, 1975" \f t**}

	Area '000 km^2	%
Area in use	3 356	-
Area not requiring treatment	1 506	45
Area affected by:		
Vegetation degradation		
" " and little erosion	950	29
" " and some erosion	467	14
" " and subst. erosion	284	8

Table 2.4 Land degradation in New South Wales, 1988{tc "**Table 2.4 Land degradation in New South Wales, 1988**" \f t}

	Severity	% State affected	Area (sq km)
Water erosion			
sheet and rill	moderate	1.81	14 510
	severe	0.53	4 250
	v.severe	0.31	2 520
gully	moderate	5.68	45 500
	severe	4.80	38 490
	v.severe	0.67	5 400
	extreme	0.07	570
Mass movement of slopes	present	2.90	
Wind erosion	moderate	14.06	112 700
	severe	9.04	72 460
	v.severe	1.57	12 550
Saline seepage	moderate	0.54	
	severe	0.66	
Irrigation salinity	moderate	0.52	
	severe	0.25	
Surface scalding	moderate	9.18	73 570
	severe	0.88	7 060
Soil acidification	moderate	6.65	53 300
	severe	3.38	27 120
Soil structure loss	moderate	6.48	51 910

Technologically, the most difficult aspect of the soil erosion problem is that we do not have methods for measuring erosion rates over large areas and short time periods. There have been some clever attempts to develop such methods but none have taken off. One of these is the idea of measuring the change in levels of radioactive fallout in surface soil as an indicator of loss of surface soil.[64] Geoff Pickup uses remote sensing to track the migration of `erosion cells' across arid landscapes. The national survey being planned at present would establish a grid of reference sites across the country where soil losses could be accurately tracked through time and related to prevailing conditions. At the time of writing, the States are having difficulty in agreeing on details of this survey but it would be irresponsible if it were abandoned, as seems likely, in favour of a national land capability survey.[65] If a major land capability survey is attempted, it should concentrate on those parts of Australia where most agricultural production takes place (the wheat-sheep zone and the Murray-Darling Basin) and on predicting the threats of erosion, compaction, salinisation and acidification to land capability in those areas.

A further technical difficulty with soil erosion studies is that it is not easy to relate soil loss to declining crop and pasture productivity.[66] Topsoil loss and exposed subsoil lead to lower infiltration, more runoff and therefore less available water. Nutrient levels are reduced and structure (the size of soil crumbs) lost. The importance of erosion will depend on the depth and quality of topsoil and the nature of the subsoil. Often subsoil has inherently less water storage capacity and less capacity to support plant growth.

The angle of slope above which soil should not be cultivated varies with rainfall intensity, the cropping system and the soil type; some soils absorb water more readily than others. Further studies are needed to unequivocally demonstrate to farmers what rates of soil loss they can tolerate and what this means in terms of cropping frequency and cultivation practices..

Salinisation

> Many commentators on the salinity problem in Western Australia appear to infer that it was a wrong decision to clear for agriculture because it caused the salt problem. I consider such a view to be manifestly wrong. Although two to three per cent of agricultural land has become saline as a result of clearing, agricultural production has continued to rise. The increase in production per unit area due to technological improvements has been more than sufficient to offset the effects of salinity---and other forms of land degradation.
>
> Norman Halse
> Former Director General,
> Western Australian
> Dept. of Agriculture[67]

This is an interesting observation but it fails to recognise that the question the commentators are trying to ask is whether we would have cleared as much land for agriculture if the salinisation hazard from doing so had been recognised at the time, i.e *with hindsight*, was clearing excessive? While not accepting Halse's implied `no', the answer is not a clear `yes' despite the fact that dryland salinisation is a land degradation process which has removed thousands of hectares of agricultural and grazing land from productive use, not only in Western Australia but in all mainland States.

In the case of Victoria, about 6.8% of the State already contains large areas where surface soils have become severely :salt-affected and 16.2% contains smaller salt-affected patches. Plants grow poorly in salty soils, not only because of the direct effects of sodium and chloride on cell functions but because it is much harder for a plant to extract water against the osmotic pressure of salty soil-water.[68]

The immediate costs in terms of production losses associated with dryland salinisation and the subsequent costs from the triggering of other forms of land degradation are enormous (estimated at $65 million per annum for the riverine plains of the Murray-Darling Basin alone).[69] Since dryland salinisation problems develop slowly, it is important to make every effort to look decades ahead and try to determine the potential severity and extent of the problem. **Given our present knowledge, dryland**

and weathered/jointed bedrock to the atmosphere. The cropping and pasture systems introduced following clearing cannot evaporate and transpire all rainfall entering the soil, nor can they use local groundwater to the same depth as the tree vegetation they have replaced. As water tables rise, strata previously only wetted intermittently remain saturated and where these strata contain soluble salts these will be dissolved and remain in solution. Salts are thus (re)introduced into upper soil profiles as water tables rise towards new equilibria.

Eventually, the soil surface is reached and direct seepage (groundwater discharge) to the surface initiated, especially on valley floors. Alternatively, before this happens, the root zone of the agricultural vegetation may be reached, resulting in its death and further accelerating the rate of water-table rise. There may be a corresponding increase in subsurface flow to streams and seepage to valley floors. Evaporation of surface seepage further concentrates dissolved salts and this prevents or retards the re-establishment of even salt-tolerant vegetative cover which, in turn, leaves the surface vulnerable to other land degradation processes. Generally, the more saline the encroaching local groundwater, the greater the range of susceptible vegetation, the larger the area where salinity levels are intolerable to roots and the greater the difficulty of re-establishing new vegetation. Nevertheless, salinisation processes are complex and time taken for dryland salinisation to appear following clearance of native vegetation in salinisation-prone areas is highly variable, sometimesup to 50 years.[71]

Fig. 2.3 The dryland salinisation process

Adapted from *Ecos*, **Vol.4**, 1978.

Acidification

While not such a massive hazard as erosion and salinisation, the slow acidification of soils under improved pastures in south-eastern and south-western Australia is threatening to reduce both crop and pasture productivity over large areas. **The problem is really only just emerging as significant acidification can take up to 50 years to develop and many of these pastures are only 30 years old.**

The problem is centred on 70 000 sq km of pastures using subterranean clover and superphosphate fertilisers. While these two form the cornerstone of southern Australian agriculture, their obvious immediate benefits have tended to mask the fact that, very slowly, they make the soil more acid. Problems of soil acidity may appear as any of several plant nutritional disorders caused by excessive or inadequate amounts of various elements. Acid soils release manganese and aluminium in quantities toxic to plants. Breeding of acid-tolerant plants is one solution which is being pursued, but application of large dressings of lime is the only practicable response at this time. Australian farmers, unlike European farmers, have not learned to accept the necessity for this expensive practice.[72]

Superphosphate boosts soil organic matter and hence organic acids; atmospheric nitrogen fixation into ammonia by clovers releases acidifying hydrogen ions. Nitrate pollution of groundwater can be an associated problem.

In many of the older improved pastures of southern Australia scattered reports of failures of lucerne plantings, clover decline and manganese toxicity in rape provide just a hint of what will happen on a large scale unless remedial action is taken.

Dammed rivers

There are problems in Australia when it comes to managing water resources by damming rivers to allow flow rates to be matched to user needs

* water resources are not near population concentrations

* good dam sites are scarce due to flat topography and porous soils (for instance, lack of suitable dam sites threatens to limit Darwin's population to 300 000);

* even if the average flow is the same, because of the large year-to-year flow variability in Australian rivers, a dam here needs to be about 11 times larger than a dam reliably delivering the same water in the United States

* over the continent, evaporation losses from dams are generally high. As reservoir size increases, the larger the evaporation loss in relation to volume stored and there is a maximum size above which a dam cannot usefully store water.
The only advantage that the Australian environment possesses for water storage is that of a comparatively long life for dams because of the low rate of geological and man-made erosion and thus of siltation.

Not to be discouraged, we now have more than 300 large dams, including 117 on the Murray-Darling system alone. Since 1970, however, proposals for major water resource projects have been scrutinised much more closely than before. Previously dams had been seen as catalysts for regional development and as highly successful political handouts rather than as economically justified development projects. Large storage construction has slowed down, e.g. only three of the eight very large storages in New South Wales have been built since 1967. We are probably approaching the stage where only the political pressures to supply water to large *urban* populations will suffice to get major new dams built.[73] The Victorian Government has just recently welched on a commitment not to draw Melbourne's water from north of the Great Dividing Range.

River management issues
Due to zealous vegetation clearing and other landscape disturbance in their catchments, most rivers in the more densely settled parts of Australia probably carry a lot more sediment today than in pre-European times. This sediment gets deposited in dams where it shortens their effective storage life or ends up silting coastal lakes and estuaries. This has two effects; it makes subsequent floods bigger and better and it reduces the biological complexity and range of habitats in riverine ecosystems. This has further consequences for fisherpersons and recreationists, among others. The common practice of desnagging rivers (removing fallen timber) to improve flow rates adds to the loss of natural fish habitat. To date no big dam has gone out of commission as a result of silting up.[74] The Burdekin dam in north Queensland is one which is silting up rapidly.
Australia's flatness means that we have never had more than a few **wild rivers** suitable for such recreations as white-water canoeing.[75] Dams and locks have subdued a number of these and others are under threat.

Eutrophication (the fertilisation of rivers and lakes by runoff from farming areas where fertilisers have been applied) is widespread, except in northern Australia. Such additional nutrients promote algal growth which in extreme cases leads to total transformation of riverine and inshore ecosystems. Coral reef systems are at particular risk because corals normally thrive only in low nutrient conditions (nutrient `deserts'). Eutrophication is hard to control because it is usually caused, unintentionally, by the actions of many people over a wide area of catchment. Changes to flow regimes associated with river regulation, particularly the reduction in *moderate* floods, release of cold water and rapidly fluctuating water levels have had a significant effect on native aquatic biota.[76] For example, warmwater fish have been replaced in the lower reaches

Fertility shifts

A community of living things, an ecosystem, requires 30--40 chemical elements for survival. Some of these flow into the ecosystem, pass through its plants and animals and out again as part of the carbon dioxide, nitrogen, oxygen and hydrologic cycles. The rest, including phosphorus, potassium, calcium, magnesium, iron, sodium and the so-called trace elements largely come from the weathering of the rocks of the earth's crust.
In a natural undisturbed steady state, the flow of these `crustal' nutrients into and out of the ecosystem is usually small compared with the quantities which circulate within the system. In an undisturbed forest, for example, the quantities of crustal nutrients held in leaves, litter and soil flora and fauna are much greater than the quantities coming in from weathering and leaving via soil erosion, `harvesting' etc. Destruction of an ecosystem's vegetation can lead to accelerated loss of its nutrient `building blocks' and hence to a reduced capacity to regenerate a community similar to that existing before disturbance. Trees, for example, play a role in `pumping up' nutrients leached deep into the sub-soil.[78]

Harvesting (removing) ecosystem products, not necessarily by man, can similarly reduce regeneration potential, the impact of this loss being dependent on the soil's natural fertility, i.e. its available reserves and the rate at which `new' crustal nutrients become available for building plants and animals.

One ecosystem's loss though is another's gain. Accelerated loss from one ecosystem will boost the nutrients available elsewhere. If the receiving ecosystem is `deficient' in the bonus nutrients, it will begin to support more plants and animals and adapt to change the numbers of one species relative to another. Natural fertility sinks for lost nutrients include animal camps, termite mounds, bat camps, run-on groves in arid areas, estuarine sediments and coastal mudflats. Australia's large populations of coastal wading birds depend on nutrient concentrations built up over many years in intertidal mudflats.

Before European settlement, most parts of the continent, including the continental shelf, would have been experiencing relatively small changes in their pools of crustal nutrients available for supporting ecosystems; gains from bedrock weathering would have matched eventual losses to the ocean depths, with nutrient transfer in dust, sediment and runoff being the main pathways for this process.

One type of fertility shift which took place in geologic time has recently been recognised as being of critical importance to the survival of forest-dwelling mammals today. Wayne Braithwaite's work in east-coast forests shows that mammals are much more abundant in forests growing on fertile soils, i.e. soils developed on rocks containing high concentrations of nutrients.[79]

Causes of significant changes since white settlement in the distribution of crustal nutrients, called **fertility shifts** here, include:

* accelerated wind and water erosion, particularly of nutrient rich topsoils, following destruction of native vegetation;

* more frequent high-intensity bushfires leading to nutrient transport in smoke. Whether there has been a net fertility shift from more to less fire-prone regions is not known. Fires also have other less direct effects on fertility transfer such as increasing the risk of nutrient loss through erosion;

* widespread use of chemical fertilisers on crops and pastures. Australian wheat yields declined dramatically in the late 19th century, illustrating the limited natural fertility and poor cohesiveness of most soils. Eighty years of subsequent fertilisation have failed to lift yields much above 1.5 tonnes per hectare, approximately the same as in the early years of wheat cropping. The movement of fertility from Nauru, Ocean Island and Christmas Island, our main sources of rock phosphate for fertiliser, has of course been massive. Conversely, nutrient transfers overseas in (e.g.) 1976 wheat exports (8 million t) have been calculated to include 34 400 t of elemental potassium, 24 800 t of phosphorus, 12 000 t sulphur, 8800 t of magnesium and 2400 t of calcium.[80] Livestock exports in 1978--79 contained about 40 000 t of phosphorus which, together with phosphorus in grain exports, equalled 40% of phosphorus applied as fertiliser that year;[81]

toxic amounts; these are `on-site' fertility shifts, as are the effects of trees and earthworms in bringing subsurface nutrients to the soil surface;

* sheep camps. Sheep camps can provide useful redistributions of nutrients sometimes, by creating areas of up to 10% of a paddock where fertility loving out-of-season pasture species can flourish;

* sewage disposal. Cities like Sydney which discharge sewage at sea remove nutrients from effective circulation to a much greater extent than cities like Melbourne which use sewage to fertilise pastures. In the 1970s, about 4500 kg per day of elemental phosphorus was being discharged in Sydney's sewage, about five per cent of the amount applied annually to New South Wales crops and pastures.[82]

* Mining moves large quantities of minerals around, but this has little effect per se on the availability of nutrients to ecosystems.

Do we understand how natural systems work?

The idea of land systems

In the 1940s, Chris Christian and Alan Stewart developed the **land-system** concept to help describe the vast unknown natural regions of northern Australia which CSIRO were charged with evaluating for their agricultural potential. It is an extraordinarily powerful idea, resting on the observation that even complex landscapes are built up from a relatively few types of `mosaic tiles' or `building blocks' called **land units.** These are repeated in characteristic patterns over large areas (perhaps hundreds of sq km) with each pattern being called a **land system** . Each type of **land unit** can be described as having a characteristic type of natural vegetation growing in a characteristic soil on a characteristic type of terrain (Fig 2.4).[83]
Land units themselves can often be further `explained' in terms of the processes which favour particular sorts of vegetation on particular soils of a climatic region, or in terms of the processes which favour the formation of particular types of soils in particular parts of the landscape. For example, cracking clay soils impose such expansion-contraction stresses on tree roots in seasonally wet-dry climates that only grasses can survive on these soils.

The land-system idea is well illustrated by the following extract from a handbook issued by CSIRO Rangelands Research Centre at Alice Springs (now the Centre for Arid Zone Research).

> To the casual observer it may appear that the semi-desert regions of central Australia are vast areas of flat to undulating landscapes vegetated with Spinifex, Mulga or Mitchell grass. However, the landscapes of central Australia are quite variable and include a tremendous range of environments. In general terms central Australia consists of a number of basin and range structures which are broad and flat. There are five main landscapes with topography, soils and vegetation strongly correlated. The cross section of typical basin and range topography shows the relationship between the units.
>
> The five main landscapes are
>
> 1. Hills. The highest parts of the structures are hills and mountains with rocky slopes and narrow valleys. These rugged areas usually have spectacular scenery. But, more important, they are the catchment areas for water.
>
> 2. Foothills, piedmont plains and floodplains. These occur as a fringing strip adjacent to the hills and extending into the basins along

Fig. 2.4 Block diagram of a land system

From Perry, 1962. The figure is a page from a land system survey report of the type produced extensively by CSIRO from the mid-1940s to the mid-1970s. The block diagram illustrates the `shape' of the country and positions the land units or landscape building blocks described in the table.

Fig. 2.5 Cross-section of a central Australian landscape

From Anon, 1981a. The diagram shows a typical cross-section of basin and range topography in central Australia. The photograph (Courtesy W. van Aken, CSIRO) illustrates the left hand section of the diagram down to the foothills. The laterite plains and sandplains extend for 50 to 240 km.

similar land units in the same locality. The handbook quoted above goes on to describe the strong association between the five landscapes and land use in central Australia

> Pastoral pursuits (cattle predominantly) are heavily dependent on the foothills, piedmont plains and floodplains. Most of the cattle graze on these landscapes for most of the time and the majority of station homesteads are on or near them. The lateritic plains are inferior, but are important as a reserve during extended dry seasons.
>
> Aboriginal land use is concentrated on the foothills, piedmont plains and floodplains with some use of the Spinifex sandplains and dunes. The absence of water in the latter and the pressure from cattle grazing on the former make for potential land-use conflicts.
>
> The use of the rangelands for recreation tends to be concentrated on the rugged areas with spectacular scenery such as the MacDonnell Ranges and Ayers Rock and the Olgas. On the other hand livestock industries mainly utilise the very extensive flanking plainlands. Thus while there is scope for more integration between these two industries, they tend not to compete for the same areas and are thus complementary. There has been an upsurge in the reservation of National Parks and Flora and Fauna Reserves, some of these lands were former pastoral leases but in other instances specific environments with no former defined use have been put aside.

Land systems recognise the systematic way in which, over large regions, soils, plants and animals change as one moves from the higher to the lower parts of the landscape. Do we understand why particular types of land occupy particular parts of the landscape? It is largely the movement of rainfall runoff from ridges to drainage lines which is responsible. In semi-arid landscapes for example the movement of water from runoff areas acts to concentrate the limited resources of both water and nutrients into run-on areas. In central Australia much of the mulga country consists of a grove-intergrove pattern, with each unit consisting of a closed runoff-run-on system for falls of rain of less than about 25 mm. About 95% of both ground vegetation and trees grow in the run-on groves.[85] Run-on groves in turn become refuges for the survival of small mammals which have difficulty in moving between widely separated refugia (unlike birds).

Before leaving land systems, consider the word *land*. Christian and Stewart use it in the same rich sense as Aldo Leopold.[86]

> By land is meant all the things on, over, or in the earth.

It is extremely useful to have a word which encompasses the plants, animals, rocks, soils, waterbodies etc. in an area, perceived at a human scale, i.e. with the naked eye. This is how *land* will be used here.

A change in the weather story

ENSO

While land systems are a powerful tool for understanding the spatial distribution of our

El Nino (meaning the Christ(mas) Child) is an area of abnormally warm water that occasionally appears off Peru in late December, possibly as a result of submarine volcanic activity. This warming and subsequent cooling down are associated with a reversal every three to eight years in relative atmospheric pressure and wind directions between the western and eastern Pacific---called the Southern Oscillation. It is the switch to higher atmospheric pressures and drier air masses over the Australian region which is significantly correlated with subsequent drought conditions in Australia. The full story is more complicated and still far from understood, but **drought prediction is now a very real possibility**.[87] This in turn will allow cropping plans to be modified, stock numbers to be run down in a controlled fashion, water supplies to be rationed and a host of other adaptive responses to be organised. Such optimism must be tempered by `chaos' theories which recognise that models of complex dynamic systems like weather often produce vastly different results under very small differences (errors) in inputs.[88]

Fig. 2.6 The El Nino process

From Brett, D., 1990. During an El Nino-Southern Oscillation event the normally warm waters of the western Pacific and their associated rain-bearing clouds move east away from Australia.

Long-term climate trends

Even if ENSO is imposing a short-term cycle on Australian weather, there are still the questions of whether we are also experiencing underlying long-term trends in or will experience sudden `permanent' shifts in such things as average rainfall, average temperature etc., either nationally or by region.

There is little evidence of persistent major climate change during the past 100 years of weather records. Despite the general acceptance of the reality of some atmospheric warming in coming decades as a result of increasing carbon dioxide levels in the atmosphere, there is no clear evidence of this translating into climate trends to date.

The problem is partly one of statistical method. Year-to-year rainfall, for example, is so variable that it is difficult to test whether a run of extreme years is the start of a trend or just an unsurprising sample---not forgetting the need to discount short-term cyclic effects before looking for long-term trends.[89] Non-scientists do not appreciate that the decision to accept a particular `signal-to-noise ratio' as indicating that a `real' change has occurred is ultimately personal and not an `objective scientific fact'.

Are Australian ecosystems different?

An ecosystem can be broadly defined as a biotic community (community of living organisms) and its abiotic (non-living) environment. As emphasised in popular texts such as *Web of Life*, the reigning paradigm of ecological science is to see ecosystems in terms of `food chains' or `nutrient cycling'. Carnivores, at the top of the food chain, eat nutrients in the form of herbivores which eat nutrients in the form of plants. Plant and animal by-products and plants and animals which die uneaten are broken down by micro-organisms (the decomposers) from complex to simple nutrients which are taken up by plants to be cycled up the food chain once more.

Well, yes and no

Ecosystems differ primarily in the groups of species which play these generic roles. South African ecosystems, for example, are universally known for their veldt-grazing `charismatic mega-herbivores' such as the lordly elephant and their canine and feline carnivores. In Walden Pond it is likely to be snails and insects eating algae, slime and duckweed and being eaten by fish and crustaceans. Ignoring differences in species per se, noteworthy features of Australian ecosystems include

Termites as herbivores. Thousands of years ago Australia had large herbivores and carnivores, African-style, but these were probably hunted to extinction, and their place taken by a few smaller herbivores such as the kangaroos---and termites. Termites perform the herbivore function of eating cellulose (some also eat wood lignin), the main structural component of plant material. Several species harvest grasses and their activities directly parallel those of grazing animals. In drier parts of the pastoral zone, the liveweight of termites and their cellulose consumption may at least equal that of grazing stock.[90] One consequence of this form of grazing is that nutrients tend to become `locked up' in termite mounds, remaining unavailable until the death of the colony and erosion of the mound. The exception is where termite colonies expand by hollowing out living trees which then benefit from being `fertilised'. In places, such hollowing out is important for creating nesting sites and refuges for birds and animals, further emphasising the key role of termites in Australian ecosystems.

Adaptation to fire and infertility. Australia appears to have provided a unique environment for the evolution of fire-adapted trees and shrubs suited to temperate climatic conditions and soils of low nutrient availability.[91] More, in regularly removing litter, fire may be substituting for the bacterial and fungal decomposers of wetter ecosystems.
Fire is an exceedingly complex and poorly researched determinant of ecosystem behaviour. Seasonality, intensity and frequency of burns, previous fire history, relative area burned, browsing or grazing pressure and access for recolonisation of fauna from unburnt areas are all important factors influencing the post-fire history of natural systems.[92] Some plant communities (e.g. lowland grasslands and heathlands) can lose diversity or become prone to invasion in the long-term absence of fire, whereas others (e.g. rainforest and alpine vegetation) take long periods to recover from fire.

European interference with `natural' or unregulated fire regimes can take two forms. Deliberately infrequent burning or even the attempted exclusion of fire can lead to intense wildfires and severe damage to flora, fauna and property. Conversely, a too frequent application of `prescribed' burning (i.e. prescribed according to the amount of ground litter accumulated) may cause an eventual loss of nutrients in smoke such as to reduce the more nutrient-dependent species in the community. Too short an interval between fires can also eliminate plant species whose juveniles are slow to reach a fire-resistant form.

The Australian fauna is also adapted to frequent fires. Limited experimentation suggests that wildfire does not seem to eliminate any species of bird or mammal, although abundances and relative abundances may change dramatically after fire. Intense forest fires, for example, can produce a flush of regeneration which can support large increases in animal numbers. More research is needed, however, before fire could be contemplated as a tool for routine management of Australian fauna.[93]

Defenceless plants and animals. Most of our flora has apparently evolved with few strong defences against the weakening effects of defoliation and trampling by mammalian herbivores (e.g. by concealing their growing tips deep inside their foliage). Many have not been able to survive the arrival of cattle, sheep and rabbits; the palatable upright kangaroo grasses of Victoria's western plains are a good example. Australian trees on the other hand have developed strong defences (e.g. leaf tannins) against insect herbivores and this partly explains the success of so many Australian tree species in other countries.
Before the arrival of the Dingo thousands of years ago, Australia had few large predators (*Thylacine*, native cats, eagles) and many small mammals with few defences against predation were widespread---we think. We do not know just what impact the Dingo has had but we do know that the rate at which small mammal ranges are contracting has increased markedly since the arrival and spread of the European Red Fox. Just why the fox seems able to wipe out mammal colonies that survived the Dingo is not clear, but that threat is critical to the survival of mammals and ground-nesting birds already reduced to a few colonies.[94]

Stop-go production. Over most of the country ecosystem activity is driven in stop-go

The predominance of low and variable rainfall means that arid and semi-arid ecosystems have evolved in such a way that each rainfall event produces a pulse of growth followed by a period during which declining soil moisture increasingly limits plant production. Around Alice Springs, for example, about 70% of single falls of rain only provide enough soil moisture to promote active plant growth for about four weeks. Rarely do follow-up falls allow this active growth to continue. Not unexpectedly, plants have developed characteristics which ensure survival through drought at the expense of those that favour high productivity.

Limits to prediction and understanding

Succession and disturbance

Ecologists have traditionally described how plant and animal communities respond to being **disturbed** (including being cut down, burnt, storm-damaged, diseased or, in general, being stripped of living material or **biomass**) as a **succession** in which the mixture and populations of species present changes predictably till an unchanging steady state called a **climax community** is reached. This traditional, unidirectional view of succession is nowadays seen as an oversimplification; communities recover from different types of disturbance in different ways.
The sorts of questions which can be posed about ecosystem recovery following a disturbance include[95]

* What is the path of recovery after the disturbance?

* Does the system recover to its initial state, or does it change to some new state? Alternatively, how far can a system be disturbed before regulatory mechanisms break down?

* If the system shows evidence of returning to the initial state, how rapid and complete is the recovery?

While ecologists have developed a number of useful concepts (e.g. **resistance** to disturbance, **resilience** in recovering from disturbance [96]) and associated measures for describing the observed behaviour of disturbed ecosystems, they still have a very limited ability to predict quantitatively (numerically), in terms of species numbers, the consequences of particular disturbances for particular ecosystems. Nonetheless, experienced ecologists can often make useful qualitative predictions about the directions of change of particular species populations following commonplace disturbances.[97] For example, while there are **redundant** species in most ecosystems, many have **keystone** species which, if removed, induce the loss of other species; the Cassowary is a seed disperser for large-fruited rainforest trees, probably the only disperser for some species.

One particularly difficult aspect of such predictions is whether or not species lost from a particular occurrence of a type of ecosystem will be replaced by recolonisation from other nearby occurrences of similar systems; predicting colonisation by `new' species is similarly difficult in the absence of empirical evidence. Australian ecosystems are especially difficult to study because of the massive and extensive disturbances they have experienced and the rates at which they are still changing in response to those disturbances.[98]

Box 2.3 Major sources of natural system disturbance

* floods, fires, droughts, storms

* pastoralism, mining, forestry, agriculture, urbanisation

* tourism and recreation

* clearing of natural vegetation

growing with the seasons. Disturbance, too, (e.g. by fire, by ploughing) will sometimes push an island up out of the sea ; it is disturbed landscapes which are most vulnerable (receptive) to successful invasions (expansions).
The `fortunate' species are the ones occupying islands large enough normally to support viable (self-sustaining) populations but also within dispersal range of other islands from which recolonisation can occur should catastrophe strike. Possibilities for successful inter-island colonisation depend on a species' **mobility/dispersal strategies** (e.g. winds versus ocean currents; flying or swimming versus floating) and the extent and inhospitability of the intervening sea. Barriers can be as diverse as mountain ranges (e.g. for small birds), temperature zones (e.g. Mountain Pygmy Possum) or prevailing winds (e.g. screw-worm fly).

While Australia has a wide diversity of biogeographical environments, many of them are relatively small and isolated and many species can find their habitable islands only within one or two of these regions. One of the significant hazards of predicted climatic change for such species is that their small isolated islands will disappear without other habitable islands springing up within colonising distance.

To a limited extent we can identify, in terms of climate, vegetation etc, what type of landscape qualifies as habitable, actually or potentially, for a species.[99] This is not quite the same thing as knowing the geographic distribution of that species.

Ecological islands tend to both lose and gain species under disturbance. The **equilibrium theory of island biogeography** states that the number of species on an island tends towards an equilibrium because of a balance between immigration and extinction rates. This equilibrium is determined in part by the size and position of the island. Small islands should have fewer species than larger islands because they have smaller populations that are more likely to become extinct. Isolated islands should have fewer species than islands close to a source of colonists because their remoteness makes them difficult to colonise. Ultimately, what happens on any one island depends on the mosaic of disturbances and responses on surrounding islands. The theory might be better named the equilibrium theory of **archipelago** biogeography. The equilibrium is dynamic in the sense that some species are regularly becoming extinct and being replaced by others.[100]

The continuing need for monitoring
We have learnt many of the principles governing the workings of the natural world.[101] There is commonly someone around who can `explain' why things are the way they are, how they got that way, and what might or might not happen to that system in the future. Much of that knowledge can be usefully expressed as rules of thumb, a form in which it can be passed from experts to apprentices. For example:

* If the predator on a generalised (unfussy) herbivore is removed, the herbivore's numbers will expand and extinguish all but the toughest plants, the numbers of which then limit herbivore numbers.

* The post-disturbance rate of recovery of species populations will be greatest for species which exhibit rapid individual growth rates, high dispersal capacities and large reproductive efforts.

* Species-poor environments fall into three general categories:

(i) `new' environments, in which the number of species is in the process of increasing
(ii) `severe' environments, which may lose all species with relatively slight environmental change
(iii) `unpredictable' environments, in which the variability of environmental properties around their mean values is relatively high and unpredictable, both spatially and over time.[102]

* The main result of using natural ecosystems for primary production (harvesting) is to reduce their species diversity (roughly, total number of species).
Commonly, such rules of thumb allow us to give a qualitative account of how the relationships between the `main' species operate (who eats whom, when and where) and the basic survival strategies of individual species. They can help with practical tasks such as identifying `fragile' ecosystems. Cold-country ecosystems are fragile because slow-growing vegetation takes so long to recover from disturbance. Arid ecosystems are fragile because they have very limited nutrient reserves to draw on.

controversial *Limits to Growth* study of the 1960s.[103] Natural systems are very complex (i.e. one change sets off cascades of consequences) and situations which intuitively appear the same according to some rule of thumb may be actually quite different in terms of the numerous **feedback loops** which regulate most such systems (in feedback loops a change in the amount of output from a process leads to a change in the amount of input).

Complexity aside, when all the rules of thumb have been counted, there still remain numerous starkly gaping holes in our scientific knowledge of particular ecosystems. For example, many flowering plants, perhaps several thousands, have not even been described and named; the roles played by invertebrate species (spiders, beetles etc.) and micro-organisms in ecosystem functioning are poorly documented and understood.

Our knowledge of the future is increasing each year in the sense that we are less commonly `surprised' by what happens. We are making comparatively little progress though in predicting what *will* happen as distinct from being able to list all the things that *might* happen. Partly this is because so much of what happens in the natural world is driven by events which, at best, we only understand probabilistically, e.g. that there is a 50% chance in western Victoria that the autumn rains will come before April. However, even assuming foresight about such important `random' events, we only occasionally have the knowledge to pick confidently which scenario will eventuate, e.g. just how much topsoil will be lost from this paddock *if* it rains x mm?

It is this limited ability to predict in quantitative non-probabilistic terms which makes **monitoring** of resources and environments so important. Monitoring is a substitute for having enough understanding to model trends. If it is important and if you cannot predict it then you have to keep measuring it! By regularly measuring how the important dimensions of a system have changed you can detect how close it is to approaching a **threshold state**, i.e. an estimated limit or boundary value where the ability of the system to perform the functions required of it is in jeopardy.[104]

This situation is no different from the way we have to manage socioeconomic systems. If unemployment gets too high as measured (monitored), some countervailing action such as reducing interest rates is taken even though the effects of such action cannot be accurately predicted. It is monitoring which then tells us if the countervailing action has worked or needs further adjustment.[105]

3. GAZING OUT TO SEA: THE INTERNATIONAL ENVIRONMENT

Living in a community of nations presents Australia with opportunities, problems and responsibilities. Many of these are resource-based in the sense that if Australia's, or any other country's, natural resources were to change or be used differently, our opportunities etc. would also change.

Are our resources special in a world context?

Special in what way? I am thinking more generally than the economic concepts of comparative or absolute or competitive advantage. Every country has unique resources but there are aspects of our resource complement which especially attract the interest of foreigners of various persuasions---investors, tourists and travellers, immigrants, scientists etc. Clearly, recognising the scope and origins of such interest is a necessary preliminary to deciding whether or not we wish to take advantage of that interest in any way.

Powerful landscapes

Australian landscapes raise powerful emotions in many of us but with one possible exception there is no reason to think any more powerful than any other native land. The exception is that modern Australia has produced a group of extraordinary painters who have `crystallised the mute stirrings of our responses to the land'. Had anybody ever seen a country town before Russell Drysdale painted pictures like `Sofala'? Now it is hard to see one any other way. Every time you take a trip to the back country, you see Drysdales all over the place![106]
For tourists, it is the colours of Australian landscapes which are of central appeal---red foregrounds and blue backgrounds

> Although distant mountains are blue, in fine weather, in many other parts of the world ... Australia displays some of the richest blue and violet shades ever seen. Whether it is the distant MacDonnells in Namitjira's watercolours, or the steep slopes of New England, or the Blue Mountains, or the distant view south from Kosciusko, the more lasting impression is one of colour even more than of form. The best viewing sites, seasons and hours of the day should be noted and made known for each notable landscape. Just as there used to be `colour clocks' and `colour

> calendars' in the old-fashioned gardens of England, there should be available similar observations and knowledge to Australians and tourists in Australia.[107]

One semiotic puzzle is the difference between interpretation of;s of the Australian landscape by visual and verbal artists. As Daniel Thomas has noted, most visual interpretations of the landscape see it as benign.[108] This contrasts with the death, destruction and despair which is so much the focus of our early romantic poetry as collected in books like *Austral Garden of Verse* (Hold hard, Ned. Lay me down in the shade once more ...).

The majority of course do not respond passionately to their ugly-beautiful land. The truth is, as Aboriginal lawyer Pat O'Shane has said, (white) Australians are frightened of the place. Park planners have told me that an axiom they follow in designing walking tracks is that average Australians will not venture more than 600 m from their cars. I have certainly felt scared on occasions when lost or `temporarily out of position' in the bush; I have felt apprehension on first encountering a new type of bush---like the towering, enclosing monsoonal tallgrass of the Top End or the dark mosquito-ridden depths of mature Brigalow.

Natural wonders

Marsupials are definitely special

Australian `beasts' have evolved unique strategies for coping with life's basic problems such as reproducing, eating and getting around. For example, recent work on kangaroos shows just how extraordinary their hopping is; as the kangaroo lands it stores energy in its leg muscles which is then released to aid the next spring. Also, its guts are loosely attached inside and as these flop up and down with each hop they drive air in and out of the lungs semi-automatically!

It is the wonderment factor which brings tourists to see our wildlife, but apart from an occasional `bird spotter' tour, we have done little to capture tourists who want more than `bus window' exposure to this richness. Another reason why our natural resources are so interesting to the tourist trade is that they are still relatively natural; that is a significant part of their appeal.[109]

Partly because the immature young of marsupials can be studied `in the pouch' they provide unmatched opportunities to understand many basic physiological processes. Australian scientists have seized the opportunity and continue to make significant contributions to mammalian physiology with all that this implies for medical science.

Even in the lower orders, Australians are special. We have ant populations of great diversity and antiquity for instance. Perhaps the Australian Tourist Commission could look into the possibilities for `ant spotter' tours?

A share of the World's heritage

The World Heritage Convention of UNESCO came into force in 1975, with the aim of ensuring international co-operation for the protection of outstanding natural and cultural components of the heritage of humanity. Each signatory country, of which Australia is one, is required to do everything possible to ensure the permanent protection of its World Heritage areas. Criteria for assessing whether a nominated area will be listed include uniqueness, evolutionary significance and cultural or natural value. Australia has seven areas on the World Heritage List including, most recently, the Subtropical and Temperate Rainforests of Eastern Australia in northern New South Wales and the rainforests of north Queensland. The others are

* Kakadu national park, a spectacular, biologically rich and (Aboriginal) culturally significant subregion;

* Willandra Lakes Region, an area of significance for charting landscape change and containing Aboriginal cultural remains up to 40 000 years old;

* Great Barrier Reef, the largest collection of coral reefs in the world;

* Shark Bay in Western Australia (since backed by the Federal Government);

* Nullarbor Plain;

* Kimberleys;

* Central arid zone;

* The Great Sandy Region of Cooloola and Fraser Island;

* Cape York Peninsula;

* Eastern arid region covering Lake Eyre and the Simpson desert;

*South-west Western Australia;

* Australian Alps;

* Sub-Antarctic islands (since backed by the Federal Government);

* Christmas Island and Rowley shoals;

* Houtman Abrolhos Islands.

The Figgis-Mosley book with descriptions and photographs of these areas is almost too painful to look at when you realise that you will probably never see most of them. Australia is a truly wonder-filled place.

The idea of placing areas on a World Heritage List is a bit like awarding medals in wars--most of the heroes do not get one. The world is full of places which should be preserved for coming generations. Nevertheless, `the medium is the message' and the mere existence of a World Heritage List draws attention to some of the `jewels in Earth's crown'. On the one hand listing probably protects an area from flagrant destruction; on the other, the increase in visitors which listing brings is likely to accelerate natural deterioration. On balance, a sensible strategy would be to get as many Australian places listed as possible, after confirming by proper procedures that controlled tourism, conservation and the provision of `environmental services' were to be that place's primary functions.

Also of world significance are the 12 or 13 Australian national parks which have been nominated as Biosphere Reserves. As planned under the UNESCO-sponsored Man and the Biosphere program, this system of reserves is intended to represent relatively undisturbed samples of ecosystems in the full range of bioclimatic regions to be found on each continent. We have 18 or so bioclimatic regions as mapped at global scale and the six or so unrepresented regions are predominantly in Queensland. Each unrepresented region already contains at least one large national park and it would be undemanding to complete the Australian complement of biosphere reserves.[111]

Rare minerals, abundant minerals

The development of advanced materials is a major frontier of so-called sunrise technology which the Australian government identified as a key research area, somewhat belatedly, in 1985.[112] The list includes ceramics (e.g. for engine blocks, high-temperature superconductors), plastics, new alloys, composites (e.g. for airframes), semiconductors, optical fibres, biomaterials (e.g. for body parts). What is relevant from a resources perspective is that Australia has major reserves of many of the scarce minerals which are inputs for producing these new materials, e.g. 30% of the world's known deposits of zircon, eight per cent of the world's titanium, large reserves (i.e in the top five countries) of tungsten, cadmium, tantalum, bismuth and manganese and 50% of the world's yttrium (emerging as a key to producing high-temperature superconductors).[113] As well as the possibilities for exporting, having reserves of rare minerals would appear to confer an absolute advantage for undertaking their subsequent processing and fabrication.
Australia yields a wide variety of gemstones including 70--80% of the world's sapphires

Some major overseas-financed farming ventures (including Lakefield Downs, Tipperary and Coastal Plains) have been predicated on importing superior management and adequate capital to achieve economies of scale and have foundered on technological arrogance and harsh seasons. As the original Anglo-Celtic settlers found, you need experience and luck to make a pile farming in Australia.[114]
What is true is that we have a comparative advantage in farmed land---over three ha of tilled land per person in Australia, perhaps 10 times the average for the rest of the world. More, this figure has been growing, at least till recently, whereas in many of the older developed countries it has been declining with population growth and urban expansion.[115]

Diverse living environments

Australia extends through 33 degrees of latitude and has almost the full range of habitats found in the whole of the rest of the world. The range of living environments, work environments, play environments available to Australians and their visitors is as varied and accessible as anywhere, although a little short on snowfields perhaps. My gratuitous contribution to the tourist industry is the idea of `high-diversity' tours: coral reefs, rainforests, deserts, high country, wilderness and wild rivers---all in 10 days.
The image of Australia which seems to appeal overseas is one of outdoor living and beach-oriented recreation. Our tourist promotions naturally de-emphasise stingers, crocodiles, sharks, sea snakes, mosquitoes, bush flies, sand flies and skin cancer. The oppressive northern `wet' season has been given a marketing facelift and become the `green' season. Ha Ha.

Some of the things which have traditionally been regarded as drawbacks to life in Australia are emerging as tourist assets in an overcrowded world---empty space, isolation, deserts, wilderness.

Takeaway flora and fauna

Trees for chipping, trees for growing
Despite our limited forest resources, we seem very willing to make our eucalypt forests available for woodchipping at bargain-basement prices to Japanese interests. The reason for allowing this is usually given as jobs and job protection. More sustainably, Australian eucalypts, sheoaks and acacias are now valued and grown in over 70 countries for firewood, shelter and timber. By further research into matching species to environments (we have over 500 *Eucalyptus* species) it should be possible to expand this achievement, particularly in the Third World where eucalypts have been very successful in protecting soil and helping to support burgeoning populations in various ways.

Wildflowers and other plants
Australians have been slow to take commercial advantage of their native flora. There are undoubtedly major world markets for Australian native plants, both as cut flowers and in pots.[116] Australia has over 600 species of orchids alone for instance. The annual wildflower displays of the Perth and Kosciusko regions are sufficiently colourful to attract tourists in large numbers. The downside is that of the commercially exploited species (banksias, boronias, kangaroo paws, ferns etc.), 34 have a very restricted distribution and 12 of these are considered endangered or vulnerable.[117] Tea-tree oil, extracted from the leaves of *Melaleuca alternifolia*, contains a natural antibiotic and is low in skin irritants, making it a powerful agent for helping to heal wounds. Demand is strong and *M. alternifolia* plantations are being established as an alternative to harvesting natural stands. To maintain a commercial edge, breeding and selection for oil content will be necessary.[118]

Breeding to the point where plant-variety rights have been granted has recently created the possibility that Australia might at last reap commercial benefit from Macadamia nuts, the one tree crop she has given the world. Up till now, Macadamias have earned far more for Hawaii than for Australia.

Songless bright birds

The unknown sea

Establishment in 1979 of the 200 nautical mile Australian Fishing Zone under the Law of the Sea Convention brought 8.9 million sq km of ocean under Australian control, the third largest fishing zone in the world (and that does not include any claim we might make with respect to waters off the `Australian ' sector of Antarctica). This is a large fraction of the world's oceans. While we are slowly learning about the resources and natural processes of the continental shelf, we know very little about much of this area. In the meantime its main interest to the world is its fish stocks.

Gaps in the Australian resource base

Offered three wishes to significantly change Australia's resource base, would we be inclined to accept? If Australia had been endowed with better soils and more reliable rainfall, it would almost certainly have been more heavily populated in 1788 and we might now be as overpopulated as (say) Africa. The same feature can be a problem or an opportunity depending on how you look at it and at the social and technological context. One can readily imagine a `problems' scenario rather than a `progress' scenario associated with almost any suggested `improvement ' in our resource base. What if we were less isolated for example? Being largely surrounded by oceans is nowadays a significant strategic and environmental asset. Even French nuclear testing in the Pacific offers no *direct* threat to the Australian environment at the present time.

What if we had a history of fighting off invaders? We might nowadays better appreciate what we have (assuming we won) and be prepared to work harder to nurture and protect it. **For every gain there is a loss, and for every loss there is a gain.** One generation's problems become the next generation's opportunities; the dead heart yields mineral wealth; trace elements open up the Esperance sand plains; the Birdsville track becomes a desirable tourist destination; climatic change wipes out the western wheat belt but creates a `sorghum belt' in north-central Queensland. On balance it would probably be safer to knock back the genie's three wishes.

International relations

Playing a part

There are many ways in which Australian resources and resource-using experience become available to foreign countries, companies and people. At the most obvious level we export minerals and agricultural products; we host tourists; we provide foreign aid in several forms including supplying experts in various resource-using technologies, notably dry-land agriculture and engineering.
There are other more subtle examples. As noted, eucalypts are now important trees for timber and fuel in many countries and since practically all of the hundreds of species are endemic (unique) to Australia, we provide seed to the world and have a clear duty to maintain the *Eucalyptus* gene pool for breeding improved varieties where they are needed.

To what extent do our resource exports hurt others? Our coal produces about two per cent of the world's carbon dioxide emissions (but less than its share of acid rain); our uranium ends up God knows where. Our mineral and agricultural exports are not highly subsidised by world standards but nonetheless probably take markets which would otherwise be supplied, in smaller quantities and at higher prices, by Third World countries. Sugar is the obvious example. By the same token, Australian grain exports keep lots of people alive and one seldom-heard `moral' argument for holding the Australian population constant is that this will allow us to remain a major exporter of food to a hungry world.

Pressures to do this and that

As the world gets hopelessly overcrowded in the next century, will we come under irresistible pressure to allow mass migration into our perceived empty spaces? The Northern Territory is the interface between Australia and south-east Asia. While not advocating frenetic efforts to `develop the North' to demonstrate that there is no room

Will we come under pressure to supply uranium for electricity generation? Will we come under pressure to reduce our rate of resource consumption? We are in the 26% of the world which consumes 80% of all resources flowing through the world's economic system.

And then there is commercial pressure. Are we going to be in the clutches of transnational companies keen to impose resource-management regimes which are not in the interests of ordinary Australians? The economist Ted Wheelwright has led the voices pointing out that Australia's mining sector is under a higher degree of foreign control than that of any advanced capitalist country and the significance of this for such economic management matters as exchange rates, balance of payments, capital transfers and tax avoidance.[120]

The world political regime which will have to evolve if large transnationals are to be controlled may well be the *force majeure* which determines just how our resources will be used to help a troubled world. **If we do not want to be forced to manage our resources under international guidance, we must, of our own volition, begin demonstrating that we are going to do our share to help the world through what looks like being a difficult century.**

Doing more

Transferring skills and recipes

Should we divert more of our resource-management expertise from being used in Australia to being used abroad? For example, the impact of sea-level rise next century in Australia will be negligible compared to its impact in the South Pacific and in Bangladesh. Recently Australia has offered to monitor sea-level change in the South Pacific (we cannot even monitor it properly here!). Should we be sending planners and engineers to such places to help prepare? Such action is self-interested as well as altruistic.

When work on our own problems yields results of use elsewhere, how much effort should we put into technology transfer? Current research into how to grow crops and pastures on the difficult red and yellow earths of the monsoonal north has potential application to a large part of sub-Saharan Africa, north-east Brazil and parts of Kenya and India.

A research contribution

The perspective of modern science is that we live on a small planet with limited resources. Nowadays many scientific studies of the environment must necessarily be based on an international, global view. To study the pollution caused by acid rain, the effects on the atmosphere caused by burning fossil fuels, the destruction of ozone in the upper atmosphere, the radioactive and particulate fallout produced by atomic explosions, the conservation of species and other problems, it is essential to consider the planet as a whole and to learn how to analyse global problems quantitatively. As the most politically stable, affluent and developed nation in the southern hemisphere, Australia has an obligation to contribute a southern perspective on global environmental problems. Australia has good scientists who, provided they are funded, can make worthwhile contributions to such international efforts. But science must not become a substitute for action.

Less panoramically, we also have an obligation to put some of our miserly aid funds into developing practical everyday technologies (stoves, wells, farm implements etc.) for less developed countries. While this can go badly wrong (inappropriate technology), producing more output from fixed inputs is the only hope for improved living standards which many countries have until they get their populations stabilised. Similarly, commendable moves are in train to ensure that all Australian aid is `environmentally sound', e.g. by formally assessing the environmental risks of programs.

Free riders?

We have an obligation (call it enlightened self-interest) not to become `free riders' on a wide range of resource overexploitation and global sink problems including

* pollution of the world's oceans (sewage, oil, garbage, toxic wastes ...);

country and even though we have high energy use per head we contribute little in percentage terms to these problems. Similarly, our isolation means that they impact relatively lightly on us. All the more reason to self-regulate our behaviour. If the moral argument does not appeal, think of it as a low-cost/high-return boost for our international image!

International treaties and conventions

Treaties which we have signed and which have direct relevance for resource management in Australia, quite apart from helping with resource management elsewhere, include:

* **Convention on international trade in endangered species of wild fauna and flora.** Signatories stipulate that government permits are required for all trade in listed endangered or vulnerable species. The aim is to reduce international illegal traffic in wildlife.

* **Convention for the protection of the world cultural and natural heritage** (the World Heritage convention).

* **Convention on the law of the sea.** The 1982 Law of the Sea Convention is a remarkable effort by about 160 countries to establish an overall framework for managing the world's oceans and their resources.[121] While extending Australia's `claim on resources' zone to 200 nautical miles, the convention obliges us to fish the area or licence others to do so up to a declared capacity set by Australia. The convention, for example, provides the `muscle' to ban the use of drift nets in the zone, nets up to 50 km long which snare all sorts of non-target species.

* **Australia--Japan and Australia--China migratory birds treaties.** These are basically conventions for the protection of about 90 species of birds which migrate between these countries and Australia, particularly including waders (such as the Japanese Snipe) and seabirds.

* **Ramsar convention on wetlands**. Thirty-nine wetlands with a total area of 44 549 sq km have been designated by Australia for inclusion on the **List of wetlands of international importance especially as waterfowl habitat**.

* **Biosphere reserves**. UNESCO has promoted the establishment of securely managed examples of `representative and outstanding natural and semi-natural areas of global significance', one for each major biogeographical region. As noted, Australia nominated 11 national parks as biosphere reserves.[122]

* **International convention for the regulation of whaling**. Australia has played a leading role in attempts to reduce whale catches to sustainable levels.

The meeting of international treaty obligations is an area where the Federal Government can legitimately be active in natural resource management. Though signing international treaties as a back door into increasing the scope of Federal participation in natural resource management seems a policy of despair.

A bit of an empire

Australia makes claims of varying validity on an awful lot of the world (Map 3.1):

* one old continent plus its 200 mile fishing zone;

* forty per cent of Antarctica (plus a fishing zone?);

* a number of island Territories including their fishing zones (Macquarie Island, Heard and MacDonald Islands, Cocos Keeling Islands, Christmas Island, Coral Sea Island Territories, Ashmore-Cartier Reef).[123]

Map 3.1 Empire of the Commonwealth of Australia

Even in winter, the sun only sets for a few hours a day on this empire. What are we going to do with it? We are certainly not going to defend it with guns.

Consider Antarctica. The ice-free parts amount to only a few per cent of the continent, but these areas tend to be extremely important for wildlife. Penguins, petrels and seals use the small amount of ice-free land and the near-shore fast ice for breeding and resting while relying on the ocean for food. **Biological processes such as plant growth operate slowly, intermittently and on small scales; they can be easily disrupted and they recover slowly. Antarctic ecosystems have to be classed as extremely vulnerable to disturbance.**

These ice-free areas are where tourist operators want to set up shop and where mining would be somewhat more feasible. But we need to know much more about Antarctic animals and their environments before being able to predict the effects of mining or tourism on their survival. Let the point be repeated in case it did not register. **We need to know much more about these animals and their environments before being able to predict the effects of mining or tourism on their survival.**

To date there is little evidence of fabulous mineral wealth. At this stage, a dollar spent prospecting in Australia looks like earning much more than a dollar spent in Antarctica (the Bruce Davidson argument all over again). Unfortunately, several countries are raising the possibility of state-subsidised mineral exploration.

Australia has now decided not to sign the **Convention on the regulation of Antarctic mineral resource activity**. Phillip Law, founder of the Australian bases at Mawson, Casey and Davis, and a thoughtful man, says development of Antarctica is inevitable, indeed necessary, but will not significantly affect environmental values if tightly controlled; we should therefore help design those controls.[124] Paul Keating says such a convention would be like a starter's gun for miners and I am inclined to agree. We will have to be prepared to throw every trick in the International Law book at anyone who tries prospecting the Australian claim.

The biggest current threat to Antarctic ecosystems is not mining but krill harvesting. While it is true that these small crustaceans exist in enormous numbers in Antarctic waters, harvesting by Japanese and Russian trawlers is quite possibly reaching a stage where species which depend on krill---seals, whales, penguins etc.---will be reduced in numbers. As a warning, overfishing has probably been primarily responsible for documented declines in Arctic bird and mammal populations in recent years.

In principle, we should be prepared to accept United Nations control of Antarctica, preferably as a managed-use park in the style of the Great Barrier Reef Marine Park. A Sydney firm of cold-climate architects, Helmut Rohde and Partners, has been designing an environmentally sensitive tourist centre for Antarctica for some time which includes portable self-contained energy-efficient buildings and a year-round ice runway for large planes. If such ventures could be guaranteed not to grow and not to affect bird and animal numbers, they should at least be regarded as an option. On equity grounds though, any such limited tourist access, if ever approved, should not be rationed by price.

Drawing boundaries in the seas between Australia and her various neighbours is a complicated business and only just finished in the potentially oil-rich Timor Sea between Australia and Indonesia.[125] The agreement there for a `grey area' where oil ventures will be undertaken jointly by the two countries is a sensible compromise (albeit an unequivocal acceptance by Australia of Indonesian sovereignty over East Timor).

Learning from others

One of the advantages of a federal system of government is that the member states can learn from each other's experiences. Similarly, Australia can and must learn from the resource-management experiences of other countries.
Historically, the United States has pioneered several institutional arrangements and social technologies which we have quickly adopted. The Royal National Park near Sydney was the second national park in the world, declared several years after Yellowstone; the New South Wales Soil Conservation Service started soon after that of the USA.

In 1970 the US congress passed a *National Environmental Policy Act*. This proved to be landmark legislation which laid the ground rules for environmental protection both in

adopted its own version of the US legislation in the *Environmental Protection (Impact of Proposals) Act 1974*. In my opinion this Act has, in itself, been a near total failure. It has however spawned several State Acts which have been considerably more successful. The point is that by being aware of resource-management innovations in other countries, not necessarily with similar political structures, we have the chance to identify, and vicariously test, innovations---social technologies---for tackling our own problems.

But do we need formally to foster such a monitoring capability? Australians travel a lot and, in academic circles at least, keep well abreast of the professional literature. Probably some awareness of most overseas developments is usually present somewhere in the system, but the machinery for alerting and briefing the State and Federal decisionmakers who could decide to adapt and adopt such developments is lacking.

The obvious conduit for such diffusion is the established system of ministerial councils where State ministers with comparable responsibilities meet periodically to discuss matters of common interest and, sometimes, co-ordinate actions or legislation. For resource management, the most relevant ministerial councils are probably Council of Nature Conservation Ministers, Australian Environment Council, Australian Agricultural Council, Australian Soil Conservation Council, Australian Forestry Council. These councils are backed up by a powerful system of standing committees and various working parties.

The need is for a social technology where academics, resource-management professionals and the public are regularly invited to make suggestions for improving resource-management arrangements. This could be done, for instance, through a **Ministerial Councils Advisory Committee** given the single task of scrutinising current approaches to resource management and formulating options for alternative approaches. This Committee would report to all relevant Ministerial Councils, reflecting the perception that resource management cannot be tackled only on a sectoral basis. For example, the Advisory Committee, if it were functioning now, might be reporting on the success and relevance of America's experiment with **conservation reserves** wherein farmers are paid to retire unproductive land under threat of degradation.[126]

This is not the place to develop the Advisory Committee idea. The more important point being made is that, in its existing ministerial councils, Australia has its best chance of co-ordinating and collectively improving resource-management institutions. They are something to build on; we do not have to start from scratch.

At the other end of the resource-management spectrum, it is important that recent graduates and young resource-managers get every chance to travel, both inside and outside Australia, to see how things are done elsewhere. It is so much more efficient to learn from other people's mistakes than your own.

New Zealand

New Zealand is a good model of and for a progressive Australian State. They established something like our Commission for the Future years ago; they have grappled with drafting national land-use policy. New Zealand loggers and conservationists have recently shown Australia how diverse interest groups can reach agreement on an issue as delicate as the allocation of native forests.
Their institutions and values are close to ours but different enough to produce novel proposals for programs, policies, institutions etc. Certainly their unitary government system makes national programs easier to implement, but we shall be wise to monitor resource-management developments there. For example, they are at present undertaking a major reform of resource-management law, with the intention of redesigning their total system of management of natural and physical resources.[127]

New Zealand does in fact have membership or observer status on several Australian ministerial councils, including the Council of Nature Conservation Ministers and the Environment Council. Unfortunately, the reason seems to be more one of the New Zealanders taking the opportunity to learn from our mistakes and initiatives than the reverse.

Canada

The relevance of Canada to Australian natural resource management is that it is

Like the New Zealanders, the Canadians are well ahead of Australia in their attempts to think through the principles, the policies and the institutional arrangements needed to manage their natural resources better. For example, environmental impact assessment procedures have been particularly well developed in Canada. Also, it was Canadian researchers at the University of British Columbia who developed the collection of concepts, techniques and procedures known as Adaptive Environmental Assessment and Management, and intended to facilitate the design of creative resource-management and policy alternatives.[129]

A recent analysis of major issues in Canadian land use points up the similarities with the Australian situation.[130] Identified major issues were

* ecosystem maintenance;

* loss and degradation of prime agricultural lands;

* forest-land maintenance;

* loss of wildlife habitat;

* access to energy and mineral resources;

* coastal zone issues;

* northern development and conservation;

* issues of ownership and control;

* anticipating future land requirements;

* influencing the decisionmaking process;

* management of increasing demands and conflicts.

Sweden

The importance of Sweden is that it is a country which appears to be able to develop significant policies democratically and then set about implementing them without bogging down in a welter of rearguard actions by echelons of special-interest groups. They are decisive without being dictatorial.
Quite apart from their progressive social welfare policies, which are admirable but outside the focus of this book, they have been able to implement progressive environmental policies such as a staged reduction in the use of hazardous agricultural chemicals and the decommissioning of nuclear power stations.

Sweden is another small resource-based economy, or, more precisely, one which has moved from resources to resource processing to supporting industries. They may have lessons for us because of that, but I think the single most important thing we can learn from them is the value of giving people as extensive an education as they can absorb.

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4. PATTERNS IN THE DUST: CURRENT LAND USE

The reason why it is important to have a good understanding of how Australia is used at present is that we have to get to where we are going from where we are. In 50 years, very large parts of the place are going to look, at least superficially, similar to how they look today. Towns and cities may be bigger and built in different styles; there may be some flash new infrastructure like very fast trains around; certainly more people; some new mines; more parks; changes in farming patterns, hastened perhaps by climatic change and land degradation; more plantations and fewer clearfelled forests; and so on. The point is that, God willing, what we see will be in a clear evolutionary line running back to 1990.

To help paint a succinct picture of how Australia is used, it is convenient to think of the country as divided into seven overlapping **settlement regions**:

* The Ecumene

* The Farmlands

* The Sparselands

* The Coastal Zone

* The High Country

* The Forests

* The Mineral Enclaves

Each of these has a distinctive endowment of natural resources, opportunities and environmental constraints which has acted with social and economic imperatives to induce characteristic patterns of settlement and land-resource use. The patterns however are not rigid. The level and type of human activity has and will change over time in each region and, to some extent, region boundaries (which are pretty fuzzy anyway) will move as population grows and as industries come and go.

The Ecumene

The **Ecumene** is a mellifluous appellation for that part of the country where most Australians live (Map 4.1). Alternatively, it is that part of the country where the population density exceeds a value arbitrarily defined as `very low'. Table 4.1 shows the number of people living within half a day's drive

(150 km) of 18 points selected in such a way as to include as many Australians as possible.[1] Some 92.8% of the 1981 Australian population lived in one (or more) of these circles. There are four million people living within half a day's drive of Penrith (western Sydney) for example.

Map 4.1 The Ecumene, the sparsely settled lands and the `unoccupied' lands
Adapted from Holmes, 1985.

Table 4.1 Regions of the Ecumene (1981)

Rank and Name	Population	Cumulative per cent
1. Sydney	4 004 764	27.5
2 Melbourne	3 411 567	50.9
3 Brisbane	1 605 140	61.9
4 Adelaide	1 117 064	69.6
5 Perth	1 021 054	76.6
6 Canberra	481 689	79.9
7 Tasmania	398 804	82.6
8 North Coast (NSW)	255 406	84.4
9 West. Dist (Vic)	205 733	85.8
10 Sunshine Coast	162 791	86.9
11 Townsville	154 356	87.9
12 Rockhampton	123 821	88.8
13 Central West (NSW)	118 727	89.6
14 Riverina	111 976	90.4
15 Mackay	96 042	91.0
16 Gippsland	94 754	91.7
17 Cairns	89 668	92.3
18 South Coast (NSW)	75 194	92.8

The total area, excluding overlaps, of these 18 regions is 1.04 million sq km, about 14% of Australia. This represents a population density in the Ecumene of 13 people per sq km and a population density elsewhere of 0.15 people per sq km. For comparison, Bangladesh has a population density of 760 people per sq km, the USA has 25 people per sq km.

Capital city dominance

Capital city dominance has been the outstanding feature of Australian urbanisation since the middle of the 19th century. The proportion of the country's population living in the State capitals increased almost without interruption to reach 63% in 1971 where it has since more or less stayed.
Why do the majority of people live in the capital cities? Initially, it was a reflection of the

gold mining created concentrations of population in inland areas, the port cities gained added momentum from the trade and wealth generated by gold. The continuation of the trend into the 20th century has been fostered by industrialisation and the growth of tertiary employment, both preferentially based in metropolitan areas.[3]

It is an extraordinary settlement pattern by world standards, yet is not so unusual if one thinks of the Ecumene as being `Australia', with the Perth region an `island' separated from the East by an ocean, albeit one of red dirt.

Pros and cons of an extraordinary settlement pattern

The pros and cons of massive population concentration are difficult to sort out definitively. As individuals, we want to live in places which are interesting and convenient. If we were more dispersed we would experience fewer of both the economies and diseconomies which go with larger settlements: reduced travel costs, more crime, easier access to higher-order services, more pollution etc. If we were more dispersed, attempts to develop agricultural and mining enterprises outside the Ecumene would be less likely to founder because of the lack of infrastructure, particularly ports, roads and railways. On the other hand the very lack of people and activity outside the Ecumene is rapidly coming to be viewed as an asset, particularly by the landscape-based tourist industry. **People numbers and energy consumption are the triggers which initiate stress on natural resource systems and, by world standards, ours remain in a reasonably natural state outside the Ecumene.**

Population shifts

The above sort of debate is somewhat pointless unless it is to be used to guide the location of the extra population to which we are committed over coming years. Such guidance as there is at present occurs at local rather than at State or Federal Government level. We have no national settlement strategy (see Chapter 8). Shires, municipalities and metropolises attempt to steer whoever arrives into new housing developments, commonly sited by commercial developers with little consideration of the social costs and benefits of their decisions. With a myopic eye to rating revenues, few local authorities are interested in minimising local population increase. The Federal Opposition recently talked of encouraging migrants to settle in the Northern Territory, but not with a great deal of conviction.
Australians are fairly footloose; the average Queenslander moves every five years and the average Northern Territorian even more frequently. In State terms, according to recent censuses, a slowly increasing proportion of the population is living in Queensland and Western Australia although populations of other States are still increasing in absolute terms.[4]

For the next few decades at least, despite relatively greater recent increases in non-metropolitan populations, factors promoting urbanisation and centralisation are likely to outweigh factors promoting decentralisation (i.e. migration out of the larger cities), even though the marginal social costs of further centralisation are probably ever-higher. And this growth will be largely within the Ecumene. Why? The Ecumene contains the bulk of Australia's industrial (ports, railways, power stations), urban (schools, hospitals

etc.) and social (services, skills etc.) infrastructure. For most enterprises, development costs and operating costs are likely to be lower there. The only reasons for going outside the existing Ecumene are to exploit immobile resources (minerals, forests etc.) or to enjoy a different spectrum of amenity values (recreation, retirement etc.).

Within the Ecumene, it is the coastal settlements between Cairns and northern New South Wales which are going to grow most obviously and painfully. Perth is under something of a Greenhouse cloud, particularly in terms of water supplies, and has a more problematic future.

Impacts of urban growth

Concentrations of people impose a range of demands on the more or less fixed resources of the surrounding countryside. For example

* Demands for roading and building materials, which are expensive to transport, focus around urbanising areas.

* Developers have a penchant for ecologically sensitive areas such as dunes and for `creating' land by filling in swamps.

* Pollution problems emerge, basically because the limited assimilative capacities of regional airsheds and watersheds get `overloaded'.

* The growth of cities frequently increases the cost of supplying fresh produce (milk, fruit, vegetables etc.) to those areas. Housing and farming both have a preference for level, well-drained soils and developers can pay more for land than farmers.[5] Farmers are forced out into areas where transport and other costs are higher. While Australians have a liking for living on urban `quarter-acre' blocks, this does impose external costs on near-city farming, not to mention the higher costs of infrastructure provision compared with medium density urbanisation.

Inside cities there is a further set of resource-management problems concerned with such issues as transport systems, recreation areas, facility location. These are important and interesting but too detailed for this book. At the other end of the scale, the strategic issues of managing total population growth and the possibilities for extending or redesigning the Ecumene are considered elsewhere, primarily in Chapter 8.

Infrastructure replacement

One indirect impact of urban growth warranting more extended comment is on the rate of infrastructure replacement, both within and outside metropolises.
At the 1989 conference of the Institution of Engineers, Lex Blakey warned of an impending plunge in living standards and business efficiency due to the decay of public structures such as roads, sewers and telephone systems.[6] He estimated that annual spending on maintenance would have to increase fourfold over the next quarter century to halt the decay. Infrastructure replacement is indeed becoming an important issue in Australian urban development. Nationally, 80% of present roadworks budgets will be needed for maintenance of the road system by the end of the 1990s. Given the slow growth in budgets for infrastructure, the implication of major increases in maintenance needs is that there will have to be major reductions in funds for expanding and upgrading purposes. The South Australian Parliamentary Public Accounts Committee estimates that by 2010 replacement expenditure will swallow up all of today's capital spending budget for that State.[7]

Slowing the rate of population increase would be an effective way of making infrastructure budgets go further. **The point is, urban growth is a very real threat to the quality of existing infrastructure.** By not replacing infrastructure at the appropriate time, the present generation is imposing a burden on the next generation, a generation which is already destined to be burdened by having to support more retirees per worker than the present generation.

The Farmlands

Table 4.2 Land use in Australia---the broad picture

	Percentage of country
Arid and semi-arid grazing	43.7
Unused land	26.0
Non-arid grazing	17.4
Extensive cropping	5.8
Nature conservation reserves	3.5
Forestry	2.0
Transport corridors	1.2
Intensive cropping	0.3
Urban land	0.1

Note: Size of country is 7.7 m sq km.

Source: State of the environment in Australia 1985[9]

Recent changes

In the last 30 years the volume of Australian agricultural production and exports has doubled but the area of land farmed has increased by only 16%. That is quite impressive. The total number of all types of farms in Australia declined by 15% to reach 174 000 over the period 1957-8 to 1981-2 (this figure, by 1987--88, had dropped to 127 000). Over the same period, average farm size increased by 24% to reach 2800 ha and the rural workforce decreased by 19% to 389 000 (and is still much the same). Fewer people are working bigger farms more intensively.[10] The area sown to pasture has doubled; sheep numbers have fluctuated but are at present about the same at 149 million as in 1957--8. Beef cattle numbers have also fluctuated and are at present about 24 million.

The major change in broadacre agriculture between the late 1950s and the late 1980s has been the near doubling, from a base of 100 000 sq km (half wheat, half other crops), in area cropped to 180 000 sq km.[11] Why? Cropping has been more profitable relative to livestock production and there have been significant technological advances in crop agronomy, wheat breeding and machinery capacity. Expansion has generally been into regions of lower, more variable rainfall (less than 350 mm per annum), implying lower, more variable returns. Also, there has been a marked *intensification* of cropping in more favoured areas of temperate and subtropical Australia. In the subtropics there have been large increases in area of summer crops such as sorghum, sunflower and soybeans.

One consequence of crop expansion into marginal country and of problems associated with intensification of cropping (meaning percentage of years that a crop is grown on a paddock) in more favoured areas has been declining productivity. **Productivity** is the ratio of outputs obtained to inputs used. Despite substantial increases in inputs used in the wheat industry (machinery, herbicides, pesticides, new varieties etc.) the average annual increase in yields over the 1970s was a mere 1.8%. Productivity in the sheep industry, on the other hand, has increased substantially over the same period, largely due to an increase in sheep run per worker.[12]

During the 1970s and early 1980s, a period of continuing decline in farmers' **terms of trade** (prices received for outputs relative to prices paid for inputs), the rates of return to capital and management (excluding capital appreciation) on wheat, sheep and beef farms have averaged 5.0%, 3.8% and 2.1% respectively. Not exactly startling.[13]

Table 4.3 summarises the value of agricultural production for each agricultural zone, by 13 product categories, for the period 1983--87. The southern (28.7%), northern (12.2%) and western (10.1%) wheat-sheep zones and the southern high-rainfall zone (17.7%) dominate Australian agriculture by this measure. The surprisingly low contribution of the New South Wales high-rainfall zone is probably due to the under-recognised burden of extremely acid soils in many places.

Table 4.3 Average annual value of production (1983-87) of 13 product groups in 10 agricultural regions ($ m)

Table 4.3 continued _____

Source: Australian Bureau of Agricultural and Resource Economics

House paddock: the Murray-Darling

If the Ecumene is Australia's front garden, the Murray-Darling Basin (M-DB) is the national farm's house paddock. The catchment of Australia's most extensive river system occupies about a seventh of the continent (see Map 4.2) and produces about a third of Australia's total output from natural resource based industries. It supports 10% of the human population, a quarter of the nation's cattle and dairy farms, about half of its sheep and cropland, and almost three-quarters of its irrigated land.[14] It includes large parts of the northern and southern wheat-sheep zones and part of the

in recent years for areas sown to wheat in the Basin have been highest in north-western New South Wales and the western Darling Downs. In northern New South Wales and Queensland, where both summer and winter crops are possible, four crops (two summer, two winter) in five years are regularly achieved. Also, in limited areas of Victoria (e.g. parts of the Wimmera), there are a significant number of farmers who have sold all their livestock, often removed fences and established high-intensity cropping systems.

Two of the four regions in Australia where more than 10% of the total land area is regularly under crop are in the Murray-Darling Basin (Table 4.4). All four are suffering land degradation problems of one sort or another.

Table 4.4 Intensively cropped regions of Australia

	% of national cropland
1. WA wheat belt	26
2. Upper Darling Basin (NW Slopes and Darling Downs)	14
3. SA western and northern counties	10
4. Murray Basin (Murray Basin Slopes, Murray Plains)	10

	60

Source: Adapted from Osborn (1979)

The Upper Darling Basin;
The northern third of the Basin has undergone dramatic changes in land use, in terms of both diversification and intensification, since the second world war. These include steady increases in the production of winter grains, massive increases in summer grains and, more recently, cotton and oilseeds. Total livestock units have increased by perhaps 50%. Increased use of fertilisers and irrigation water have been the driving forces in this

transformation. **The options of running sheep or cattle and growing summer or winter crops make this the most flexible extensive farming area in the country.** The average wheat yield on the Darling Downs in the north-east of the Basin is nearly five times the national average. The Downs is commonly presented as a highly productive and efficient farming district, yet an average of four to eight mm of rich black earth is lost there each year as a result of soil erosion. At this rate, the fertile topsoil will be exhausted in 30 to 50 years. Over 10 000 ha have already been retired from cropping due to irretrievable erosion damage. Many of the upland farms in the Downs are small and probably only marginally economic. Consequently, farmers find it difficult to afford adequate conservation measures and to avoid cultivating the steeper (erodible) upper slopes. Ignorance and apathy play a part too.

Apart from erosion, which is well recognised, the Upper Darling Basin may be on the verge of experiencing more of the land degradation problems already being experienced further south. The intensification of the last 40 years has opened the way to salinisation, loss of soil structure and soil acidification. The input--output balances of water in the landscape have been massively changed and new equilibria have not been established. Current interest in the use of effective new arboricides to clear the poplar box woodlands, here and further north, will certainly increase short-term stock-carrying capacity but may also eventually induce extensive dryland salinisation. The link between tree clearing and dryland salinisation is comparable with that between smoking and lung cancer. It cannot actually be proved but giving up seems like a good idea.[15] Table 4.5 summarises clearing activity since European settlement.

Table 4.5 Vegetation change in the Murray-Darling Basin

	1988 Area (sq km)	1988 Area (%)	1788 Area (sq km)	1788 Area (%)
Grasses & Graminoids	340 393	32.7	46 416	4.5
Shrub lands	134 582	12.9	184 322	17.8
Low trees	230 592	22.1	262 204	25.3
Woodlands	283 262	27.2	389 697	37.6
Forests	51 973	5.0	154 535	14.9
Pine forest	1 210	0.1	-	-

Source: C. Parvey (pers. comm.)

Irrigation

The economics of irrigation schemes in the Basin have been strongly challenged by a number of authors. Bruce Davidson in *Australia wet or dry* (1969) draws attention to the massive infrastructure cost (channels, dams etc.) associated with setting up irrigation schemes and argues that using the same capital to extend and intensify dryland farming in southern Australia would have been far more beneficial to the national economy. Furthermore, at the time Davidson made this argument, the subsequent massive problems of soil salinisation and silting up of dams in irrigation areas had not emerged. Davidson's `opportunity cost' argument is analogous to the one he used so effectively in *The northern myth* (1966) to argue against intensive agricultural development (including irrigation schemes) in northern Australia. It seems unlikely

> It is practically impossible to irrigate and not have some water pass beyond the root zone ... The implication for this is that irrigation can in no way be sustainable without subsurface drainage as part of the irrigation infrastructure ... In time salinisation will take place if adequate drainage and disposal is not provided. The problem of salinity in irrigation will move from the problems of the Goulburn valley to Emerald and onto the Burdekin.[17]

There has been a trend in the last decade to introduce transferable water entitlements into the Murray-Darling Basin, so far only for water pumped directly by private diverters. To quote Don Blackmore, Chief Executive of the Murray-Darling Basin Commission:

> It is inevitable that transferable water entitlements will become a reality within the next decade. They are needed to formalize the market in water which already occurs via land sales. The development of transferable water entitlement policies can only enhance efficiency of water use and be of value from both an economic and environmental perspective. Transferable water entitlements will also provide significant salinity benefits in that water will invariably flow from the western more saline side of the Riverine Plain to the eastern side.[18]

It does need to be noted however that there are peculiar difficulties in creating water markets. Water resources are both public and private goods. A public good such as a river view or a healthy swamp is not marketable. It follows that if all water in a river is privately owned, there will be under-investment in such public goods. Before correcting for this, the difficult task of comparing the values of instream and offstream uses would have to be tackled. A further difficulty with water markets is that water transfers will not automatically protect third-party (downstream) interests and a social technology for ensuring this would be needed.

Privatisation of irrigation-supply infrastructure has been advocated both by governments wishing to be relieved of maintenance burdens and by farmer organisations smelling the chance to pick up assets at bargain prices. A survey by John Pigram and Helen Mulligan suggests that individual irrigators are not nearly so keen.[19]

Competition for land and water

It has been fashionable for some time to regard the `natural unit' for managing land resources as the river basin or, for smaller areas, the stream catchment. The argument is that because water flows downhill, what happens in the upper part of a catchment (e.g. water pollution, salinisation, damming) affects what happens in the lower catchment. Therefore decisions on activities in all parts of the catchment should be made simultaneously and with regard to their interdependence. This seems reasonable to all parties except those high in the basin. They are the only ones who cannot suffer from upstream decisions.

The Murray-Darling Basin Commission, representing New South Wales, Victoria, South Australia and the Australian government (Queensland has observer status) is an heroic attempt to implement this philosophy. South Australia is heavily dependent on the quantity and quality of Murray water coming from Queensland, New South Wales and Victoria. The Commission's impossible task is to reliably provide all `stakeholders', instream and offstream, with the quantity and quality (in terms of salinity, nutrients and turbidity) of water they want by storing and releasing it according to a definite strategy. In addition, they have to worry about a rapidly ageing water-supply infrastructure.[20]

For example, the Basin's irrigation industry, overlapping the Ecumene as it does, is likely to come under considerable pressure as the Basin is asked to play a larger role in providing urban water, including water to cities which are not even in the Basin, e.g. Melbourne. Adelaide, a city of over one million people, uses about 170 GL of water a year, with an average of 35% being derived from the Murray. In dry years this rises to 90%. Conservationists want regular flooding of the Macquarie Marshes and, to ensure river redgum regeneration, the Barmah Forest. Fishermen want access to full reservoirs. Water-thirsty pulp mills are needed to process pine logs from plantations in

From the headwaters to the terminal lakes, the salinity of the Murray becomes progressively more influenced by the natural inflow of highly saline groundwater. These natural inflows have been increased and will be increased still further in coming decades as a result of both irrigation and dryland farming practice. **Despite the Commission's Salinity and Drainage Strategy, changes already in place are likely to cause increased salt levels in the river over long periods of time.**[22]
What can be done? Reafforestation is normally promoted for its effect on dryland salinisation, but it should also have some effect on river salt levels. Another approach to reducing recharge of the salty regional aquifers which eventually end up in the river is to evaporate salty water off in selected `sacrifice' areas. What this allows is a tradeoff between really buggering a small area and somewhat degrading larger areas! Better irrigation practices and changes in water allocations have a part to play. There is also the strategy of praying that flow in the Darling, at least, will increase manyfold under the Greenhouse effect.

Overall, there is no clear strategy, no quick technological fix, for managing river salt levels. The problem can only be tackled by a mix of actions, none of which can have dramatic effects.

The Basin's land resources are similarly subject to an increasing range of demands including the need to conserve remnant vegetation communities, establish a meaningful system of conservation reserves, and provide land for newer uses such as extensive recreation areas, hobby farms and timber plantations.[23] The Commission is putting considerable emphasis on the formation of community groups which will identify key aspects of environmental degradation in their localities and develop and implement plans to address these. Alistair Gilmour sees these committees as `the most important innovation in environmental management in Australia in recent years'.[24]

Beefing up the Commission. Be assured, the Murray-Darling Basin is in trouble. Its land, water and biotic resources have been already or are threatened with destruction, degradation, pollution and exhaustion. We must have the courage to say that draconian measures are needed to save Australia's agricultural cornucopia. At least let us admit that strong action is an option. In the future, there must be multi-objective co-ordinated management of water, land and biotic resources, with the primary goal of managing these for the benefit of the whole community, not for special interests. This requires that the rights and duties of individuals, industries, towns and States with respect to water resources be clearly defined at the highest level.[25] The recently strengthened Murray-Darling Basin Commission is our best hope. The New South Wales Soil Conservation Service has initiated a program of Total Catchment Management but it gives every impression of being a toothless tiger armed only with a jawbone.[26]
The Murray-Darling Basin Commission is trying to establish its legitimacy at the moment, particularly in Queensland where little local need for such a body is seen. It is to be hoped that the Commission is soon in a position to consider and perhaps implement, by one means or another, a Natural Resources Management Strategy incorporating policies such as the following:[27]

* a moratorium on further clearing of native vegetation in the Basin;

* selective re-establishment of trees in areas where this would have maximum effect on the spread of dryland salinisation;

* purchase of cropping rights in marginal areas;

* imposition of erosion-retarding cropping practices;

* transferable water rights;

* a network of evaporation basins;

* water to be sold at full cost including amortisation of headworks;

* no new cities and carefully controlled expansion of exsting regional centres;

soils were developed rapidly after the second world war, using large machinery to clear the bush for cultivation. The agricultural system is based on winter-growing annual crops and pastures. The crops are mainly wheat or other cereals, and the pastures carry sheep, and occasionally cattle. Farms are large, often more than 1000 ha, and production per unit area is low by international standards. This low production is associated with low-rainfall, short growing seasons, and low fertility of the soils. Phosphorus fertilisers, and, on sandy soils, some trace elements must be applied to maintain yields.
Agriculturally, the region may yet contract as fast as it expanded; dryland salinisation is taking 250 sq km a year out of production and the region is earmarked for increasing aridity under current Greenhouse scenarios. Salt from rising water tables in agricultural areas has been leached into the rivers which flow from the Darling Plateau to the coastal plain. The Murray River (the Western Australian one) is now brackish. The large Swan and Blackwood Rivers, which were once fresh, are now too saline to be dammed for agricultural use or human consumption. This is environmental degradation on a tragic scale.

Agriculture and other land uses
Clearly, the present agricultural systems in parts of the Darling Plateau are incompatible with the production of potable water for Perth. Moreover, conflict between whole-milk production needs and urban needs for water are intensifying as Perth's population grows. Similarly, the vegetable industry on the dunes north and south of Perth is also facing urban competition over its use of shallow groundwater for irrigation.[28]
Not all the land-use problems in the South-west involve agriculture. The Jarrah forests of the Darling Plateau have multiple functions including water-resource protection, timber supply, conservation and recreation. The western Darling Plateau is being extensively mined for bauxite which is exacerbating the spread of the root-rotting Cinnamon Fungus (*Phytophthora cinnamomi*). This fungus causes Jarrah dieback, now affecting 10% of the region's forests.

Dieback is a major threat

Dieback of shrublands, woodlands and forests caused by *Phytophthora* species has been tagged a greater threat to conservation in south-western Australia than other more visible agents of land degradation such as salinity. Humans have been the main agents of dispersal of these introduced pathogens through movement of infected soil and plant material.[29]

With respect to flora and fauna conservation, only 7% of the wheat belt still has native vegetation and much of this is heavily degraded and losing both plant and animal species. Extraction of large quantities of groundwater on the coastal plain will dry up the chain of biologically and recreationally important shallow lakes which run north and south of Perth.

In the south-west corner of the country there are clear signs that diverse demands for the use of natural resources are overtaking the capacity of the region to meet those demands.[30]

... and the rest of the farm

Take out the Murray-Darling Basin and the south-west of Western Australia and the rest of the farm largely comprises the rangelands, the eastern coastal fringe (the high-rainfall zones) and the summer rainfall areas of central and north-central Queensland.

High-rainfall zones
Agriculturally speaking, the high-rainfall zones, where soil waterlogging is more likely to inhibit plant growth than soil dryness, range from the sugar lands of Cairns to the superfine Merino country of southern Tasmania.
The intensively farmed parts of the Queensland high-rainfall zone comprise the wet tropics of Cairns-Ingham, the Atherton tableland, the Burdekin, Mackay-Proserpine and Bundaberg-Maryborough. Apart from the recently deregulated sugar industry, the

on well-structured kraznozem soils with a great capacity to accept water.

Elsewhere in the high-rainfall zone, farming systems are well-established and without the overwhelming problems of so much of Australian agricultural industry. By the same token, prospects for large output increases are not obvious. Winter wheat for grazing and grain on the arable parts (say a third on average) of properties in the high-rainfall zone is an interesting possibility.[31] After all, Tasmania was once the granary of Australia! Livestock production based on productive improved pastures is particularly important. **The key to the relatively high standards of land management in the high-rainfall zones is that the land is valuable enough per unit area to warrant expenditure on improvements and, in the face of degradation, preventive and ameliorative measures.**

Central and north-central Queensland

North of the Murray-Darling Basin, and largely in the northern wheat-sheep zone, are the established cropping areas (grains/oilseeds, cotton) of the central highlands and the Dawson-Callide valleys of the Fitzroy Basin, and it is around the margins of these areas (as well as the edges of the Upper Darling Basin) that dramatic increases in crop area have been occurring. For example, between 1980 and 1984 the area of crop in Belyando shire (Clermont area) increased from 41 000 ha to more than 106 000 ha. While considerable potential for further westward and northward expansion certainly exists, the rate is likely to be dampened by the problems of developing stable farming systems in these climatically variable areas, the lack of suitable crop varieties and inadequate marketing facilities.[32]

Also throwing emphasis back to livestock farming is the continuing improvement in the range of pasture species available and the advent of efficient new tree-killing chemicals. There is a danger here. Clearing woodland on low-fertility soils raises its short-term carrying capacity but all too frequently leads to loss of fertility and the invasion of unpalatable species.[33]

The Sparselands

Most of Australia, 82%, has a population density of less than 1000 people per 8000 sq km and qualifies as sparsely populated, as what John Holmes calls the **sparselands** (Map 4.1).[34] There are no precise boundaries but the sparselands are essentially those parts of Australia outside the area identified above as the Ecumene and they therefore include a few isolated urban and mining centres such as Alice Springs, Broken Hill and Mt Isa.

Most of the sparselands can be further described as **rangelands** meaning that they are largely used for grazing sheep and cattle on native vegetation. In this sea of pastoralism, occasional islands of mining, urban and tourist activity appear. Climatically, the sparselands include the central arid zone, its surrounding semi-arid zone and the wet-dry tropics (five months wet, seven months dry) of northern Australia.

Discussion here of how the sparselands are used and the functions they perform will be divided into a general perspective on the pastoral industry followed by more focussed sections on (a) the Arid zone and (b) the North.

Mainly sheep and cattle: the rangelands

Australia's pastoral zone or rangelands, to use the American term more common nowadays, occupy about two-thirds of the continent and are used for sheep and cattle grazing on native vegetation (63%), vacant Crown land (21%), Aboriginal lands (12%), conservation (3%) and defence and other uses (1%). Sheep are mostly run in the more southerly parts of the rangelands where they are supposedly protected from predatory dingoes by a 9 960 km long wire fence stretching from central Queensland to the Great Australian Bight.

Property management

The pastoral industries are organised into very large management units; the average size of sheep properties is 210 sq km and cattle properties are much larger, averaging 2500 sq km. Practically all of the country's 4000 plus pastoral properties are held on long-term leasehold tenure, either by absentee investment companies or family-owned

Most properties are fenced into a few large paddocks with one or several watering points. Water is provided by drilled wells equipped with windmills or by surface catchment dams. Particularly in the cattle industry, but also in the sheep industry, stock movement is controlled as much by the distance between watering points as by fences. Shepherding is not practised. Pests and diseases are minimal so that handling of animals is reduced to lamb marking and shearing (sheep) and branding and selection for sale (cattle).[35]

Matching stock numbers to available feed is the major ongoing decision facing pastoralists. Do you start destocking after three dry months? four? five? Not only is feed-producing rainfall variable, but it is not generally recognised that feed production varies more than proportionately with rainfall. For example, when the rainfall received in a particular year is half the median, forage growth may be reduced to one-quarter.[36]

The basic nature of Australian pastoralism is such that there are fewer operations to upgrade than there are for agricultural production in higher rainfall areas. Fodder conservation is generally regarded as uneconomic, although the idea of setting aside `plantations' of mulga or saltbush as `living' drought reserves warrants further analysis. A technology permitting moveable watering points as a way of spreading grazing pressure would be welcomed. Proven successful rangelands management technologies identified by Barney Foran and others include[37]

* tick resistance and heat tolerance in cattle;

* use of aircraft and motorcycles for mustering;

* improved radio communications;

* polythene pipe and pre-cast storage tanks;

* trap yards and automatic stock-weighing facilities;

* low-cost electric fencing systems;

* `pour-on' parasite control;

* remote electronic monitoring of stock waters;

* prescription burning for pasture management;

* mineral supplements;

* computer-aided livestock marketing;

* multi-decked roadtrain transport;

* genetic gains in animal productivity.

The practical challenges are to increase labour productivity and maintain---not increase---carrying capacity. Increases in labour productivity have indeed been significant but the concomitant, given worsening cost:price ratios, has been to increase the amount of land needed for a viable owner-operator enterprise. Fortunately, restrictions in several States on maximum areas which can be leased by one person are being relaxed, albeit administratively rather than legislatively. South Australia has no limit on the amount of land which can be leased by one person.

Allocation and property rights

The issues which dominate discussion of management of the rangelands are almost exclusively concerned with some aspect of property rights, i.e. who is or should be entitled to do what, when and where, in the rangelands.

For example, an excellent 1981 report on the administration, management and tenure of South Australia's pastoral lands has major sections on:

* tenure

While Aborigines hold the largest proportion of Australia's rangelands after pastoralists, most of their land has poor prospects for viable grazing enterprises.[39] When colleagues and I first reached this conclusion, I thought it made an interesting contribution to the land rights debate, but no one wanted to know. Aboriginals do not necessarily want to use their lands for pastoralism of course but it is true that lands which are among the more productive for pastoralism will usually be more productive of native plant and animal foods.[40]

In that study, about 24% of the rangelands has been categorised as having high viability prospects (meaning it is capable of surviving climatically and financially hard times) and 41% as having medium viability prospects if used for pastoralism (Map 4.3).[41] About 89 000 sq km of this total remains ungrazed, two-thirds of which is vacant Crown land in Western Australia and South Australia (Map 4.4). This area, along with the 250 000 sq km still available for development as cropland or for improved pasture (largely in Queensland), constitutes Australia's last agricultural `frontier'. Whether the frontier should ever be pushed back is another question.

Map 4.3 Viability prospects for pastoralism

From Cocks and others, 1986. This map was produced by expressing the expert judgements of an experienced rangelands scientist about the viability of a handful of areas as a set of rules which were then applied to all the rangelands.

Map 4.4 Ungrazed rangelands with high and medium viability prospects

From Cocks and others, 1986.

The ungrazed areas of the rangelands effectively constitute an informal conservation `reserve' system for the various vegetation communities represented there. Rangeland types with the lowest percentage of their area currently ungrazed are the

Mitchell grasslands (1.0%), the semi-arid woodlands (1.4%) and the mixed-tussock grasslands (5.2%). **Approximately 50 000 sq km would have to be withdrawn from grazing, Australia-wide to meet the arbitrary but recognised target of conserving five per cent of each of the 10 main rangeland types in each State where they occur.**[42]

Has pastoralism a future?

Carrying capacity. The advent of pastoralism initiated a downward trend in the amount of standing vegetation across the rangelands. The degree of loss can be roughly inferred from trends in stock numbers with time. In all districts where this has been studied, stock numbers rise rapidly to a high peak following settlement. An even more rapid decline to about a quarter of peak numbers then occurs, generally in a drought period. Subsequently numbers stabilise at about a third to a half of their peak value, but this stable value is maintained only by the development of additional watering points which have the effect of increasing the area available to stock. In the Western Division of New South Wales, the great drought of 1901--02 brought sheep numbers down from 13.5 to three

million. Since then, sheep numbers have varied between two and five million, never reaching the old totals.
Has the inherent capacity of the rangelands to carry domestic livestock decreased in the last hundred years? Answering this question is complicated by the effects of runs of good and bad seasons and changes in uncontrolled grazing pressure, viz. increased numbers of rabbits and kangaroos. A run of good seasons can mask a slow decline in long-term carrying capacity.

For example, would it be possible to increase stock numbers in the rangelands once again if they were left ungrazed for a period? We do not know and perhaps it is not the key question. The answer is likely to differ from place to place. Rabbit grazing has stopped tree and shrub regeneration in some areas; it also exposes the soil to the occasional erosive rainstorms. Increased wildfire frequency does likewise. Physical trampling by increased numbers of domestic, feral and (some) native animals has also destroyed soil structure, increasing erodibility. **Over very large areas there has been an erosion of the fertile few centimetres of topsoil, and this is likely to be a major barrier to revegetation.** In the semi-arid woodlands of eastern Australia, loss of the original pastures has been followed by a steady increase of shrubs useless for stock. Fire is the best way to get rid of shrubs, but once shrub numbers pass a critical density, insufficient grass remains to carry a fire hot enough to destroy them. K.O. Campbell, as usual, puts the issues succinctly:

> What we want to know is whether a new ecological balance can be established which will enable an economically viable cattle industry to persist indefinitely. If the answer is no, then perhaps we should withdraw these lands from pastoral occupation and concentrate on more suitable areas of the continent. Perhaps the answer will be conditional--- a viable industry is possible provided institutional changes are initiated such as enlargement of holdings and the redistribution of land. Still another very real possibility that must be faced is that the lands of Central Australia can only be economically used for pastoral purposes as a slow mining proposition.[43]

Large lightly stocked properties are probably the only way in which short-term economic survival and long-term carrying capacity can both be ensured in the rangelands. Without these prerequisites, eventual degradation due to overgrazing is likely, given the cautious rate at which most graziers destock going into a drought. While land administrators have the power to regulate grazing intensity on any area of land, Australia has yet to find a truly successful way of preventing overstocking. Recommendations for a 43% reduction in sheep numbers in the Gascoyne (WA) catchment in 1972 raised a political storm. A social technology which has implementation difficulties, but which could be worth thinking through would be to purchase grazing rights on pastoral properties, effectively setting ceiling stocking rates and thus encouraging amalgamation. A cheaper alternative, but one with political difficulties, is to impose stocking rate ceilings as lease covenants. Because of the social benefits of retaining the rangelands pastoral industry, there is a strong case to be made for social technologies such as tax averaging, which allow some smoothing of pastoral incomes from year to year.[44]

Questions of social policy. Policy debate on appropriate future directions for Australia's pastoral zone will increasingly focus on social equity and quality of life issues. There are three major questions: Who shall provide basic services and under what conditions? To what extent should locational disadvantage be overcome by public intervention? To what extent should government endeavour to rationalise service provision by encouraging a restructuring of land use and settlement in remote areas?[45] Twentieth-century technologies (air transport, radio, satellites etc.) have enormously improved the quality of life in the rangelands, but it is still extremely expensive to provide basic communications, transport, health and educational services to the few people scattered through the bulk of the rangelands, meaning those areas inland from the Ecumene fringe and away from the handful of major urban centres (Darwin, Alice Springs, Broken Hill, Mt Isa, Kalgoorlie). Government continues to play the main role in providing these, commonly at subsidised or cross-subsidised prices. On efficiency grounds, there would appear to be a case to be made for withdrawing this support in, at least, areas with particularly poor viability prospects.

able social benefits in having a cover of people, no matter how sparse, across the rangelands. They demonstrate to the world that most of Australia has low potential for human occupation. Being highly self-reliant, such people might (or already do) act as nuclei for a range of operations including search and rescue, defence operations, surveillance and reconnaissance, weather recording etc. They could act as rangers or wardens for the protection of natural resources in various ways, e.g. controlling feral animals. They would of course have to be paid, and pastoralism might have to play a secondary, or even negligible, role in their activities. As the basis for a new social technology, the idea is not greatly different, in principle, from European ideas of paying farmers to farm in traditional ways rather than profit-maximising ways in order to protect landscape and wildlife values.

Arid zone

The **arid zone** is arbitrarily defined as those parts receiving less than 250 mm or 10 inches of rain a year in the south, 350--380 mm in the north.
The arid (and semi-arid) regions of Australia usually have only 10--70 rain days per annum occurring in 3--24 clusters of rainy days. Generally no more than 5--8 such clusters, and sometimes only one, are large enough to affect the life cycles of the region's plants and animals. Further, rainfall is spatially variable, occurring often in patches of only a few sq km. The flora and fauna of the arid zone have been well reviewed by Owen Williams and John Calaby.[47] Reptiles and ants are particularly well represented.

Five deserts and some mountains
It is place names which conjure up the arid zone. Gibson, Great Victoria, Great Sandy, Simpson and Sturt: the arid zone's five major deserts occupy 20% of the country.[48] Three mountain ranges, the Flinders, the Kimberleys and the Hamersleys, flank the country's arid margins, and in the centre there is another group:MacDonnells,Olgas,Musgrave and Petermann.[49] It is these harsh mountain ranges which provide the physical basis for the booming tourist industry.
Central Australia is too well vegetated to conform to the common concept of a desert, but the visual dominance of stony slopes and rock faces creates an impression of remarkable barrenness. The scarcity of meteorological stations makes it difficult to determine whether the ranges have moderating effects on the harsh climate, but stations above the 500 m contour enjoy about 50 mm more rain a year and lower temperatures than the adjacent sand plains.[50]

Rainfall gradients and complex geology combine to form a great diversity of mountain habitats. These habitats, in particular the sheltered gorges and waterholes, harbour species of plants and animals which are relics of former high-rainfall periods or are outliers of species that normally live in higher-rainfall areas. Examples of large relic plants are the palm, *Livistona mariae* and the cycad, *Macrozamia macdonnellii*.[51]

Competition for resources
Pasture ecologist Owen Williams once remarked that the whole of the central Australian cattle industry has about the same turnoff (deliveries to market) as a couple of good properties south of Dubbo. Ray Perry once observed that it cost CSIRO more to survey the Alice Springs region's resources than the land was worth. I have not gone back to check either figures, but the drift is right. Although the industry is hardly worth worrying about in production terms, it plays and will continue to play a key role in land-use--land-management debates, along with the other activities competing for a foothold in central Australia---tourism, Aboriginal lands, conservation, mining and recreation (including wilderness experiences).
The pastoral industry controls the bulk of the land in the central ranges. Most is too rugged to be managed economically; over large areas feral animals, notably horses, are completely uncontrolled and vegetation is unmanaged. The tourist industry wants access to this resource, but has no say in its management and is forced to focus on a few small reserves, all subject to rapidly growing tourist pressures.

There are numerous features in the MacDonnells and other ranges which could be included in tourist circuits. The Northern Territory Conservation Commission is planning a major park in the MacDonnells and this will be the trigger for a surge in visitor numbers. Great care will be needed to do this in a way that protects conservation values.

for facilities such as `over the horizon' radar stations. Rocket ranges and radar sites need big empty buffer zones and could in fact be very useful additions to the informal conservation reserve system.

Near Alice Springs there are substantial groundwater resources below largeish patches of soils suitable for horticulture.[52] Transport costs are the main barrier to supplying out-of-season fruit and vegetables to coastal cities. Large groundwater reserves also raise the longer-term possibility of `sunbelt' urbanisation in the style of the American south-west. In summer, the central Australian arid zone experiences some of Australia's highest heat-stress values, but winter is very pleasant.

The point to be made is that there is a clear need to plan central Australian land use and not leave development and conservation of the region to a series of ad hoc `first come, first served' decisions. It is my belief that if this were seriously attempted, it would still be possible to accommodate most interests reasonably well. **The sort of thing which goes wrong with piecemeal decisionmaking is that if two areas are equally suitable for use A, no attempt is made to develop the one which is likely to be less valuable for some prospective use B.**

The North

The North is sometimes thought of as everything north of the Tropic of Capricorn or north of 26°south, but it is more illuminating to think of it as three subregions---the Cape (Cape York and the Gulf Country), the Top End (of the Northern Territory including Arnhem Land and the Barkly Tableland) and the Kimberleys, the mountains of northern Western Australia. Life in all three is dominated by the profoundly seasonal wet-dry climate. In the future, life in all three will be increasingly shaped by proximity to Asia.
Since the beginning of non-Aboriginal settlement, northern Australian development has been firmly based on the commercial exploitation of natural resources---minerals, water, soils, vegetation and fauna. As is still the case, lack of industrial, urban and social infrastructure has been a serious impediment to development. Aboriginal lands and low-intensity pastoralism are the main extensive land uses, with pockets of mining, urbanisation, tourism and national park.

John Holmes describes the northern cattle industry thus:

> These are Australia's most inferior pasture lands, with their extremely low nutritional value in the dry season enforcing a grazing regime characterised by uniquely low stocking densities, usually below two beasts per square kilometre. Cattle are of poor quality suffering annual nutritional stress, poor weight gain, high mortality and calving rates commonly below 40%.[53]

Areas which can only be classified as inferior breeding country include north Kimberley, Top End, Northern Territory Gulf Country and Cape York proper. Nevertheless, the continuing replacement of British breeds of cattle with Brahman- and Africander-based breeds has the potential to lift productivity dramatically in the northern beef industry.[54]
Clearly though, the role of lead sector in the development of the North has passed from agriculture to mining, with tourism not far behind. Using a relaxed definition of northern Australia which includes the Pilbara and the Bowen Basin, the region now yields a substantial proportion of Australia's mineral exports and contains a high proportion of all currently planned mineral developments. Similarly, two of the major foci of the tourist industry, Kakadu and the Great Barrier Reef, are in the North, as are future foci such as Cape York and

Like minerals, much tourism is an `export' and this sparsely populated triplet of regions already plays a critical role in maintaining Australia's economic health. There is every reason to expect that this role will become increasingly and proportionately more important.

That is not all. The North is vitally important for three other reasons: defence, quarantine and conservation.

The yearly alternation between wet and dry seasons helps in promoting habitat diversity and thus species diversity. Dick Schodde has produced figures which confirm that Cape York has the richest higher-vertebrate fauna in Australia and that the Kimberleys and Arnhem land in the Top End are not far behind (Table 4.6). The Cape York flora (2533 recorded species) is similarly richer than the Kimberleys flora (1673 species).[55]

Table 4.6 Numbers of species of amphibia, reptiles, birds and mammals in the major faunal regions of Australia

Region	Amphibia	Reptiles	Birds	Mammals
Cape York Peninsula	49	176	380	97
Arnhem land	29	133	287	59
Kimberley	33	156	269	56
Central east coast and ranges	58	153	374	76
South-east coast and ranges	43	79	342	66
South-west Australia	24	109	255	48
Australia	179	600	710	246

Source: R.Schodde, unpublished data.

Cape York

The main resource-based activity on Cape York is cattle grazing on large properties around Weipa and the Mitchell River to the south. Despite the fact that graziers in the northern parts face difficult mustering conditions and an uneconomical 600 km trip to Cairns to market stock, pastoralism remains the main activity over much of the Cape. Down the western side of the Cape, and south of the Iron Range National Park on the east, there are extensive Aboriginal lands with sizeable communities at Weipa,Aurukun, Lockart River and Bamaga. These communities are among the few still in a semi-tribal state and, as such, vulnerable to cultural dislocation.
Natural-resource-based activities in addition to `cattle hunting' include

* Mining. Comalco's bauxite mine at Weipa sits on one of the largest bauxite deposits in the world, with the mineral lying so close to the surface that extraction is cheap and the venture profitable. The only other current mining activity in the Cape York region is an offshore gold mine on Horn Island.

* Fishing. The main target fish in the numerous estuaries of Cape York region is

increase the risk of outbreaks of exotic disease (see Chapter 7).

The need for such a land-use-planning exercise is greatly increased by the prospect of a commercial spaceport being built on the Cape. The Cape, north of Weipa, is well located to launch satellites cheaply (some 20% greater payload than from Cape Kennedy) and reliably into equatorial orbit.[57] Construction of the proposed spaceport would also require the construction of a small town and an all-weather road from the south and almost certainly would generate a tourist boom. The site favoured at present, Temple Bay, is particularly valuable for conservation and vulnerable to development. In terms of what is there now, a spaceport represents a massive social (e.g. Aboriginal communities) and physical (e.g. roads, acid exhaust gases from rockets) impact on the Cape. **Now is the time, the only time, to think carefully and synoptically about the economic and environmental future of the Cape.**

An exciting, but politically improbable way of managing Cape York Peninsula would be to bring it under the control of a new **Great Barrier Reef and Cape York Park Authority**. The Cape and the Reef are closely linked, ecologically and economically. The existing Marine Park Authority has demonstrated that it is possible to manage a great natural resource with respect for both utilisation and conservation interests.

Top End

The population of northern Australia is concentrated in the Northern Territory, particularly Darwin (70 000 people and falling) and Alice Springs (22 000 people). Because of a build-up in defence personnel, another 10 000 people will arrive in Darwin by 1995. The rate of population growth in the Territory was about four per cent per annum till recently, but has fallen sharply.
The primary production future of the Top End remains mixed:

* Broadacre dryland cropping (maize and sorghum) is still far from profitable and, in any case, would be limited to about 800 sq km in the Daly Basin.

* Commercial forestry faces a number of problems including cyclones, termites and woody weeds.

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[1] Cocks, K.D., and Walker, P.A., 1985.

[2] Blainey, G., 1966.

[3] Rowland, D.T., 1977.

[4] Australian Bureau of Statistics, *Censuses of population and housing* and *Australian demographic statistics quarterly* (various)

[5] McDonald, A.M., 1987.

[6] House of Representatives Standing Committee on Transport, Communications and Infrastructure, 1987.

[7] South Australian Parliamentary Public Accounts Committee, 1987.

[8] Davidson, B.R., 1967.

[9] Department of Arts, Heritage and Environment, 1985.

[10] Reeves, T. G. *et al.,* 1986.

[11] Australian Bureau of Agricultural and Resource Economics, 1989.

[12] Reeves, T.G., *et al.,* 1986.

[13] Reeves, T.G., *et al.,* 1986.

[43] Campbell, K.O., 1966.

[44] Drought policy review task force, 1990.

[45] Holmes, J.H., 1988b.

[46] Holmes, J.H., 1985.

[47] Williams, O.B., and Calaby, J.H., 1985.

[48] Williams, O.B., and Calaby, J.H., 1985.

[49] Mabbutt, J.A., 1983.

[50] Taylor, S.G., and Shurcliff, K.S., 1983.

[51] Griffin, G.F., and Morton, S.R., 1988.

[52] Fleming, P.M., 1983.

[53] Holmes, J., 1986.

[54] Vercoe, J.E., 1980.

[55] Clarkson, J.R., and Kenneally, K.F., 1988.

[56] Anon, 1989a.

Anon, 1979.

[57] Ford, J., 1988.

* On the other hand, the (small) buffalo industry has considerable scope for expansion in several markets: tourism, game meat, live-animal exports and pet meat. There is both potential and need for major genetic improvement in buffalo stock.

* The local fishing industry, based on barramundi in the estuaries and prawns in the Gulf, is growing rapidly at present. Under a bilateral agreement 135 Taiwanese pelagic fishing vessels operate in offshore northern waters.

* The environment (soils and climate) is very suitable for cashew nuts; world demand is extremely high and there is considerable genetic potential for increasing yields. Plantations are being developed at Adelaide River and on Melville Island. Lesser opportunities exist for other tree crops. Vegetables and flowers for Asian markets grow well and are being produced in slowly increasing quantities.[1]

The outstanding physiographic feature of the Top End is the treeless, sedge-dominated coastal floodplains. A major rice-growing experiment in the 1960s at Humpty Doo near Darwin failed to demonstrate that these floodplains, comparable with those supporting enormous populations in southern China, could be intensively farmed with technologies then available. Half a million Magpie Geese helped Territory Rice Ltd reach this conclusion. The prickly weed *Mimosa pigra* is emerging as a major problem on these plains. With 300 sq km of dense to isolated plants at Adelaide River, the area has, in effect, been abandoned and the tourist development there is threatened. The problem is not yet as bad elsewhere.[2]

Tourism. Tourism in the Northern Territory is predominantly park-based. The Northern Territory Tourist Commission is actively adding new tourist destinations to the major attractions of the national parks at Kakadu, Uluru and Katherine Gorge. The

* The rate of growth in cattle numbers and the rate of spread of improved *Verano* pastures do not suggest a major expansion in the offing for the beef industry. Nevertheless, the percentage of *Bos indicus* blood in coastal areas is now quite high. The Brucellosis and Tuberculosis Eradication Campaign has led to intensification of cattle operations in the better areas and withdrawals at the extensive margin. important to relieve pressure on Kakadu and Uluru, but this is far from the planners' minds. Rather, their complaint is that the Australian National Parks and Wildlife Service has managed Uluru and Kakadu too conservatively in terms of coping with booming visitor numbers.

Planners in the Conservation Commission have a better appreciation than those in the Tourist Commission of the need to `(i) conserve representative samples of major ecosystems; (ii) cater for current or projected recreation demands without compromising the visitor experience and threatening existing conservation values'.[3] To this end, the Conservation Commission has established a register of sites of recreation and conservation significance to guide their land acquisition and management programs.

Minerals. The mining industry has dominated other sectors of the Northern Territory economy (tourism, livestock, fishing) since the mid-1960s. The place is extremely rich in minerals . For example:

* Prospects for further major discoveries of oil (and gas) in the Timor sea, 300 km offshore, are excellent.

* About 13% of the world's uranium occurs at the Ranger, Nabarlek, Jabiluka and Koongarra sites in Arnhem land and other potential sources in the South Alligator Valley. Along with royalty rates and land rights, uranium mining has been a highly controversial issue in the history of mining development in the Territory.[4]

* The world's largest lead-zinc deposit (190 000 million tonnes) is located at McArthur River.

* One of the world's largest high-grade manganese mines is located on Groote Eylandt.

* The Gove Peninsula supports a major bauxite operation.

Kimberleys

Despite an area of 422 000 sq km, the Kimberleys support only about 15 000 permanent residents, mainly in the towns of Broome, Derby, Fitzroy Crossing, Halls Creek, Kununurra and Wyndham. This population would be higher if a 1940s proposal to establish a 70 000-strong Jewish settlement in the East Kimberleys had received Federal rather than just State approval. The then-Minister for Immigration, H.V. Evatt, refused to consider the proposal on the grounds that Australia encouraged only individual migration, not mass migration.[5]

The natural division of the region is into the East Kimberley based on the Ord River in the Carr Boyd Range, the West Kimberley based on the Fitzroy River plus the semi-desert plains to the south, and the North Kimberley bounded inaccessibly by the King Leopold Range to the south and the Durack and other ranges to the east. The Kimberley Plateau, which rises to 800 m and covers 130 000 sq km, is the dominant feature of the region.[6] Despite the extreme tidal range, large deepwater ports could be developed on Bonaparte Gulf if warranted.

Agriculture. The Kimberleys are either too dry, too steep or too stony for dryland cropping, but do contain good dam sites and sizeable areas of irrigable soils on the mighty Ord and Fitzroy Rivers. As is well known, the Ord River irrigation scheme has not proved commercially successful to date. About 700 sq km are suitable for irrigation from Lake Argyle, but the actual area irrigated has never risen above 60 sq km. Transport costs and insect pests have ensured this. Further south, along the lower Gascoyne River, good soils, a satisfactory water supply and the Perth market 1000 km away have combined to permit the growing of vegetables and subtropical fruits. It is not difficult to foresee Kimberleys irrigation farmers meeting the fresh-food requirements of the Pilbara and Darwin in a short time. Large-scale rice growing at Camballin on the Fitzroy River failed in the 1950s.

The cattle industry depends on small areas of productive river-frontage country, much of which has been badly eroded.[7] While most of the Kimberleys are held

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only very rich deposits are likely to be developed in the short term.

There are huge bauxite reserves on the species-rich Mitchell plateau, but little short-term prospect of these being developed given the plethora of alternatives. Oil has been found around Barrow Island, but is insignificant compared with the natural-gas fields of the North-west Shelf.

The discovery of a large diamond province south of Lake Argyle has resulted in the region's first major mine. With a production of 35 million carats a year, this is the world's largest diamond mine---by volume, not value. It has also triggered very extensive diamond exploration over a wide range of rock types.

Tourism. The Kimberleys have the potential to become a major tourist area based on coastal resorts and inland features such as the brittle sandstone towers of the Bungle Bungle Range.[10] Today, the industry is in its infancy. Developments have been initiated or planned for Walcott Inlet, Bungle Bungle Range and the Berkeley wilderness north-west of Wyndham. All have been criticised by conservation interests as being insensitively sited.[11] Decisions on siting of the future road network are central to defining opportunities and constraints on the evolution of the tourism, wilderness, conservation pattern.

Wilderness and conservation. About 3.5% of the Kimberley region, some 14 800 sq km, is reserved as national parks or nature reserves. Existing reserves include both small special features such as Geikie Gorge and large reserves such as Prince Regent River and Drysdale River. In the 1970s, a government committee recommended the creation of 12 on-shore reserves and 18 island reserves. The adequacy of the reserve system is being reviewed again by the Western Australian Government. Surveys of plant and animal distributions are badly needed. The potential for world-class wilderness areas is considerable. In addition to the recently declared Purnululu (Bungle Bungle) National Park, areas which have been identified as having reserve potential include

* Mitchell Plateau;

* Walcott Inlet;

* Edgar Ranges;

* Roebuck Bay and Eighty Mile Beach (one of the most important roosting sites in the world for migratory birds);

* King Leopold Range;

* Oscar, Napier and Geikie Ranges;

* Rowley shoals.

The future of Kimberley rainforests is a major issue. There are over 500 patches of rainforest in the Kimberleys, the largest being about 100 ha. Because they are remnants of an earlier age, they have high conservation value. Unfortunately, many are proving vulnerable to an increasing number of manmade wildfires in the region.

The Kimberleys are somewhat behind the Top End and Cape York in the development stakes. There is not quite the same urgency about controlling haphazard development, but the breathing space can only be several years. It is not particularly bold to predict that the Kimberleys will be the next major environmental battleground after Cape York. The medium-term key to managing the region, including its defence role, will be the coverage and quality of the road network.

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for a further standard-gauge connection across to Queensland. For example, such a line would facilitate the opening of an envisaged $250 million manufacturing development at Phosphate Hill near Mt Isa.[13] The fact that a facility might be useful is not of course an argument that it should be built; that depends on the opportunity cost of foregone projects.[14]

Australia is more susceptible than most countries to the watery threat of mine warfare;; by volume 99.9%, and by value 82% (over $33 bn a year) of Australia's export trade goes exportsby sea{xe "exports:by sea"}. In 1940 a single German mine layer dropped 230 mines off the eastern seaboard, caused millions of dollars of damage and disrupted Australian shipping for months. At least 16 vessels, over 18 000 tonnes of shipping, were sunk.

Australia's vulnerability to mines has, if anything, increased since then. The bulk of domestic and interstate trade is shipped from just a handful of ports including Port Hedland{xe "Port Hedland"}, Barrow Island{xe "Barrow Island"}, Port Kembla{xe "Port Kembla"}, Sydney, Newcastle{xe "Newcastle"} and Mackay{xe "Mackay"}. Mines are an ideal weapon for terrorists or countries wishing to make a point anonymously or in a way that will not automatically result in escalation. Mines have become much harder to detect, increasing the disproportionate response required to sweep or hunt them. Australia needs and is slowly acquiring offshore mine-clearing capability.[15]

Other potentially vulnerable important infrastructure in northern Australia includes the North-West Shelf{xe "North-West Shelf"} gas fields and, if they get built, the Dampier--Moomba gas pipeline{xe "Dampier--Moomba gas pipeline"} and the Darwin--Alice Springs railway. Meanwhile, it is the quality of the northern road network which is the focus for much defence thinking.

> In far north Queensland the progressive improvement of the Peninsula Development Road from Lakeland to Weipa high up on the west coast of Cape York Peninsula has great significance for the defence of the region as well as for regional development. However, until such time as this road is improved to all-weather standards and is extended to Bamaga on the tip of Cape York, the Peninsula will persist as a strategic vulnerability of very significant proportions. The extent of the isolation of Cape York Peninsula, that is north of the Jardine River, and the emptiness of the Cape itself south of the Jardine is extraordinary. This, combined with the unimpeded `porosity' of the Torres Strait Islands ... constitutes a serious and exceptional vulnerability in security terms generally---to illegal immigration; to fisheries, customs and quarantine violations; and to all manner of perceptions of low-level defence contingencies.[16]

The more general point behind this quotation is that there is considerable interdependence between military and resource-management/development planning in northern Australia. **Serious attention needs to be given to Jol Langtry's suggestion for a national organisation to co-ordinate** defence**national security planning**{xe "defence:**national security planning**"} **with regional and national development.**[17]

Defence is one dimension of northern coastal surveillance. The others are customs, immigration{xe "immigration"} and quarantine, with the last being most relevant to a discussion of resource management. The current system of aerial littoral surveillance for quarantine purposes (`Coastwatch') has recently been judged ineffective in the Lindsay report.[18] This committee recommended that a new program of agricultural agriculturequarantine{xe "agriculture:quarantine"} measures (Northern Australia Quarantine Strategy{xe "Northern Australia Quarantine Strategy"}) be developed based on enhanced monitoring, sampling and surveys for various plant and animal pests and diseases and their vectors in northern Australia and in neighbouring countries. There is a draft plan prepared for fighting an outbreak of exotic animal disease on Cape York, but it needs to be developed further and integrated with a modern information system and a research program for understanding the spread of diseasesexotic{xe "diseases:exotic"} disease as well as any improved programsdisease surveillance{xe "programs:disease surveillance"} program (see Chapter 7).

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protection etc.[19] State government agencies have also undertaken most of the major coastal engineering works, often, until relatively recently, with little participation by local residents and users of the affected resources. Offshore, the *Seas and Submerged Land Act 1973 (Cwlth)* brought all land below the low-tide mark under Commonwealth control although the States, under subsequent agreement and coastal waters legislation, continue to control fisheries and other resources out to three nautical miles.[20] Whether this will remain the case following a decision in November 1990 to extend Australia's territorial sea from three to 12 nautical miles offshore has not been decided.

The resources available for coastal-zone management in most coastal local government areas are pitifully small. Protection of shorelines, upkeep of recreation areas and repair of storm damage require costly programs for beach replenishment and dune maintenance. Local authorities tend to resist coastal protection schemes which potentially restrict rating bases and are particularly concerned about the extent to which local taxes provide benefits to non-resident visitors. In Queensland, a few local councils have refused development applications only to have their decisions overturned by the State Government.

The questions of central concern to coastal-management agencies are about allocation (which groups get access to which resources) and about operations---selecting ways of implementing and controlling allocated land uses. Important tools of present-day coastal management include land-use planning, policy statements, environmental impact assessment and the preparation of site management plans. Unfortunately, perception of the need for coastal-zone management has arisen only in the last 20 years or so and many historical mistakes remain---not to mention ongoing problems which remain unaddressed.

Pollution and waste disposal are widespread, although generally localised, issues in coastal-zone management. Examples include

* runoff of agricultural chemicals (e.g. of insecticides to the Great Barrier Reef)

* eutrophication following fertilisation from runoff nutrients. Algae grow so prolifically on the surface that they deprive the water below of oxygen and light, thereby killing most marine organisms (e.g. Gippsland Lakes, Peel Harvey estuary in WA)

* pulp mill effluents (e.g. at Lake Bonney, South Australia)

* sediment loads (e.g. silt from the Mt Lyell mine (Tas) has destroyed the ecosystems of Macquarie Harbour)

* offshore sewage disposal (e.g. Sydney, La Trobe Valley).

* heavy metal pollution (e.g. the Derwent estuary, Gove Peninsula)

* toxic algae (e.g. in Port Phillip Bay, Gippsland Lakes, Port Adelaide, Peel Harvey estuary (WA). These probably arrived originally in some of the 60 million tonnes of ballast seawater unloaded each year in Australian waters and destined no doubt to introduce further pests. The toxic effects run right up the food chain to humans.

* loss of fish nurseries. Seagrass beds, which are important fish-nursery areas, are being lost through various forms of pollution around Australia, e.g. eutrophication and heavy metals in Western Australia, sewage in South Australia, sedimentation in Victoria.

* overdevelopment of biologically important estuaries. Estuaries with high conservation value which are under threat from development include Burdekin River (Qld), Corner Inlet, Port Phillip and Westernport Bays, Gippsland Lakes (Vic), Port Adelaide River (SA), Tamar River (Tas), Tweed, Richmond, Hunter and Hawkesbury Rivers, Lake Macquarie, Port Jackson, Botany and Jervis Bays (NSW).[21]

* oil spills. In 1968, the Merlin A7 oil well blew out in Bass Strait. In 1970 the tanker *Oceanic Grandeur* struck an uncharted rock in Torres Strait and Australia witnessed its first major oil spill.

* The rate of growth in cattle numbers and the rate of spread of improved *Verano* pastures do not suggest a major expansion in the offing for the beef industry. Nevertheless, the percentage of *Bos indicus* blood in coastal areas is now quite high. The Brucellosis and Tuberculosis Eradication Campaign has led to intensification of cattle operations in the better areas and withdrawals at the extensive margin. South Australian coastline including Yorke Peninsula. Large stretches of the South Australian coastline have been made inaccessible to the public.

Other examples of bad misuse of the coastal zone include the destruction and draining of wetlands (often valuable fish nurseries) for urban developments, including canal estates in northern New South Wales and Queensland. Every State has its examples of poor coastal-zone management although it is Queensland which is the current laggard in acting on the need for improvement.

Mineral sands mining for heavy minerals such as rutile, zircon and ilmenite has been a major coastal-zone industry and likely to be so again (notwithstanding several inland discoveries, notably Horsham in Victoria). It is confined essentially to three sections of the coast:

* central New South Wales to Gladstone

* inland from Capel and Bunbury, south of Perth

* the east coast of King Island in Bass Strait.[22]

The industry generates little pollution, but it cannot be pretended that the landscapes which are reconstructed nowadays following sand mining are anything like as ecologically rich as pre-mining landscapes. **Some mineral-rich sandscapes such as those of Fraser Island probably have too high a conservation value ever to be mined. Equally, one can sympathise with sand-miners who see valuable deposits lost forever under residential developments and freeways. Mining in advance of such developments would be sensible.**

Irrespective of the degree of CO_2-induced climatic change pending, the Australian coastal zone will undoubtedly continue to undergo major anthropogenic and, to a lesser extent, non-anthropogenic changes. As the primary example of `natural' change, the widespread beach erosion experienced in recent decades will probably continue; there will still be localised areas of coastline build-up of course, including areas where sediment from accelerating upper-catchment erosion following deforestation is already being delivered.[23] Many prime recreation beaches (e.g. Adelaide, Gold Coast) are already regularly replenished with trucked-in sand.

The need for co-ordinated management of the coastal zone is illustrated by the fact that erosion of Gold Coast beaches increased rapidly following the construction of retaining walls on the Tweed River which diverted the former longshore northern drift of sand. Unless effective controls can be developed, natural erosion will continue to be exacerbated by off-road recreational vehicles destroying dunes and beach ridges in many areas, e.g. the Coorong.

Fishing

Sea fisheries are of three types: demersal, inshore and pelagic. Demersal fish are those living on the sea bottom of the continental slope, the ones normally caught by trawling, e.g. gemfish, blue grenadier, orange roughy. On the east coast almost all the known demersal resources are being utilised. Those of the south coast are not heavily utilised (much of the bottom is not trawlable) and those of the west coast up to Shark Bay unknown. It is the area of the North-west Shelf and beyond to the Gulf of Carpentaria that presents the most interesting possibilities. Several countries including Japan and the Soviet Union fish the area, but are taking probably less than half the estimated maximum sustainable yield of 90 000--150 000 tonnes per annum.
Inshore fish, crustaceans, and shellfish live along the coastline and in estuaries. The best-understood species are scallops, rock lobsters, prawns, oysters and abalone. Scallops and abalone have been overfished in recent years, but the rock lobster fishery, particularly in Western Australia, is widely regarded as well managed. Western Australian legislation aimed at maintaining the industry at a viable level includes regulations on minimum catchable size, lobster pots that allow smalls to escape and limits on total fishing effort. Annual lobster production in the West has now stabilised.

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Table 4.7 Quantities of fisheries products Australia: 1979--80 compared with 1989--90 (kt)

	Prawns	Lobster	Abalone	Scallops	Oysters	Fish
1979-80						
	22.0	14.5	6.4	16.4	8.3	57.1
1989-90						
	21.7	15.0	5.5	5.0	8.2	110.0
	(190)	(193)	(90)	(12)	(47)	(185)

(Figures in brackets are values in $m)

Many marine species that are distributed throughout parts of south-east Asia and the Pacific also occur in Australia. Some of these have been overexploited outside Australian waters and Australia offers the best chance for their long term conservation. Examples are mangrove species, marine turtles, dugong, saltwater crocodiles and trochus shell. Australia has hundreds of mostly small marine reserves, most of which are attempts to protect commercial fishing activities.[24] Queensland and Western Australia are most advanced in actively developing a system of marine and estuarine protected areas. New South Wales is the most backward because of bureaucratic in-fighting for control of such reserves.

Population growth

Inescapably, the dominating force for change in coastal Australia into the next century must be that of increasing population. Most of the 11--15 million extra Australians we can expect by then will be found in and around the existing major metropolitan and provincial centres, i.e. like 85% of the present

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population, they will be living in or close to the coastal zone.[25] Table 4.8 and Map 4.5 illustrate (a) local and (b) regional population pressures on different parts of the Australian coastline. Map 4.5 shows numbers of people living within half a day's drive of different parts of the coast in 1981 and Table 4.8 gives changes since 1971 in the number of people living within three km of the coast.

Map 4.5 Population pressure on the coastal zone

From Cocks and Walker, 1985. For each half by half degree gridcell overlapping the coastline, a figure has been calculated for the total number of people living within 150 km of the centre of the gridcell.

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Table 4.8 Recent changes in coastal-zone population

* The rate of growth in cattle numbers and the rate of spread of improved *Verano* pastures do not suggest a major expansion in the offing for the beef industry. Nevertheless, the percentage of *Bos indicus* blood in coastal areas is now quite high. The Brucellosis and Tuberculosis Eradication Campaign has led to intensification of cattle operations in the better areas and withdrawals at the extensive margin.

	1971	1986	71:86	%Chnge
D Arnhem Land -C.York	9 602	13 047	3 445	35.9
C9 Cooktown	401	308	-93	-23.2
B2 Townsville -Cairns	59 841	95 406	35 565	59.4
C3 Bowen-Mackay	33 177	48 095	14 918	45.0
B4 R'hampton -Maryb'ough	44 546	73 538	28 992	65.1
A1 Brisbane+ G&S Coasts	234 631	400 914	166 283	70.9
B1 NSW North Coast	63 929	140 779	76 850	120.2
A2 Newsydneygong	1402 311	1515 294	112 983	8.1
B7 NSW South Coast	15 206	42 352	27 146	178.5
C6 E.Gippsland -Far Sth NSW	7 561	14 939	7 378	97.6
B6 Tasmania	249 296	296 793	47 497	19.1
B9 West Gippsland	5 686	9 543	3 857	67.8
A3 Melbourne				

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Rest of Australia	9360 400	11478 333	2117 933	22.6
Australia	12755838	15602156	2846318	22.3

Note: Identifiers before names locate regions on Map 4.6.

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Given the Australian penchant for coastal recreation and increasing real incomes, it is a most reasonable scenario to foresee the coastal zone from Cairns to Adelaide continuing to be our main setting for resource and environmental conflict, competition and controversy.[26] Rising demands for accessible sites near population centres for both productive and consumptive uses will have to be met from a fixed land supply. Unfortunately, coastal resources are what are known to economists as **positional goods** i.e. available only in fixed quantity; as population increases, average coastal resources per person decrease. In practice, positional goods in our society are largely rationed by price. For example, it is psychologically very important to be free to hike right around the rim of the country, but up-market coastal-resort developments are already threatening the accessibility of a number of areas for the hoi polloi.

The pervasive coastal issue for many years then is likely to be the impact of interest-group demands and their associated externalities on a resource which is scarce and essentially fragile in its scenery, landforms, waterbodies and vegetation. Coastal-degradation issues most frequently foreseen in the 1979 CSIRO survey were concerned with questions of despoliation from open-cut, strip and sand mines, coastal erosion and instability, and pollution.

Succinctly then, for most people, the likeliest coastal scenario is one of declining access to a degrading resource. However, at the risk of being over-optimistic, the emergence of techniques for the management of development, such as participatory land-use planning stand to increase the legitimacy (public acceptance) of an increasing number of resource-allocation and management decisions. Four Australian States (Victoria, Queensland, South Australia and New South Wales) have enacted legislation specifically for coastal-zone management in response to coastal erosion, to coastal land-use conflicts and to improve co-ordination between the numerous State agencies interested in the coastal zone. Federally, it is Labor party policy to establish a National Coastal Management Working Group to develop, under the auspices of the Minister, a **National Coastal Management Policy**.

Impact of climatic change

Current predictions of climatic change in coastal Australia over coming decades include sea-level rises of 20 to 140 cm and increased storminess, including cyclones penetrating further south than at present. In fact, the most recent scenario from CSIRO Division of Atmospheric Research (August 1989) reduces the predicted sea-level rise to a mere 20--30 cm.
Of all parts of Australia, the coastal zone is likely to be particularly affected by climatic change because, in addition to these direct effects, the coast would experience a range of effects derived from changes to vegetation, runoff and land use in non-coastal catchment areas (Box 4.1).

Box 4.1 The many effects of climatic change on the coastal zone

1. **Primary changes**
* higher air temperatures
* higher atmospheric CO_2 concentrations

2. **Second-order effects**
* warmer seas
* relocation of dominant air masses
* increased plant photosynthesis
* changes in evapotranspiration

3. **Third-order effects**
* net sea-level rises
* more southerly cyclones
* regional changes in amount, intensity and seasonality of rainfall

4. **Selected fourth-order localised effects in areas of increased rainfall** (including

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Box 4.1 (continued)

6. **Selected multi-order effects/impacts on human activities**

Recreational land use
. increased ultraviolet radiation hazard
. narrowing of recreational beaches
. erosion and reshaping of recreational beaches
. loss of public access to shoreline
. changes in climatic comfort indices
. intrusion of cyclones into new vulnerable areas

Residential land use
. increased flooding due to increased runoff, higher water tables, reduced drainage heads
. increased erosion of shoreline residential land
. effect of raised water tables on septic-tank efficiency
. inundation of canal estates
. changes in climatic comfort indices
. intrusion of salt water into groundwater supplies

Commercial fishing
. loss of nursery areas, e.g. increased breaching of coastal lagoons
. silting of maricultural areas, e.g.oyster beds
. changes in location of commercial species due to changes in sea temperatures and estuarine salinities
. loss of fishing time through increased storminess

Ports and shipping
. inundation of low-lying infrastructure
. hazards of increased storminess

Industrial, agricultural and commercial land use
. reduced efficiency of seawater-cooled operations
. increased flooding and erosion of agricultural lands
. inundation of low-lying infrastructure, e.g. airports
. salinisation of groundwaters used for irrigation

Tourism
. effects of increased runoff, sea levels and sedimentation on attractiveness of Great Barrier Reef

Conservation of natural environments
. increasing mismatch between reserves, environments and faunal distributions
. impact of flood mitigation works on floodplain wetlands

Mining
. loss and/or redistribution of mineral sands.

Source: Cocks, Gilmour and Wood (1988)

As ocean volumes swell with increasing temperatures, sea levels will rise. The physical consequences of sea-level rise per se can be broadly classified into three categories: shoreline retreat, temporary flooding, and saltwater intrusion. Effects on natural (unmanaged) systems are difficult to predict, but at this stage it can be guessed that rates of change, particularly on rocky and tidal-flat coasts, will be low enough to permit smooth rather than abrupt transitions to new states, e.g.

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Highlighting the importance of getting a smooth adjustment of the ecosystems on tidal flat coasts is the fact that about two-thirds of Australia's east-coast commercial fish catch is composed of species that depend on mangrove estuarine areas.[27] Probably little can be done to modify the way most physical and biological systems will evolve together and even if it could, agreement on what to do would be difficult to reach.

One legacy of Australia's 19th-century dependence on sea transport is that many coastal settlements are situated at the navigational limits of rivers and are particularly vulnerable to flooding. Increased rainfall, increased storminess and drainage systems backed up longer because of reduced heads (fall to the sea) will increase the frequency, but not really the nature of flooding in east-coast settlements.

Saltwater intrusion via both breached barrier formations (e.g. the lower Murray in South Australia) and higher sea levels per se (e.g. Kooweerup Swamp on Westernport Bay, Victoria) will affect water supplies to coastal agriculture in a limited number of locations. In the Burdekin delta in north Queensland saltwater intrusion into groundwater is already a problem and this may intensify. Perth and Newcastle are the only large coastal centres dependent on groundwater, but they are unlikely to be affected in this way.

Ultimately, changes in lifestyle for most Australians as a result of coastal-zone changes are likely

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In a recent conference paper on the implications of the Greenhouse effect for coastal Australia, colleagues and I came to the following conclusions:[28]

1. With the exception of increased flooding in coastal settlements, the impact of marine-mediated climatic change by 2030 on settled areas of coastal Australia will be small. Impacts on coastal agriculture are most likely to be via highly localised saltwater intrusion into (a) rivers and (b) groundwaters used for stock watering and irrigation. Impacts on coastal recreation are most likely to be via the accelerated erosion of numbers of east- and west-coast sandy beaches.

2. Many of the adverse economic impacts of sea-level rise might be avoided if timely anticipatory actions were to be taken. **As of now, design of new infrastructure should be based on the assumption of future higher sea levels, e.g airports, housing, marinas, septic tanks, sewerage systems, roads, bridges, power plants.** There is an associated need for improved briefing of engineers, home builders etc. A need to cope with increased coastal flooding, taken together with the already dilapidated state of many urban drainage systems, can be viewed positively as creating an opportunity to redesign environmentally sound drainage infrastructure, e.g. use of grassed waterways for cleansing water.

3. Contemporary trends in all States towards improved coastal planning and management need to be encouraged, including that of increased recognition for the role to be played by local communities. One need is to follow land-management practices which are already recommended, but little implemented. Another is to develop and apply methods for large-scale impact assessment in priority areas of high population pressure, vulnerable infrastructure and increased hazard from erosion, cyclones/storms, inundation and flooding (Map 4.6). Such methods must particularly recognise a full range of impacts and their different effects on different groups of people.

Map 4.6 Areas of greatest impact of sea-level rise

From Cocks and others, 1988. Within metropolitan regions (A), the greatest level of potential impact is at A1 and the least at A5; similarly for major urban regions (B) and minor urban regions (C). Rural regions (D) are not ranked.

4. Given the uncertainties inherent in the climatic-change issue, scientists, quite rightly, will wish to emphasise the need for more research, but at the same time they must resist the temptation to orchestrate fully this `tenuous melody'. Several scientists have already warned the scientific community against tunnel vision, groupthink and an unwillingness to recognise potentially positive effects of climatic change.[29] Already there is a community scepticism about the rapid changes foreseen in scientists' far-off Greenhouse scenarios.

5. As an umbrella conclusion, the prospect of climatic change is best regarded as an inducement to begin taking a wide range of adaptive actions which, irrespective, we should already be taking.

The High Country

Islands in the clouds

Australia has very little high-altitude land.[30] Apart from the Eastern Divide, the only country above 600 m is small parts of the Hamersley Range in the arid north-west and the MacDonnell Range in the centre (Map 2.2). At the base of Cape York, the Divide is

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]The cold high country, meaning firstly the mainland alpine and subalpine areas lying above about 1300 m and receiving regular snowfalls, occurs in patches (islands) extending from Australian Capital Territory (360 sq km), through the Snowy Mountains (2600 sq km) into the Victorian Alps (2300 sq km). A recent proposal for a 16 400 sq km Australian Alps World Heritage area includes all of this.[32] The central Tasmanian plateau contains most of our other cold high country (4900 sq km). In toto the cold high country occupies less than one per cent of Australia. Ours is the only continent without even one active glacier.

In the alpine zone, above 1830 m, snowgum woodlands of the subalpine zone (down to 1370 m) give way to treeless herbfields. High-yielding alpine ash forests occur up to 1500 m.[33] Botanists such as John Turner, Alec Costin, Stella Carr and Dane Wimbush have carried out the long-term observations which allow us to understand the dynamics of high-country vegetation change reasonably well. **The key to the fragility of high-country ecosystems is that plants grow slowly at low temperatures and hence take a long time to recover from any disturbance.** Thus, at subalpine altitudes, routine burning to produce a `green pick' and grazing it, even at low stocking rates, turns grassland into eroding shrubland which, if protected, will eventually revert to grassland---provided enough soil remains. From a management point of view the message is that vegetation changes markedly when disturbed, but if left alone probably recovers after a very long time.

Roles and functions

Grazing and water catching
For 120 years or so the main role of the cold high country, in land-use terms, was in providing summer grazing for sheep and cattle. In the mid-1940s it was recognised that grazing had changed the alpine and subalpine vegetation so as to expose the soil to erosion. Kosciusko State Park was declared in 1944 in New South Wales and in 1946 graziers and soil conservation authorities agreed to limit grazing on the Bogong High Plains in Victoria.[34]
At that time it was clearly recognised that the alpine areas fed the headwaters of a number of our most important rivers with snowmelt, including the Snowy River with its visionary possibilities for being turned inland for hydroelectricity generation and irrigation. The water-catchment function was to be regarded as pre-eminent. Water yields could be increased by, for example, using snow fences and plantations high in the catchments to trap more snow. Today this would conflict with trends to conserve the high country in as natural a condition as possible.

Despite the evidence that the relatively low numbers of summer-grazing cattle in the Victorian Alps are causing and have caused serious damage to plant, soil and water resources, the Victorian Government has been politically unable to accept the advice of the Department of Environment and Conservation and exclude cattle from its newly declared Alpine national park.

Skiing, fishing, hiking, horse trekking
While graziers are slowly losing their access to the high country, largely to protect water supplies, new debates are arising about how these areas are to be used. Today, the main commercial use of land above 2000 m is snow sports. Even this is a marginal undertaking since the length of the snow season (around 16 weeks) is short by world standards, meaning that the capital tied up in resort infrastructure has little time to earn its investors a return each year. Accentuating this, records for recent decades show that the length of the snow season has been getting shorter and that snow cover has been getting shallower. Greenhouse warming can only reinforce this trend and reduce the areal extent of the snowfields. In summer, the high country increasingly supports extensive recreation pursuits such as trout fishing, bushwalking and horse trekking. Conferences too.
These apparently innocuous activities can have serious effects on high-country ecosystems, at least when large numbers of people are involved. Clearing treed areas to enlarge ski slopes reduces catchment effectiveness in a number of ways (e.g trees collect water from mists) and raises the possibility of major erosion if done carelessly. The newest threat is all-terrain vehicles which turn tracks into ever-widening

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(the body managing most Victorian ski resorts) of their statutory responsibility to provide snow sport facilities to the whole community, not just the rich.

The bogs and fens which maintain stream flow in dry periods and in winter when flow is especially needed for electricity generation are particularly susceptible to trampling, whether by cattle, horses or bushwalkers. An alpine bog invariably dries out permanently once a drainage line forms in it.

The high country offers a classic example of competition for and conflict over a limited natural resource. Even bushwalking and horse trekking can come into conflict, e.g. when bushwalkers on a popular trail start to resent bedding down on steaming horse dung. Overall though, the high country still seems manageable provided that its various uses can be kept to moderate levels. **This is in fact the basis of much successful natural resource management; start actively managing the resource before it is buggered up and do not let any interest group's greed get out of hand.**

In 1979--83, after years of public debate, the Victorian Land Conservation Council allocated 14 800 sq km of their high country to increase the area of parks plus other reserves plus the area of State forest to 49% of the total area at the expense of previously uncommitted land.[35] The plan made provision for alpine resorts and for areas with grazing, water production and hydroelectricity generation as their prime functions. All in all it was an excellent example of thoughtful, deliberate and responsive land-use planning, albeit based on somewhat inadequate information. More is the pity that similar exercises are not being carried out in other high-demand areas such as the Top End, Cape York and, indeed, the high-altitude Tasmanian Central Plateau.

The outstanding resource of the Tasmanian Central Plateau is its water yield, and this has been almost fully harnessed for the generation of hydroelectricity. The major land-use activities include forestry, grazing, recreation and tourist uses. Fishing is excellent in the numerous lakes.[36] Management of the region is complicated by the fact that 35% of the land is privately owned, with the rest being managed by various State agencies with fuzzy jurisdictions. Soil erosion due to burning off, grazing and, more recently, off-road vehicles, is severe above 900 m. Recent inclusion of much of the Plateau in a World Heritage Area may lead to its being more purposefully managed.

The Forests

As noted earlier, only about 14--20% of Australia (depending on definitions) is wooded or forested, mainly in the better-watered parts of eastern, south-western and northern Australia. This is a lower proportion than many countries (e.g. Japan, New Zealand, Canada, Sweden), but still puts us well above the world average in terms of forest area per head of population.

Forests for timber

Australia's forests produce about 17 million cubic metres of wood a year divided into various products as follows:[37]

Sawn timber and veneer	48%
Woodchips	24%
Paper and paper products	17%
Wood-based panels	7%
Other	3%

The forest-products industry is an important component of the manufacturing sector. It has a diversified structure ranging from small logging and sawmilling operations to large vertically integrated paper-products manufacturers that are increasingly international in ownership and outlook.[38]

While 1.06 million sq km of Australia is covered by forest or woodland, only 41% of this is regarded as capable of yielding timber for industry and nearly three-quarters of that is publicly owned---a third of the publicly owned forest being in State forests dedicated to timber production as the primary form of land use and 10% in conservation reserves. Since the second world war, the implicit `strategy' of the timber industry has been one

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* cypress pine forest (11% by area)

* tropical eucalypt and paperbark forest (16% by area)

Eucalypt forest
In their present condition, most Australian eucalypt forests have a very low capacity to yield sustainable high volumes of industrial wood, due to (a) the overmaturity of individual trees, with consequent low net growth of stemwood, and to (b) the low level of use relative to total wood yield. Because the removal of large and defective trees could not usually be justified economically, early forest-management practices were often too conservative to stimulate the growth of the forest as a whole (i.e. the amount of timber in an old forest stays constant from year to year). The yield of timber can be greatly increased however by appropriate silvicultural treatMent, silviculture being the science and art of growing and regenerating forests.[41] These treatMents include clear-felling, short rotation times, stand thinning, fertilising and, in some cases, the use of pesticides. They can have dramatic effects on the appearance, composition and functions of forests.
Likewise the yield can be increased by raising the level of use through integrated sawlog and pulpwood operations. For example, sawmilling converts less than half gross log volume into sawn timber. By pulping logging residues in an integrated operation, total use is much greater. Such integrated harvesting requires careful supervision to minimise environmental impacts. **The main argument against woodchipping is that there is insufficient knowledge about its long-term effects to ensure that irreversible degradation of the forest resource does not occur. There is a strong case for pausing with woodchip projects while the effects of existing operations are monitored.**

Rainforest
Australia had about 36 000 sq km of rainforest of all types in 1788. The present area is under 20 000 sq km, nearly half having been diverted for agricultural, forestry, urban development and other purposes.[42] Still remaining are

* 7000 sq km of tropical rainforests on the wet coast between Cooktown and Ingham

* 6000 sq km of subtropical rainforest between Ingham and northern New South Wales

* the temperate rainforests of southern New South Wales, Victoria and Tasmania.
Timber output from rainforests is now less than five per cent of the Australian total. It is used for specialities such as veneers, plywoods etc. and for general construction. Research into the production of specialty woods from plantations of both tropical (e.g. Queensland red cedar) and temperate (e.g. Tasmanian blackwood) rainforest species is in progress.

Other forest uses and functions

In presenting arguments for the dedication of Crown lands as State forests, forest services have traditionally stressed the role of forests in watershed protection, domestic and industrial water supply, and wood production, considering all three to be compatible.[43] A significant share of forest land in the vicinity of Perth, Melbourne, Sydney and Brisbane is devoted to metropolitan water-supply catchment. The conservation of flora and fauna in undisturbed forest habitats has been catered for by setting aside flora and fauna reserves. Similarly, forest recreation parks and scenic reserves have been established.
Nevertheless, there has been strong criticism of the emphasis on wood production in Australian forest management. Such criticism stems in part from changing social values

* The use of forests for informal outdoor recreation is increasing more rapidly than population growth and this trend is expected to continue.

* The rate of growth in cattle numbers and the rate of spread of improved *Verano* pastures do not suggest a major expansion in the offing for the beef industry. Nevertheless, the percentage of *Bos indicus* blood in coastal areas is now quite high. The Brucellosis and Tuberculosis Eradication Campaign has led to intensification of cattle operations in the better areas and withdrawals at the extensive margin. nently disappear, perhaps go extinct. The known distribution of the now extinct Tasmanian Tiger coincides with what were once among the most fertile forested areas in that State.

On the mainland, the populations of a number of species, including the Koala, are already severely affected. Much of the best-quality forest is in private ownership and can be expected to disappear rapidly if current plans for over a dozen new pulp mills around the country, some in areas containing Koalas, go ahead (Map 4.7).

Map 4.7 Supply area for the proposed Grafton pulpmill in relation to sightings of Koalas in New South Wales, 1985--87

Produced by Paul Walker from data supplied by the NSW National Parks and Wildlife Service. Exercise: Locate the supply area for the existing pulp muill at Newcastle.

There is great scope for conflict over the allocationfesxe

of forest resources. It seems inevitable that policies for forested public lands will increasingly be overtly oriented towards multiple use, meaning the use of the land for more than one purpose. This brings a need for well-informed and sensitive planning of forest-land use. The starting point for land-use planning is knowing what is there. Unfortunately, Australian forests have never been well inventoried for their wood, water, recreation, wilderness, landscape and plant and animal resources. Without big improvements in inventory work, prospects for conflict resolution are much reduced. A national forest inventory is at present being organised by the Federal Government and this should provide useful context for planning at the strategic level.

Forest management

There is also great scope for conflict over themanagement practices used by foresters. Three kinds of management operations deserve particular attention because of their potential to affect environmental values:

* intensive timber harvesting

* the planned use of fire;

* the establishment of plantations of exotic pines.

Harvesting techniques involve the removal of either single trees, groups of trees or whole stands (clearfelling). Since the early 1970s when it became widespread, the system causing most public concern is clearfelling. Precautions to protect animal species which depend on old trees or high-nutrient vegetation can be built into harvesting strategies. Erosion and stream siltation are other hazards which can be avoided with careful management.

Annual burning of regrowth is practised on a small area of forest in Australia and State agencies support some research into the cumulative effects of repeated prescribed fires on soils and site productivity, and on flora and fauna conservation. At the same time they pursue a goal of minimising damage to the timber resource by wildfire.

The conversion of eucalypt forest to pine plantations is perhaps the main criticism of softwood afforestation programs. A socially acceptable forest policy probably must contain a large softwood plantation component as this is the only way at present to ensure a large part of our wood supplies in the foreseeable future. **Pine plantations represent only about three per cent of forested land, but currently provide about 34% of harvested volume.** They grow wood at about 18 cubic metres per hectare per annum which is about 50% higher than well-managed native forests and about 20 times higher than `average' native forests. Hardwood plantations are still very much under trial, but if well managed could enjoy up to double the annual increments of softwood plantations.[44]

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The Mineral Zone

Production and exports

Australia is an important world source of minerals and energy (Box 4.2). She has massive resources of black and brown coal in New South Wales (Hunter Valley, south coast) and central Queensland (Bowen Basin). Identified black-coal resources amount to over 54 000 million tonnes. Brown-coal resources are estimated at 46 500 million tonnes, mostly in Victoria (La Trobe Valley) and mostly economically recoverable.[47] However, massive reserves do not necessarily reflect a capacity to influence world mineral markets; that is more a function of production relative to other countries. Box 4.9 shows Australian percentages of Western world production of major minerals.

Box 4.2 Australia's world role as a mineral producer

* by far the world's leading producer of bauxite and third-ranked as an exporter after Jamaica and Guinea

* source of about half the world trade in alumina

* the world's leading exporter of refined lead and lead bullion

* the world's major producer of minerals from mineral sands, including the titanium ores rutile (titanium oxide) and ilmenite (iron-titanium oxides), zircon (zirconium silicate), and the thorium ore monazite. Monazite also contains the rare earths cerium and lanthanum.

* the leading exporter of rutile, zircon and monazite concentrate

* significant exporter of copper, tin and tungsten

* increasingly large exporter of liquefied petroleum gas

* recent entrant to the world diamond market (world's largest producer by volume)

* the world's largest producer of sapphires (about 70% of supplies)

* a major supplier of manganese, iron ore, nickel, zinc, ilmenite concentrates, synthetic rutile and coal

Table 4.9 Australian percentages of Western world mineral production

	%	Rank
Rutile concentrate	45.3	1
Zircon concentrate	44.4	1
Bauxite	39.5	1
Alumina	31.8	1
Ilmenite concentrate	22.2	1

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The destination of mineral exports has changed markedly in recent decades:

Destinations of mineral exports 1965-85

(per cent of value)

	1965	1985
Europe	41	14
Asia	41	63
America	16	12

Two-thirds of exports to Asia are to Japan and there is now a strong mutual dependence between the two countries. Australian mines have been particularly vulnerable to the state of the Japanese economy in general, and the steel industry in particular.

Major mining centres

The great onshore mining centres of Australia today include Pilbara (iron ore), Bowen Basin, Hunter Valley, La Trobe Valley (coal), Eastern goldfields of Western Australia, Weipa, Darling Range and Gove (bauxite). Individual mines at Mt Isa, Groote Eylandt, Roxby Downs/Olympic Dam, Argyle and Broken Hill are well known and important (Map 4.8). In 1982, Mount Isa Mines accounted for the following shares of national

* The rate of growth in cattle numbers and the rate of spread of improved *Verano* pastures do not suggest a major expansion in the offing for the beef industry. Nevertheless, the percentage of *Bos indicus* blood in coastal areas is now quite high. The Brucellosis and Tuberculosis Eradication Campaign has led to intensification of cattle operations in the better areas and withdrawals at the extensive margin.
production: copper 65%, lead 39%, zinc 26%. Mt Isa's proven recoverable lead-silver-zinc reserves are extensive and capable of sustaining current rates of production well into the next century. Offshore there are the two major oil and gas fields of Bass Strait and the North-West Shelf.

Map 4.8 Major mining centres of Australia

Rundle and the Alligator Rivers region could become great mining centres depending on whether there is a future for shale oil and uranium respectively. The Kimberleys are unexplored but highly prospective.

Depending on politics and prices, possible future major mining regions include Alligator Rivers region (uranium, gold, palladium), Kimberleys (still little explored) and the Timor Sea (oil and gas).

The Pilbara is a well-established region in which sizeable `company' towns---Mt Newman, Paraburdoo, Tom Price, Goldsworthy etc.---outnumber and overshadow both the old towns and the new `non-company' towns of Karratha, Wickham and South Hedland. The principal mining activities are iron ore, salt and natural gas from the North-West Shelf. The Pilbara has the resources to become a major industrial as well as mining region.

Profits

All mining in Australia is undertaken by the private sector, basically a small number of very large companies predominantly under foreign ownership and control and a much larger number of smaller Australian-owned companies. Thirty-one companies receive 94% of all mining income.[49] Profitability of the big traditional mining companies in Australia depends very much on base metal prices and the value of the Australian dollar. However, a new generation of companies is emerging, focusing on a different range of commodities with better operating margins: gold, mineral sands, uranium, platinum and diamonds. To quote Ian Story, `these companies are characterised by low debt, relatively high current profitability, good earnings growth potential, moderate price/cash flow ratios, a significant exposure to gold, minimal exposure to base metals and innovative industrial relations strategies.'[50]
For example, production of gold, the catalyst for Australia's first population boom, has increased in line with world prices and liberal tax concessions in recent years and Australia has the capacity to again become a very large supplier. Much of the current output boom is an attempt to get the stuff out of the ground before tax concessions on gold production are withdrawn.

Box 4.3 New methods in mining

Australian mining profits are in no small part due to the development and use of new methods

* Mount Isa Mines is developing the world's first laser-guided tunnelling machine. It is capable of doubling the rate of new shaft production from four to eight metres a day.

* Australian batteries, winches and pumps are all highly successful mining exports.

* The Australian developed **Sirosmelt** technology for copper and lead smelting reduces plant construction costs, produces clean slag, reduces fume emission and lowers energy needs. It seems destined for world wide adoption.[51] The **HIsmelt** process is a direct iron-ore smelting process which reduces gas emissions and which can be implemented in small plants, thus avoiding a concentration of development at one site.[52]

* The use of satellite imagery for locating ore bodies, precise timing of explosions in blasting, sensors in steel furnaces and computer control of rolling mills are other

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* In copper, nickel, lead, zinc we export refined metals, but do not go further except for the home market. The reasons lie in economics and market strategy. We produce refined and substantially processed nickel mainly for marketing reasons; if we had not established our own processing capacity in Australia, we would have been at the mercy of our competitors in a small market. To protect our own industry, quoting mining magnate Arvi Parbo, we have gone into processing these ores beyond what we should economically.[53]

Because modern mining is capital-intensive with relatively low running costs and small wage bills, its multiplier effects in terms of inducing production and consumption in other sectors of the economy are relatively low.[54]

Mining and other land uses

In the 1950s, the mining industry began to be affected by increasing public concern for `the quality of the environment'. Faced with a rising awareness that preservation of natural features such as scenery and plant and animal habitats had a value to society, governments increased the controls on discharge of potentially polluting emissions such as water containing sediments or chemicals and noxious gases. Whereas the industry once, by and large, had priority in land use, it now had to justify its activities in competition with other potential uses of the land. Governments also began to take account of the likely effect of a proposed mine or processing plant on the surroundings before deciding whether it should go ahead, and required that, where feasible, mined-out areas be rehabilitated by reshaping and revegetating the surface so that the site could be used for other purposes.
Most mines and mining settlements are raisins in the agricultural or pastoral cake. Per unit area, mining can be worth immensely more than agriculture. In Victoria, mines of the last century rarely occupied more than a hectare and some produced over $150 million worth of gold at today's prices. Today, careless gold mining, damaging to land and water alike, is infuriating environmentalists, particularly around Bendigo,Ballarat and Stawell.

While it is true that even open cut mining takes little land compared with agriculture and forestry, it can impose environmental and resource impacts over large areas for long periods. This is particularly true of large dust-producing, noisy, water-demanding coal-energy operations located in the more densely settled areas of the Ecumene. Hunter Valley, Latrobe Valley and the prospective Rundle operation are good examples.[55] Still, I am inclined to agree with Cliff Ollier that

> If we look at the impact of mining in detail we find some genuine environmental problems and some genuine answers from the mining industry. We also find that the standards expected of the mining industry differ from those expected of other activities, that the mining industry is suffering from `selective indignation' ...[56]

Part of the explanation could be that the industry is largely foreign-owned and has thrown up an unfortunate number of confrontationist spokespeople who have served their industry poorly. At various times, the mining industry has come into conflict with practically everybody---Aboriginals, conservationists, farmers, urban residents. Recently, the Pacific Asia Travel Association warned that mining in Kakadu could threaten the international tourist trade on the grounds that visitors come to see unspoilt wilderness, not mining.[57]

Apart from direct destruction of relatively small areas of land (perhaps in ecologically significant areas though), environmental issues surrounding mining focus on waste disposal, rehabilitation, water management and nuisance problems (dust and noise).

* The rate of growth in cattle numbers and the rate of spread of improved *Verano* pastures do not suggest a major expansion in the offing for the beef industry. Nevertheless, the percentage of *Bos indicus* blood in coastal areas is now quite high. The Brucellosis and Tuberculosis Eradication Campaign has led to intensification of cattle operations in the better areas and withdrawals at the extensive margin. concentrated our population in pleasant medium-sized cities in the subtropical to cool-temperate regions. After a late start, we have done well in exploiting our minerals. We have made the most of limited timber resources, running down native hardwood supplies, but building up high-yielding softwood plantations. We have achieved major status as suppliers to the world of wool, meat and wheat, developing numerous innovative technologies along the way. At least in the south, we have comprehensively harnessed the little surface water we have. We have protected such major natural features as the Barrier Reef and the rainforests; our national park system is extremely well developed by world standards. We have used our resources to build a prosperous and pleasant society.

True, we have not learned how to use productively and sustainably the wet-dry tropics, the drier, droughtier rangelands or the continental shelf. We may be about to come a cropper with our temperate and subtropical systems (erosion, salinisation, acidification), with our fishing industry (overfishing) and with the rangelands (falling carrying capacity). But, surely, if we heed the warnings and grasp the opportunities, such difficulties will be overcome.

I have no quarrel with this optimistic view of the way we are using the place. It is important nationally, just as it is personally, to have a positive view of oneself and one's achievements. All I ask is that we remember the Easter Islanders.

Land use is a one-way street

Virgin land can have a range of use possibilities which can be typed in terms of the degree to which they imply alteration of the original natural systems, viz.:[58]

*** Extreme to total alteration:** Habitats for most indigenous species are greatly altered or destroyed; very few species are able to persist or reinvade; species composition is drastically simplified or composed of introduced species. Examples include high-density urbanisation, intensive horticulture, infilled wetlands, large dams and mining operations.

*** Highly altered/modified:** Here, a range of indigenous species persists, but sensitive species die, become vulnerable or reproduce erratically; many exotic species are frequently present; the range of plant forms present is likely to be reduced; age distributions of populations of some species are likely to be restricted. Examples include crop-pasture agricultural systems, low-density residential areas and clearfelled native forests.

*** Low degree of alteration:** Here, the main effect of using natural systems lightly is that a proportion of species will be lost; introduced species may be present, but a majority of species is likely to be indigenous; the age distribution of populations of some species is likely to be modified; relative species abundance may be altered, but the system is effectively stable. Examples include undegraded rangelands, selectively logged forests and managed waterways.

*** Essentially unaltered:** System behaviour here is within the original range of possibilities; disturbances are intrinsic to the system. Examples are areas which have not been exploited by man to any extent. These include much of the coastline, Antarctica, some reefs and islands, some high country, south-west Tasmania, many national parks and interiors of the large deserts. Such areas have attributes which prima facie make them suitable for use as conservation reserves.
Apart from some possibility of a system moving from a low degree of alteration to an effectively unaltered state, **it is doubtful whether natural systems can be purposefully transformed from a more to a less altered state** along the above progression. The infant science of restoration ecology which studies such questions has only a few small expensive practical successes to its credit.[59] Even mining companies which spend millions of dollars revegetating spoil dumps etc. claim only to be rehabilitating the land, not restoring it to its original state.

The implied principle for resource-management decisionmaking is that much greater consideration needs to be given to minimising land-use changes which increase the **degree** of natural-system alteration (maximal to minimal) compared with those which,

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Still a commodity-based economy

Simply characterised, the Australian economy is based on the exporting of raw materials and the importing of consumer and capital goods.
After 200 years, commodity exports still account for almost 70% of Australia's total exports and it is this which makes land/resource use decisions so economically important (Table 4.10).

Table 4.10 Commodities as percentages of total exports 1987--88

Wool	12.8	
Coal	11.6	
Aluminium and alumina	8.7	
Gold	6.0	
Oil and petroleum products	5.5	
Beef	4.9	
Iron ore	4.4	
Wheat	4.2	
Sugar	1.7	
Zinc	1.3	
Lead	1.1	
Uranum	1.0	
Copper	0.9	
Lamb	0.7	
Barley	0.4	
Nickel	0.4	
Cotton	0.3	
Total	65.0	(= $27 bn)

The sorts of choices which this book is addressing affect commodity production and are therefore central to national prosperity as conventionally understood. The Australian dollar is seen by world financial markets as a commodity-based currency, rising and falling in concert with prices for wool, wheat, beef, coal, iron ore, gold, oil, aluminium, copper, nickel, lead and zinc. To date, attempts to raise tourism earnings, manufacturing and high-technology exports have been only modestly successful (Table 4.11). As domestic spending rises with export incomes, imports normally rise more than proportionally, thus increasing the trade deficit and the cost of debt servicing and triggering efforts to dampen domestic demand and choke off imports. We are not willing, to quote Dr Coombs, `to aim for a rate of economic development which can be financed from our own domestic savings, and preferably which permits a gradual reduction in foreign ownership and external indebtedness, public and private.'[60] In these broad terms, the Australian economy is relatively easy to understand.

Table 4.11 Gross Domestic Product, imports and exports of goods, OECD nations, 1986

It is important not to get mesmerised by the balance of payments deficit and the level of foreign debt. As John Pitchford points out, a balance of payments deficit (like a budget deficit) represents a collective decision to consume now and pay later.[61] Provided that things do not go wrong with our ability to repay, this is a legitimate choice, though one that I personally do not favour. That is because I am not convinced that present

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* strategic import replacement;

* selective development of high technology industry;

* selective development of the transport and communications sectors, both nationally and internationally.

A surprisingly high proportion of Australia has fair to good prospects for resource-based economic activity of some sort. That includes agriculture, mining and tourism. The rangelands and several mining regions face a somewhat bleak future. Forestry- and fishing-based regions are entering a period of adjustment. The Murray-Darling Basin and south-west Australia are about to enter a long struggle to maintain their agricultural industries. Nonetheless, most areas have natural assets on which significant economic activity can be based, demand and environmental considerations permitting.

Perennial and pervasive conflict

The players differ, but the game is the same. In all parts of the country, there is conflict and competition for the rights to use the local natural resources for anything from wilderness to Japanese retirement villages. Basically, the intensity of this conflict varies with

* local and regional population density;

* rate of population increase;

* number of potential land uses.

Within the coastal zone of the Ecumene, areas within half a day's drive of major cities particularly satisfy these conditions and experience a never-ending series of disputes. At the other extreme, not even the great unpopulated deserts are free of argument. Should the Nullarbor be a World Heritage area? Should the Woomera rocket range be reopened?

Vigorous debate about resource use is an indicator of a healthy democracy, provided this is not a substitute for protection of the public interest. This book is about not going round in circles, it is not about impulsively jumping off cliffs.

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[2] For a short readable account of ecological relationships in the Top End see `The monsoon tropics' in Newsome, A.E. (ed), 1987.

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[7] Kimberley Pastoral Industry Inquiry, 1985.

Hacker, R.B., (ed), 1982.

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* The rate of growth in cattle numbers and the rate of spread of improved *Verano* pastures do not suggest a major expansion in the offing for the beef industry. Nevertheless, the percentage of *Bos indicus* blood in coastal areas is now quite high. The Brucellosis and Tuberculosis Eradication Campaign has led to intensification of cattle operations in the better areas and withdrawals at the extensive margin.

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[53] A. Parbo, quoted in Anon, 1989c.

[54] Sharma, P.C., and Richmond, W.H., 1986.

[55] Evans, D., and Bradford, S., 1982.

Kalma, J., and Laut, P., 1982.

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[57] Peake, R., 1989.

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[60] Coombs, H.C., 1990.

[61] Pitchford, J., 1989.

5. THUMBSUCKING: OPPORTUNITIES AND IMPERATIVES

What are the big options?

The range of options which will be available for developing, conserving and managing Australia's natural resources in the 21st century will depend in turn on even more fundamental decisions which, as a community, we have to take purposefully or which will emerge by default. The three which stand out as important and which are all discussed further elsewhere are

* What population should we be planning for? (Chapter 9)

* Is there an ideology we can rely on to routinely organise and guide society's decisions? (Chapter 10)

* In what form should we accumulate wealth? (see Chapter 10) And by what means? (Chapters 5 and 6)

Equally, our options will depend on what the rest of the world does. Apart from war and some less threatening apocalypses (see Chapter 7), the contingencies which could near-fatally disrupt Australian society are

* mass migration movements in the Pacific rim

* world economic collapse

* runaway environmental degradation on a global scale.

Population

Dominating all other decisions with the potential to affect the way in which we (a) produce from and (b) conserve our natural resources are those we make with respect to numbers and distribution of people and the amounts of energy they use, directly and indirectly. We will consider the all-important population question separately presently. For this introductory comment it can be taken that the Australian population will roughly double to 30-odd million over coming decades. Some of the repercussions of this are given in Box 5.1.
When the population reaches 30 million we will be able to have another debate about population levels. At 60 million the debate may not be quite as vigorous; people are likely to be somewhat hungry, sick, neurotic and spiritually impoverished. At 120 million ...

At some population level it will be obvious even to Simple Simon that we have `enough' people. In the meantime it is important not to be overwhelmed

by the population issue. We must think our options through on the assumption that no such *force majeure* will destroy the possibility of any worthwhile future, while simultaneously working to neutralise that contingency.

Box 5.1 Some consequences of a doubling of Australia's population

* a significant reduction in food exports (with its balance of payments implications)

* a significant increase in the size of domestic markets (with some promise of reaping economies of scale in producing (cheaper) goods for those markets)

* demand above maintenance levels for housing and infrastructure while population is still growing (with its implications for the construction industry)

* a significant loss of natural areas to development (with its implications for gene and ecosystem conservation)

* higher levels of all types of pollution, including people pollution (with its implications for human, plant and animal health). Very, very roughly, both resource degradation and production of goods and services increase proportionately with energy consumption. Total energy consumption is currently increasing at about two per cent a year.

* a significant reduction, for the average person, in ease of access to such naturally limited recreation resources as rivers, beaches and snowfields. I never forget a friend's description of Japanese fishermen lined up beside an artificial stream catching the fish which one could clearly see being thrown in upstream. Japan is just about to become the richest country in the world!

The rule of 72

A useful rule of thumb is that anything growing at a compound rate of X% per annum will double in, roughly, 72/X years. So, a population of 16 million, growing at 1.6% per annum will double to about 32 million in about 45 years.

Ideology

Ideologies are also rules of thumb, rules for responding unthinkingly to the sovereign issues of the day. In the Middle Ages ideologies equated with religious faiths. From a world viewpoint the overarching issue today is (still) ownership and control of the means of production. The extreme ideologies are still Marxism and Fascism, implying total support by the State for the aspirations of Labour and Capital respectively. Closer to home, it is widely accepted that we have, and will continue to have, a mixed economy incorporating both State and private control over the use of resources. Australian ideological positions are a subset of the Marxism--Fascism spectrum and are couched in terms of whether there should be somewhat more or somewhat less State control. Believers on both the left and the right of this spectrum would claim the same utilitarian goal, namely, the greatest good of the greatest number. Rightists argue that less State control will increase total wealth more rapidly, wealth which can then be shared by all (more jam for everyone tomorrow). Leftists argue that increased wealth does not `trickle down' in practice and increased State control is needed to ensure a more equitable distribution of existing wealth today (more equal amounts of jam today).

Wealth forms

I often wonder what the Vintners buy

Conventionally, increasing productivity does two things:

* releases labour for new industries (this is how new industries, `sunrise' industries say, become possible);

* generates surpluses for further capital growth.

Growing capitalist economies derive their surpluses from `primary growth sectors' where possibilities for innovation or for the exploitation of newly profitable or hitherto unexploited resources yield high profits and set in motion expansionary forces elsewhere in the economy. Changes in demand and new technologies become more important in this process as unexploited resources become scarcer. Formal models of this process are not particularly enlightening, but it has been discussed with remarkable insight in the writings of Joseph Schumpeter.[1]

Now, here is the exciting bit. If you do not want to produce more and more conventional or even sunrise-industry goods every year, surpluses can be invested in leisure, environmental protection, culture or anything else that is valued, but does not lead to increased productivity (Right-wing hardliners argue that Australians have already invested handsomely in leisure---on the job.). Erosion-prone land can be retired instead of being worked, national parks can be extended into State forests, we can go sailing.

Unfortunately the choice is not that direct; the people who decide how to use surpluses may not want to go sailing, in particular, they may not want *you* to go sailing. Also, when entrepreneurs decide that surpluses should go into increasing production (as they usually do), they can expect political support because this creates jobs which `solves' the problem of getting a share of the community's wealth to all those extra people.

Every society which can produce a surplus resolves these questions one way or another. The Aborigines do it by talking, centralised economies do it by making horrendous numbers of calculations and we do it by deciding how much tax to take from entrepreneurs and then leaving the rest up to them.

In the immediate discussion the point is not one of how to choose wealth forms or suggest what the answer should be, but to recognise that there is a choice and that it is a very fundamental one.

Do we really have room to move?

There is no possibility of a clear majority of Australians agreeing on national population goals, a national ideology and quality of life priorities. Only hindsight will reveal the implicit choices we made on these matters. However, in the sense that our hand is not being forced by the rest of the world and because we do not have one or two problems which dwarf all others, we do have options; plausible cases can be made out for a range of positions. Countries like Bangladesh do not have options; they have imperatives.

Future of the physical-biological fabric

Australian society may well be able to survive big changes in climate, air and water quality, soil resources, species abundance and other dimensions of the natural environment. We just do not know. But a Martian scout would probably report that we were trying hard to find out. Unfortunately, our experiment is not very scientific; we do not have a `control' treatment for comparing what happens in a massively disturbed system with an undisturbed system.
A Baconian scientist, arguing inductively, would advise caution. History is littered with societies which buggered their resource base in one way or another and subsequently disappeared. It is not much of a point to say that we know more about these things than the Easter Islanders or the Mesopotamians. Our extra knowledge is negated by our increased capacity to change the biotic and physical fabric. We are Easter Islanders with ecosystem models, perhaps, but we are also Easter Islanders with chainsaws!

Soil

Why should we be concerned about our soil resources? People have been whingeing about soil erosion for 100 years now and nothing too disastrous seems to have happened (Box 5.2). One man's erosion is another man's alluvium; one man's dust storms are another's loess. And of course there was the Northern Territory Minister who stated that he was in favour of erosion---hadn't it produced the Katherine Gorge, Ayers Rock and other profitable tourist attractions?

Box 5.2 Why erosion may not be so bad

Bruce Davidson, ever the gadfly, has argued why soil erosion need not be regarded as a major form of land degradation in Australia at the present time[2]

* Erosion was considerably worse before the rabbit was brought under better control with myxomatosis and better poisoning techniques in the 1950s.

* In the southern wheatlands, the change from the traditional bare fallow--wheat rotation to legume pasture--wheat in the 1940s has reduced both wind and water erosion. The pink snows, caused by the deposition of wind-blown soil in the Australian Alps, which were common in the 1930s, are no longer found.

* The $2 bn or so frequently quoted as the total cost of repairing all damage due to erosion and salinisation after 200 years of European settlement is less than the loss caused by a single severe drought.

* Due to the application of superphosphate and trace elements and the use of leguminous pastures, most of Australia's intensively used soils are far more fertile today than in 1788.

Principles for a national soil-conservation strategy

Land degradation, described by the then Federal Minister for the Environment, Senator Richardson, as `this dull issue', is not yet `an idea in good currency' and, to date, has not attracted substantial government funding.[3] This appears to be changing and that means that someone should be thinking out the options for a **national soil-conservation strategy**

There are four important principles to be kept in mind when creating such a strategy:

* prevention is better than cure;

* rehabilitation is not necessarily the correct response;

* the land degradation problem is as much social as technical;

* vegetative cover is the key to land protection.

Principle 1: **Prevention is better than cure**. Renewal of badly eroded soil is not feasible on the human time scale. It is nonsense to suppose that the rate of soil formation under Australian conditions is anything other than negligible.[4] Long-term maintenance of soil fertility demands the management of soil as a non-renewable or irreplaceable resource. A large part of any national soil-conservation effort should be directed towards finding profitable farming systems which also maintain soil productivity. It may be possible to live with slightly higher annual soil-protection costs, but not a massive repair bill. The principle is the same as setting up a depreciation account to avoid episodic major outlays.

One reasonably sensible and politically feasible way of approaching degradation prevention is to attempt to ensure that all land is being used within its so-called capability. For example, the New South Wales Soil Conservation Service has mapped

salinisation in and beyond the Upper Darling Basin in coming decades as a result of a new round of tree clearing, it will demonstrate to the world that we are a nation of fools, unable to learn from the clearest of lessons.

Principle 2: **Rehabilitation is not necessarily the correct response**. A degraded soil which is not physically eroded can nearly always be restored to fertility at a price. Indeed, a soil which is neither eroded nor chemically contaminated (e.g. by salt, heavy metals) will commonly regain its fertility unaided if left undisturbed long enough. Even chemically contaminated soils move slowly towards new equilibria. Repairing low-value, low-productivity land is unlikely to be economic. The correct procedure is to carry out a comprehensive cost-benefit study on each specific rehabilitation proposal and find out if the returns are greater than from alternative uses for those funds. Even better, we need ways of setting priorities for using limited funds over many projects simultaneously.

Principle 3: **The land-degradation problem is as much social as technical**. Over the years traditional campaigns and legislative programs have been remarkably ineffective in persuading farmers to adopt even those soil-conservation practices which do not affect immediate profits.[6] There is still a lack of awareness among many land users of the consequences for the land of their actions, e.g. the relationship between overgrazing and the spread of noxious weeds. While crusaders like Bryan Roberts, a local soil-erosion prophet, can get a bit boring at times, they are playing a recognisable part in fostering and legitimising a **soil-conservation ethic** in the rural community, i.e. a belief that one *ought* to conserve soil, that one has a *responsibility* to conserve soil.

One particularly promising social technology here is the emergence of `landcare' groups around the more densely settled parts of country. These groups are both symptomatic and supportive of the new respectability of conservation farming. The Federal Government has recently allocated $320 million over 10 years to a **National Land Management Program** proposed jointly by the National Farmers' Federation (NFF) and the Australian Conservation Foundation (ACF).[7] The establishment of 1600 local landcare groups is a major part of this proposal.

Such voluntary measures are palatable to farmers and, through peer-group exposure, reinforce the idea that the landholder has primary responsibility for land management. Providing technical and other support to landcare groups is likely to be an effective way of spending public money. Conversely, that effectiveness will be difficult to monitor.

Other parts of the ACF-NFF proposal accepted by the Federal Government include assistance with producing individual farm plans and provision of better land-capability data.

There is less enthusiasm for the current American idea of **conservation reserves**. Here, the farmer is paid a fixed sum per hectare per year to withdraw erodible cropland from production.[8]

Principle 4: **Vegetative cover is the key to land protection**. The main cause of soil deterioration in all parts of Australia is excessive pressure on the land: too many stock, cultivating too frequently or on slopes that are too steep, insufficient fertiliser, or any system of forestry or agricultural management which leaves the surface soil bare of vegetation at times when storm rains may occur.

Devegetation often, but not necessarily, leads to accelerated erosion of land cleared for crop and improved pasture in wetter areas of Australia where soil-conservation measures are likely to be cost-effective. It may also lead inevitably to salting in some such areas and is highly likely to lead to wind erosion in the drier rangelands. In grazing areas, it is particularly important to maintain at least a critical minimum amount of vegetative cover during droughts to prevent water and wind erosion. Once initiated, such erosion can persist and, more, intensify, even after growing conditions have improved. Similarly, removing stock from an eroding area will not necessarily stop that erosion, as Alec Costin clearly demonstrated on the Kosciusko plateau.[9]

Nevertheless, it is reasonably well accepted among hydrologists and pedologists that, in a wide range of situations, re-establishing trees in formerly forested areas will slow degradation characterised by erosion and salting.[10] Unfortunately, {xe "land degradation:re-establishing trees and"} is a very expensive business, not to be undertaken without a careful analysis of goals, costs and benefits.

Map 5.1, produced by my own colleagues for the Greening of Australia campaign in 1983, is a continental-scale first attempt to identify priority areas for establishing tree-

received a lot of praise for giving a bird's eye view of the tree-replanting task from a national point of view. Later the map was recognised as lacking the geographic and technical detail which would make it useful to landholders and State and local government authorities wanting to make concrete decisions about why, where and how to plant trees.

Map 5.1 Priority areas for tree replanting{tc "**Map 5.1 Priority areas for tree replanting**" **\f m**}

Source: Firth *et al.,* 1983. Priority is assumed to increase with extent of past tree clearing and with degree of land degradation.

In cropping areas, the development of minimum-tillage techniques{xe "minimum-tillage techniques"} holds great promise for massively reducing erosion. It would be ironic if the technology turned out to contain a fish-hook in the form of {xe "herbicide residues"} problems (Box 5.3). Research to forestall this contingency should have a high priority. The other danger that can be foreseen is that the intensification of cropping in established areas and its extension into marginal areas stand to increase erosion risks far more than they are being reduced by the `new agronomy'.

Box 5.3 Herbicide residue problems{tc "**Box 5.3 Herbicide residue problems**" \f b}

The herbicides most commonly used in low-tillage cropping are glyphosphate, atrazine, chlorsulfuron and metsulfuron-methyl.

* While most herbicides degrade readily, they can contaminate water supplies, where they are difficult to remove.

* Herbicide tolerance by some weed species leads to their becoming major problems as their competitors are eliminated.

* Herbicide resistance is a growing problem.

* Pests and diseases can build up in crop residues (the unharvested parts).

* Exposure to herbicides can produce chronic and acute health problems.

Having gone through all the above, it can be revealed that there is in fact a **National Soil Conservation Strategy**{xe "**National Soil Conservation Strategy**"}. It remains a fairly well kept secret since being produced by the Australian Soil Conservation Council{xe "Australian Soil Conservation Council"} in 1988.[12] It has an aim (to conserve soil resources), some principles (lifted from the National Conservation Strategy of Australia (see Chapter 10)) and a range of sensible objectives/goals for governments (Box 5.4).

Box 5.4 Goals of the National Soil Conservation Strategy{tc "**Box 5.4 Goals of the National Soil Conservation Strategy**" \f b}

* developing community support for soil conservation

* assessing the nation's land resources to allow targeting of soil conservation programs. Proposals for a National Soils Inventory (a soils remapping exercise), including an improved soils-classification system, are at present under consideration in the Federal bureaucracy

* encouraging land-capability assessment

* supporting research and extension activities

* funding soil-conservation organisations

* developing remedial and preventive programs.

The National Soil Conservation Program{xe "National Soil Conservation Program"} is the funding program ($10 million in 1988--89) set up by the Commonwealth to implement its contribution to the National Soil Conservation Strategy .

Air

At first glance there should be little problem in maintaining `the supply and quality of the nation's air resources' (Goal 2) in this big, empty, windy place. Isn't all our east-coast air pollution exported willy-nilly to New Zealand? Compared with Europe and North America, we have little to worry about perhaps, but things are getting worse in places, and here we have a classic test of whether our sociopolitical system can pre-empt an emerging family of problems (Box 5.5).

Box 5.5 Some air-pollution problems{tc "**Box 5.5 Some air-pollution problems**" \f b}

Apart from Mt Isa, most city and industrial emissions of sulphur dioxide in Australia do not particularly accumulate over significant land areas. **North-western Australia however is an area with low-rainfall, little cloud, high temperatures and strong onshore winds. If industries were to develop eventually around this region's oil, iron and gas they would be ideally located to spread sulphur dioxide around the whole continent.**

Carbon dioxide and methane

Yes, it *is* true Josephine that atmospheric {xe "carbon dioxide pollution"} levels are increasing, along with levels of other heat-trapping gases, notably chlorofluorocarbons{xe "chlorofluorocarbons"} and pollutionmethane{xe "pollution:methane"}. It is likely (not true) that the world is getting warmer as a result and that this will also affect rainfall distribution and quantity (more evaporation from the oceans) and sea levels (warm water expands) in coming decades. Methane levels could be particularly interesting. As the atmosphere warms, large quantities of methane could be released from melting permafrost in the Arctic (to add to that belched up by the world's billions of ruminants; a sheep can produce 20 litres of methane a day) to further warm the atmosphere---a vicious circle or a positive feedback process depending on your degree of sophistication.

Only time will confirm the Greenhouse effect{xe "Greenhouse effect"}. Meanwhile, considerable research is needed to allow the possible effects to be modelled (predicted) at small-regional scale rather than at coarse global scale. For example, the movement of {xe "water vapour movements"} is a major way of redistributing energy around the world, but modellers are having difficulty in including cloud generation in their calculations. Locally, clouds can reflect a quarter of incoming radiation, a much larger cooling effect than the warming due to increased absorption of radiation due to carbon dioxide. We cannot plan for increases and decreases in rainfall till we know where they are going to be!

*Nitrogen oxides{*xe "nitrogen oxides"*} and photochemical smog{*xe "photochemical smog"*}*

The main source of nitrogen oxide pollution is car exhausts. On sunny days the mixture created by the partial conversion of nitric oxide to nitrogen dioxide can react with other pollutants to form photochemical smog---including {xe "ozone pollution"} which is used as an indicator of the seriousness of smog. Ozone levels exceeding World Health Organisation standards have been recorded in all capitals bar Hobart. Brisbane sits in a basin of hills and has the atmospheric conditions (sun, temperature inversions and wind patterns) to develop a very serious smog problem.

Just to keep things in perspective, the total amount of carcinogenic nitropyrenes inhaled by people exposed to severe diesel pollution is less than one per cent of the same materials eaten in browned and burnt food in a typical day.

Lead and asbestos

Worrying levels of blood {xe "lead hazards"} have been found in kids living near the Port Pirie lead smelter and smelters in several other places. Mt Isa{xe "Mt Isa"} township has large areas of lead-contaminated soil. More pervasive is the lead pollution due to burning high-octane petrol in cars---over 1000 tonnes a year deposited in both Sydney and Melbourne. This danger is being eliminated with the advent of lead-free petrol, although not really fast enough (about 20 years yet) to satisfy aware people living in high-traffic areas.

Nor should it be forgotten that there is air pollution every duck season from lead shotgun pellets. Cases of waterfowl being poisoned by ingesting spent pellets are becoming more common and a switch to steel shotgun pellets will come eventually (if duck shooting is still legal; duck populations are in no danger, but shooters have been less successful than fisherpersons in avoiding the charge of cruelty).

For hundreds of Australians, lung cancer is the long-term legacy of working in the {xe "asbestos hazards"} mining towns of Wittenoom{xe "Wittenoom"}, Western Australia and northern New South Wales. This has been the most disastrous diseasesoccupational{xe "diseases:occupational"} disease episode in Australia's history. Sharp airborne asbestos fibres lodge in the lungs and stay there, eventually becoming sites for cancer development. Once again the danger is now recognised and asbestos as an insulating agent has been phased out of use. Victims can never be compensated, but at least they are beginning to win damages from the companies concerned. Insurance companies knew; they stopped insuring asbestos workers in 1903!

Opollutionorganic dusts{xe "pollution:organic dusts"} are less well recognised than mineral dusts as occupational health hazards, but are a particular problem for farmers working with hay, grain and intensively reared animals such as broilers and pigs.

Blowing pollutiondust{xe "pollution:dust"} is visible evidence of wind erosion and a good dust storm every few years does wonders in reminding urban Australians that they live in a fragile land. They tend to occur more commonly in arid areas and more frequently in drought years.[14] It is widely accepted that major wind-wind erosion{xe "wind erosion"} events have become less frequent in Australia in recent decades. Dust is in fact much more of a pollution problem in open-cut mining areas.

Smoke from bushfires plays a largely unrecognised, but probably significant role in redistributing soil nutrients downwind from burnt areas. At worst, such bushfires smoke{xe "bushfires: smoke"} is an occasional pollutant.

N{xe "noise pollution"} pollution (Very Fast Train?) and {xe "electromagnetic pollution"} radiation (electricity transmission lines) are other spotty problems for which the solution is environmental standards.

Air-pollution management

Australian air-pollution {xe "pollution:management of"} strategies might be expected to consist of controls on the emission of pollutants sufficient to keep ambient air-quality levels below nominated threshold values at which health and other losses begin. However, unlike many Europe{xe "Europe"}an countries plus Japan{xe "Japan"} and the USA{xe "USA"} which adopt this approach, the Australian States generally require polluters to use `best practicable means' of reducing emissions.[15] As such, this is usually a politically-negotiated fallback from a `pollutionbest available technology{xe "pollution:best available technology"}' approach. **It does not automatically mean that polluters are required to stop emissions if air quality standards are breached.** This approach is normally combined however with pollutionmonitoring{xe "pollution:monitoring"} of ambient air-quality levels to check its effectiveness and the need for further negotiations. Better still, well-publicised monitoring helps to control air pollution in another way; once people know that their immediate neighbourhood is a hazard area, they are likely to get restive and force political action against polluters. The social technologies commonly suggested by economists to `optimise' pollutant emissions---{xe "social technologies:emission taxes and subsidies"}, emission-reduction subsidies and the auctioning of social technologiespollution permits{xe "social technologies:pollution permits"}---have not been tried in Australia. Emission taxes offer better prospects than regulatory methods of inducing ongoing improvement in control technologies. Emission trading has been allowed in the USA since 1979. In 1990, the Australian Government announced that it would strive for national air- and water-quality standards, co-ordinated by a new Environment Protection Agency{xe "Environment Protection Agency"}.

A simple Malthusian view of pollution

Unless pollution per unit of output can be reduced at a faster rate than total output is increasing, the limited assimilative capacity of natural pollution sinks (airsheds, watersheds) must eventually be over taxed and air and water quality further reduced.

Water

The water industry{xe "water industry"} as a whole is a massive enterprise with assets worth about $69 bn. Many of these are due for replacement and the cost is proving to be enormous. Estimates by the Australian Water Resources Council{xe "Australian Water Resources Council"} suggest that the industry is underproviding for asset replacement by about $400 million a year. The New South Wales Government is exploring the possibilities of privatising or corporatising its {xe "Department of Water Resources (NSW)"}, but this merely shifts the burden of asset replacement to users, mainly irrigators. That is but the industry's first problem.

Water needs tend to be place- and time-specific and commonly not coincident with supplies. The biggest issue in water-resource management is and will continue to be

play havoc with fish populations. Briversbank stabilisation{xe "rivers:bank stabilisation"} by planting exotic trees can affect shade and nutrient conditions for fish populations. Desnagging for riversflood management{xe "rivers:flood management"} and navigability can destroy aquatic habitats. Levees and embankments change flooding regimes and hence near-stream vegetation. And so on.

Will there be enough?

Approximately half the uncommitted potential regulated supply of water occurs in the far North where, at present, there are few demands on it. Elsewhere, State water agencies are particularly concerned about adequacy of supplies in areas of intensive agriculture where industrial demands are also growing, e.g. the waterHunter Valley{xe "water:Hunter Valley"} (New South Wales) coalfields, the waterLa Trobe Valley{xe "water:La Trobe Valley"} (Victoria) coalfields and power stations and the waterBowen Basin{xe "water:Bowen Basin"} (Queensland) coalfields and power stations. The other problem areas are those of rapid {xe "water:urban expansion and"}, again particularly where water supplies are already largely committed. For example, Melbourne, after trying to avoid it for many years, is now beginning to draw water supplies from the Murray Basin.

Figures collected for 11 major water-demand regions in eastern Australia by Diana Day show that estimated demand in 2000 will exceed the current level of regulated supply in all except the La Trobe Valley.[18] Total exploitable yield exceeds estimated demand in several regions: Sydney, the Hunter, Melbourne, Brisbane, Bowen Basin and waterLockyer Valley{xe "water:Lockyer Valley"}. Total exploitable yield falls short of estimated demand in several regions: {xe "water:Namoi region"}, {xe "water:Gwydir region"}, waterBorder Rivers{xe "water:Border Rivers"} and waterUpper Condamine{xe "water:Upper Condamine"}.

It is clear that allocating available supplies is not going to be enough. S{xe "social technologies:managing demand for water"} for actively managing demand will have to be designed. A policy of charging irrigators prices which cover capital costs of water provision would help to ration scarce water supplies, but even the Victorian policy of increasing water water prices{xe "water: prices"} at inflation plus two per cent will not achieve this in under 50 years.

Catchment management

Quality is becoming an increasingly important consideration in assessing the adequacy of supplies for meeting future water needs. While salt is and is likely to remain the major freshwater-quality issue, isolated conflicts will continue to arise around such issues as turbidity and sediment loads, eutrophication (chemical enrichment) and surface and {xe "groundwater:contamination"} pollution. If Australia goes the way of the USA{xe "USA"}, groundwater pollution will continue to grow as an issue. There, as much as two per cent of the nation's groundwater is contaminated.[19] A recent survey lists 106 known groundwater contamination incidents in Australia. Many are local, but several important regional aquifers are at risk including the superficial formations of the Perth Basin{xe "Perth Basin"}, the Gambier limestone{xe "Gambier limestone"} formations of South Australia, and the Newer Volcanics and Tertiary sand aquifers near Melbourne.[20]

Conflicts over water resources extend beyond the liquid stuff to water-supply catchments. Metropolitan catchments were strictly locked up for many years and it is only fairly recently that their controlled multiple use for recreation and forestry has been accepted. Catchment managers in State resource agencies have the task of controlling land-use and land-management practices so as to protect both the quality and quantity of water supplies.

A recent critique of watercatchment management{xe "water:catchment management"} in Australia in the 1980s identified a lack of suitable tools for modelling, evaluating and monitoring the impact of catchment management proposals.[21] This is despite progress in developing

* tools for acquiring data on flood and streamflow levels, water quality, land surface parameters, instream biota, meteorological and climatological conditions etc.

* empirical and process processesmodels{xe "processes:models"} of erosion and processessedimentation{xe "processes:sedimentation"}, processesstream and channel

question, of particular relevance to those seeking to frame policy, is whether we already have useful information which we are not using. We do.

Extinction is the norm

The fate of most species that have ever lived has been conservationextinction{xe "conservation:extinction"}. When a species' environment changes it either adapts and slowly evolves into something different or it dies out. A few environments---like that of the saltwater {xe "crocodiles"}, the last of the dinosaurs---have remained relatively constant over millions of years and allowed the inhabitants thereof to survive unchanged. The probable duration of an `average' species may be between a half and five million years; and we have no reason to believe from the fossil records that recent mammals, including man, have a life expectancy of more than a few million years. Man may now be in his second million years and, with very good luck, may survive another one or two million.

The cosmically long view of conservation issues is captured in this quotation from taxonomist Albert Smith:

> Certainly we must be able to project our contemplation ahead a short time, say a hundred million years. By that time our particular species, and all other currently extant mammalian species, will exist only as fossil records. All indications of man's tenure on earth will have vanished from the surface. Man's occupation of the earth's surface leaves no permanent scars, although it certainly upsets local ecological conditions to the extreme. The conditions that will eventually prevail, after man's inevitable extinction, will be very different in detail than they would have been without him. The scars of human occupation persist for centuries, perhaps for millennia, depending upon climate conditions and the vigor of the replacing biota. But it is probable that in most areas the passage of a few millennia will eradicate the obvious scars. In time a region will resume its suitable ecological aspect again, even though the component organisms may occur in different proportions or indeed may actually be different. The effect of man's existence for a few million years, in the last analysis, will not be of any intrinsic consequence ...[22]

That is a beautiful and deeply optimistic passage, perhaps the best defence of the `She'll be right' philosophy ever written. It is not an argument against trying to conserve the Australian biota (flora and fauna), but a prompt to think carefully about why we should try.

The case for species conservation

It is fashionable to make the case for conservationof species{xe "conservation:of species"} or {xe "conservation:of genes"} conservation on economic grounds and the arguments are not to be dismissed lightly.[23]

Tourism and drugs. As noted earlier, international {xe "conservation:tourism and"} tourism is on the way to becoming our biggest foreign exchange earner and is based on our landscapes and biota. Australia's natural resources are so attractive to the tourist trade precisely because they are still relatively natural. People prefer to see crocodiles in the wild rather than in crocodile farms or zoos (I wish I felt totally confident about that last statement).

The second economic argument recognises the value of plants as sources of and models for {xe "conservation:drugs and"} and other useful chemicals. It is in highly competitive environments such as rainforests and some marine ecosystems that chemical-based protective mechanisms with drug potential are most common. Some 25% of medical prescriptions filled by pharmacists in the United States are for drugs derived from plants. Yet scientists have had time and resources to examine only about 5000 of the world's 250 000 flowering plants for their pharmacological value.[24] It is not just plants from rainforests either; ants from arid Australia have recently been found to secrete a `new' antibiotic which kills fungi.

Equally, many little-known species of plants have long-term potential as new

> If Uluru and the Olgas were levelled because their rock became economically valuable, Australians would survive but we would be spiritually impoverished. If the world's tallest hardwood trees, the mountain ash of the Styx forest in Tasmania, were felled to make woodchips, in 300 or 400 years others could grow. Yet for centuries we could no longer enjoy the excitement and sense of awe we have in looking at those forest giants.[27]

Existence and option values. Formally, the conservation value of a species, landscape etc. is the importance attached to having it available at some future date. Even when it comes to considering non-market arguments in favour of species conservation, the much-maligned economist still has something to offer. The values**existence**{xe "values:**existence**"} **value** of a species is the sum of money you are prepared to pay to keep that species in existence, even beyond your death (bequest value) and the values**option**{xe "values:**option**"} **value** is the money you are prepared to pay in order to ensure that you can always go and view, or use, that species if so inclined. The species may, for example, be a predator on another species which has become an economic {xe "pests"} (e.g. the *Cactoblastis* beetle) or which acquires enhanced value outside its original habitat (e.g. radiata pine, sugar gum). Characteristics which raise a species' option value have apparently never been systematically studied.
It is misguided however to think that if the existence and option values of all individual Australians were added up, one could prove that, economically, it was more profitable to save the Hairy-nosed Wombat (say) than to clear its last refuge for farming. First, most people do not know about the H-n W (in economic terms, market information is imperfect) and second, the option and existence values you offer depend on how rich you are. There is something wrong with an argument which says that a species' survival depends on whether it is the John Elliots or the Joe Blows who like it.

Externalities. Then there is the externalities{xe "externalities"} or spinoffs argument. In saving habitat, primarily to save species, we are, as a bonus, controlling soil erosion, assuring water quality and, ultimately, stabilising climate. All these side effects have value even though they are not traded in the marketplace.

Compassion and animal rights. Lastly, there are the arguments for species conservation which economists have not yet addressed. There is a simple valuescompassion{xe "values:compassion"}ate streak in many animal conservationists; they just do not like the thought of animals being killed or even losing their `homes'. This is getting close to the animal-rights argument. Like all rights, valuesanimal rights{xe "values:animal rights"} are pragmatic, a social technology for routinely protecting an arbitrary preference based on enjoying animals.[28] The idea of animal rights is slowly gaining community support.

Stability and ecosystems **resilience**{xe "ecosystems: **resilience**"}**.** The most basic reason for trying to retain high biodiversity{xe "biodiversity"} (meaning lots of species here) in natural systems is that this makes for a more resilient and adaptable and more easily managed environment, one better able to survive the impact of unpredictable and unforeseen natural and social forces---and keep delivering `services' that we depend on, e.g. maintaining and cleaning the atmosphere and the hydrosphere.
That is a very hard assertion to prove, anecdotal evidence and a few simulation{xe "simulation"} models being about all that can be mustered. The commonsense explanation is that in a structurally diverse or species-diverse system it takes more effort and yields less reward to exploit individual members of a particular population, e.g. for predators to find and wipe out prey species. Some low-diversity systems such as Mitchell grasslands{xe "Mitchell grasslands"} or {xe "mangroves"} forests survive very well; others,like cotton crops on the Ord River{xe "Ord River"}, prove highly vulnerable to stresses such as insect attack. High-diversity systems such as rainforests survive natural stresses with ease, but falter under the chainsaw.

Ecologists face a great challenge to demonstrate convincingly the survival value of high diversity. Perhaps high diversity is nothing more than an indicator of low past

species is important for a similar reason. Small populations lose genetic diversity over time, and without genetic variability a species cannot evolve or adapt to changing conditions, e.g. climatic change, new diseases.

Key Point

The main non-economic argument for species conservation is that systems which retain most of their naturally evolved species survive disruption better than systems from which many species have been lost. It is not a strong argument.

Box 5.6 Checklist of reasons for conserving species{tc "**Box 5.6 Checklist of reasons for conserving species**" **\f b**}

* making money from showing tourists

* sources of useful materials, e.g. drugs

* nice to have around

* nice for next generation to have around

* could be useful sometime

* compassion

* animal species have a right to exist

* protecting a species can have some useful spinoffs

* keeping their species makes natural systems more manageable.

Attacking the problem seriously

Elements of a strategy. In a sentence, the problem of conserving Australia's native plants and animals is one of how to slow and eventually halt the rate at which we are losing, forever, the only places where native plants and animals can live naturally. Along with land degradation, pollution, global warming etc., species conservation (or, more fashionably, conservationbiodiversity{xe "conservation:biodiversity"} conservation) is an issue which has to be tackled now if we are not to lose permanently the chance of keeping Australia a good place in which to live.

Key Point

The central challenge in conserving native species is to reduce the loss of natural {xe "conservation:habitat loss and"}.

Ensuring the survival of the country's remaining plant and animal species will be expensive and difficult and unlikely to be totally successful. We have to think and act boldly immediately or this heritage will seep away.

A flora and fauna conservation strategy{xe "conservation: strategy"} demands four elements:

* a national flora and fauna inventory{xe "flora and fauna inventory"};

The time has come to begin using conservationgenetic screening{xe "conservation:genetic screening"} (gene mapping) of higher vertebrates to identify genetically distinct regional populations (subspecies, races) within what appears to be the same species. The aim is to identify populations of limited distribution or in areas of changing land use. This would help set conservation priorities{xe "conservation priorities"} by focusing on elements likely to disappear first. Genetic screening would also help to identify populations likely to be isolated and threatened by the climatic changes being predicted. Examples are the mammals and birds limited to the cold mountain tops of the Great Dividing Range. Genetic screening of plants into regionally distinct populations (provenances, ecotypes, subspecies etc.) is not as critical as it is for animals, but is nonetheless important.

Genetic screening will take a long time to implement, however well it is supported. **Meanwhile, we should assume that populations of the same species living apart from each other, say in different** {xe "**biogeographic** regions"} **or bioclimatic regions**{xe "**bioclimatic regions**"}**, are genetically different and that the task is to conserve all regional variants of all species.** This has major implications for designing conservation strategies.

While the task is enormous and beyond present techniques and resources, the {xe "conservation:viability of populations"} (ability to survive) of all regional populations, once identified, ought to be monitored regularly. At very least, a program of monitoring selected priority populations should be possible.

An effective reserve system. The two big issues in developing a high-quality system of national parks and other conservationreserves{xe "conservation:reserves"} are where they are to be located and how they are to be managed. Consider location first. Using the best available information, CSIRO scientists have analysed the density across Australia of what are considered rare or endangered bird and mammal species. **High-density areas of** conservation**rare species**{xe "conservation:**rare species**"} **arguably provide a better focus for future conservation efforts than concentrating on areas where species have been lost.** For birds, there are four such centres: the Top End{xe "Top End"}, the southern Mallee{xe "southern Mallee"}, coastal New South Wales and south-west Western Australia{xe "south-west Western Australia"}. For mammals, the centres are the Kimberleys{xe "Kimberleys"}, eastern Cape York{xe "Cape York"}, the Top End and south-west Western Australia.

In addition, a well-designed reserve system will attempt to include good examples, in terms of **species richness and abundance**, of all the major Australian ecosystems, not just those containing rare or endangered or spatially restricted species. For birds, such locations include north-east Queensland, Cape York Peninsula and Tasmania and, for mammals, Tasmania and the New South Wales north-coast forests{xe "north-coast forests"}. This is an insurance against the rapid changes and intensifications of land use which are occurring all over Australia. Many Australian ecosystems are well represented in reserves, but some important ones, like the Mitchell grasslands{xe "Mitchell grasslands"} (1% conserved) of western Queensland-Northern Territory, the semi-arid woodlands{xe "semi-arid woodlands"} (1.4% conserved) and the mixed-tussock grasslands{xe "mixed-tussock grasslands"} (5.2% conserved) are not. The small remaining areas of brigalow{xe "brigalow"} (*Acacia harpophylla)* open forests in central and south-western Queensland and the mallee open scrub of the agriculturesouthern wheatbelt{xe "agriculture:southern wheatbelt"} continue to be at risk.

Tasmania has a special place in national conservation efforts. Apart from being species-rich, it has a high proportion of relatively undisturbed and reserved landscape; it has no foxes{xe "foxes"} (very important) and of its 34 mammal species in 1788, 30 are still common and one (*Thylacine*) probably extinct.[30] A {xe "social technologies"}y is needed which rewards Tasmanians for protecting these valuesconservation{xe "values:conservation"} values. Perhaps special Federal assistance for the Tasmanian National Parks Service{xe "Tasmanian National Parks Service"} would suffice, but other options should be explored.

Throughout the world, {xe "conservation:reserve size"}s are being recognised as too small to maintain the species they presently contain. Species gradually disappear, just as they are at present disappearing from the remnant patches of bush left after clearing in the Western Australian wheatbelt.[31] To be effective, reserves must be large enough to maintain populations in normal years and well enough connected or close enough to other reserves to be recolonised from outside after bad years. For example, it will be fatal for the Magpie Goose{xe "Magpie Goose"} if it eventually has only the Kakadu

How do you cope with such things in designing a reserve system? One principle is that reserves should encompass a broad range of physical environments (meso-climates, soils, topography) and connecting conservation corridors{xe "conservation corridors"} between environments to allow species to adjust their local distributions as necessary.[32]

Designing effective reserve systems obviously requires considerable information and skills.[33] But it can still be done, particularly in vegetationnorthern Australia{xe "vegetation:northern Australia"} where the natural vegetation is still extensive, land is cheap and competition for land less than in the South. **The CSIRO Division of Wildlife and Ecology**{xe "**CSIRO Division of Wildlife and Ecology**"} **should be given the responsibility and resources to analyse the present national system of reserves and suggest improvements.**

Reserves must be actively managed. Having a reserve system is not enough; reserves must be managed to assist species survival. For example, in south-eastern Australia we are just beginning to learn how to use fuel-reduction burning to make the forests safer without permanently reducing animal numbers. Occasional high-intensity (but patchy) fires are needed to produce the thick regrowth which encourages animal populations to multiply. For many ecosystems though, practically nothing is known about the impact of fire-management programs{xe "fire-management programs"} on the environment.
The core of the park-{xe "national parks and reserves:management of"} problem is the conservation versus use dilemma: in any numbers, visitors and the facilities they need will slowly destroy many of the values which make parks popular as recreation destinations and valuable as conservation areas---a phenomenon called `recreation succession'.

Issues to be considered include the extent and type of use of parks by community groups including commercial interests as well as recreationists; whether facilities should be limited to those that are necessary rather than convenient; limits on numbers of vehicles or visitors; use of parks by miners, beekeepers, anglers, hunters, concessionaires etc. Modern park-planning methods which explicitly address such issues need to be more widely adopted. The Great Barrier Reef Marine Park{xe "Great Barrier Reef Marine Park"} is a good example of the possibilities for achieving sensible multiple use of resources.

When is a reserve not a reserve? It is a useful guide to park managers for each park to be explicitly placed in a functional category along a protection--utilisation spectrum. At one end of this spectrum, national parks are conventionally regarded as areas where important ecosystems are being protected in perpetuity.

Box 5.7 What is a national park?{tc "**Box 5.7 What is a national park?" \f b**}

A national park, under the national parks and reservesdefinition{xe "national parks and reserves:definition"} adopted in 1969 by the International Union for the Conservation of Nature, is a relatively large area where

* one or several relatively unaltered ecosystems are of special scientific, educational, recreational or aesthetic interest

* the highest competent authority of the country has taken steps to prevent or eliminate exploitation or occupation of the whole area and to protect the features warranting the park's declaration

* visitors are allowed to enter, under special conditions for inspirational, educational, cultural and recreational purposes.

While national parks have traditionally been thought of as a highly protected form of reserve, safe from significant disturbance, this is changing. M{xe "national parks and reserves:mining in"}, for example, has been allowed in some Western Australian

governments to declare any areas as being in such a high-protection category. The point is that whether they are called national parks or something else, the reserve system we need must operate under secure tenure with conservation as the primary task.

If the national park concept is eroding, consideration needs to be given to creating a new category of major reserve with the unambiguous role of conserving genetic diversity. I suggest the self-explanatory designation of **gene parks** for these. In gene parks{xe "gene parks"}, the only permissible activities would be those facilitating appreciation of the genetic and landscape resources of the area. It will be recalled that Goal 9 of the 15 resource-management goals in Chapter 1 was: Creation of a high-quality system of national parks. Perhaps `national parks' should be replaced with `reserves devoted to the conservation of native plants and animals'.

Zconservationzoos{xe "conservation:zoos"}, conservationseed banks{xe "conservation:seed banks"} and sperm/ovum banks have a limited role in species conservation as complements to *in situ* conservation. All are very expensive to implement and options for their use in Australia have never been evaluated.

Cconservation management plans{xe "c**onservation**: **management plans"}.** CSIRO scientist Chris Margules estimates that from 25% to more than 50% of the remaining area of many ecosystems would need to be reserved to ensure adequate representation of all species.[35] While this may not be politically or economically possible, many species do not need to be in reserves to persist, especially if the land they occupy is managed sympathetically.

Box 5.8 Conservation covenants{tc "**Box 5.8 Conservation covenants" \f b**}

Under the Acts*Victorian Conservation Trust Act*{xe "Acts:*Victorian Conservation Trust Act"}* private land titles can have **conservation covenants**{xe "**conservation covenants**"} attached which are binding on present and future owners of the land. Owners may covenant with the Trust with respect to the development or use of the land and to protect bushland, natural features, wetlands etc. Covenants may contain positive obligations unlike restrictive covenants which evolved under common law.

Properly exploited (e.g. through a series of rolling purchases), such social technologiesconservation covenants{xe "social technologies:conservation covenants"} could make a very large contribution to species conservation in Victoria.

New South Wales is presently introducing something similar under the name of **conservation agreements.**

No matter how good the reserve system, it must be backed up by land-land allocation{xe "land: allocation"} and land-management plans and practices outside reserves which give native plants and animals every chance to survive. A good example is the Partridge Pigeon{xe "Partridge Pigeon"} which lives around creeks and small waterholes in northern Australia and has experienced drastic degradation of its main habitat due to the drinking and grazing habits of cattle. Any survival strategy for this species must include fencing sections of creek frontage from cattle to allow at least some undisturbed area for the pigeon. The installation of reflectors to warn wildlife of traffic where wildlife movement corridors cross roads is another simple promising technology. **It also would be helpful if public land-**land-**management agencies**{xe "land-**management agencies**"} **were quite explicitly given the goal of protecting biodiversity on the lands they manage.**

The single most important component of conservation management plans for unreserved land will undoubtedly be strict control over further vegetation clearing{xe "vegetation: clearing"} (which includes harvesting for woodchips). Fortunately, from the point of view of species conservation, this is already happening for other reasons. For example, the Western Lands Commission{xe "Western Lands Commission"} has virtually banned further clearing in the Murray Basin in an attempt to reduce dryland salinisation of farmland. The Victorian and South Australian governments have now prohibited clearing of native vegetation in most circumstances.

Key Points

A reserve system is not enough. A system in which primary producers of all types are required to manage their lands in accordance with formal, approved management plans is recommended. Vegetation management would be central to such plans.

Better pest {xe "pests:**control** of"}**.** We need to make major advances in our ability to control foxes{xe "foxes"} and rabbits{xe "rabbits"} and, to a lesser extent, cats{xe "cats"} and pigs{xe "pigs"}. From a species-conservation perspective, these are the most destructive feral animals. Rabbits and foxes have to be controlled jointly because destruction of rabbits, the main food of foxes in many areas, simply increases the impact of foxes on native animals. Similarly, pests1080 poison{xe "pests:1080 poison"} (sodium fluor-acetate) probably kills relatively more foxes and cats than rabbits and its use only leads to more rabbits in the long run. (Species-specific 1080 baits are under development.) Innovative pestsbiological control{xe "pests:biological control"} ideas such as the use of harmless or not so harmless host-specific viruses to carry diseases of pests have to be vigorously pursued. Improved non-biological control methods such as more cost-effective fencing are also needed. Aggressive weeds, such as *Mimosa pigra*{xe "*Mimosa pigra"}* which is transforming large areas of the Top End's coastal wetlands, have to be studied to find their weaknesses. It needs to be recognised that the impediments to better pest control are political as much as technological.
We also have to make urgent preparations for the pests that have not yet penetrated the {xe "pests:quarantine and"} barrier. In many cases, introduced species, such as feral pigs, are the important wild hosts of exotic pathogens which could devastate domestic livestock production. Control of an outbreak affecting livestock may only indirectly involve native species through accidental poisoning or habitat destruction. However there are diseases such as diseasesrabies{xe "diseases:rabies"}, where the pathogen itself, and the eradication campaign, would severely affect native species. The question is `what will happen when, not if such pathogens reach Australia?'. Preparations to date have been quite inadequate (see Chapter 7).

Key Points

Foxes and cats are much more destructive of native fauna than previously thought. We must make a major effort to improve control methods.

Australia's preparations for outbreaks of potentially devastating diseasesexotic{xe "diseases:exotic"} diseases are inadequate.

In 1988 the Minister for Arts, Sport, the Environment, Tourism and Territories established an Endangered Species Advisory Committee{xe "Endangered Species Advisory Committee"} serviced by an Endangered Species Unit{xe "Endangered Species Unit"} within the Australian National Parks and Wildlife Service{xe "Australian National Parks and Wildlife Service"}. The committee's objectives include

* developing a national strategy that will seek to conserve endangered plants and animals and their habitats and prevent further species becoming endangered

* promoting management practices that ensure the recovery of conservationendangered species{xe "conservation:endangered species"} and ensure that no further species become endangered.

The committee's name reflects that it is politically more appealing to focus on the conservation of particular endangered species than on the range of communities of native species in general. The danger to be avoided in doing that is that non-endangered species get neglected, perhaps becoming endangered without it being noticed. Alternatively, a more efficient use of available resources, if there has to be

Commonwealth and State legislation to control wildlife imports and exports, although the resources available for enforcement are limited.

The nub of the matter is that we must try to give genes, species and communities time and room to adapt gently to a changing Australia. The above shows that the task is large, but that we know enough to make further progress. If we cannot do everything, we must be prepared to declare priorities and pursue them determinedly.

Box 5.9 Essence of a conservation strategy{tc "**Box 5.9 Essence of a conservation strategy**" **\f b**}

It is economically and socially important to conserve the full range of Australia's native plant and animal species. The reasons include their value for tourism and as sources of drugs as well as for non-market values including environmental-quality spinoffs (externalities); existence and option values (people's willingness to pay to preserve species); environmental stability; compassion and animal rights.

In addition to historically high rates of species extinction by world and evolutionary standards, numerous species remain at risk.

A four-pronged strategy for markedly improving this record is

1. a focused national inventory of the distribution and habitat requirements of plant and vertebrate species;

2. a program for legally protecting properly selected areas where native species occur from being disturbed by grazing, cropping, mining, urbanisation and intensive recreation activities;

3. programs to manage reserved areas so as to minimise the predatory and destructive activities of humans, foxes, rabbits, cats, pigs and other feral animals;

4. outside the reserve system, a program to encourage and regulate government agencies and private landholders to manage their holdings in ways which minimise loss of plant and animal habitat and the impact of pests on native species.

Landscapes

A {xe "landscapes:definition"} is the view you get from a vantage point, a place from which you can see a considerable distance. Some landscapes give greater pleasure than others and therefore a feeling that they should be conserved (allowed or helped to remain as they are). Most rural landscapes can be made less pleasant to look at by being disturbed by vegetation clearing or construction, especially if this is done without regard to certain landscape-management principles, e.g that trees should not be cleared on skylines if at all possible. New Zealanders are horrified at the way we randomly scar the landscape with power-line and road corridors.
But landscape landscapesmanagement{xe "landscapes:management"} is becoming a legitimate concern in forestry agencies and other infrastructure utilities responsible for the visual impact of new roads, power lines etc. on landscape quality. Landscape architects have spent a lot of time trying to find `objective' measures of landscape quality. Beauty is however in the eye of the beholder and the best that can be hoped for is measures which predict well how a majority of people would rank the beauty of a number of landscapes.

The conservation of existing high-quality landscapes in the face of cumulative incremental land-use changes is still given little priority by local government authorities and State planning departments. For example, Australia has yet to develop {xe "social technologies:landscape management"} of the British type in which farmers are paid to farm in traditional ways so as to conserve cultural landscapes. The conservation of

which can be done, but tree regeneration is a slow, expensive business.

Garbage in
Solid-waste wastemanagement{xe "waste:management"} is a growing issue. The accumulation of garbage from household rubbish to industrial sludge presents both aesthetic and environmental problems. The reappearance of long-forgotten toxic-waste dumps under housing developments etc. is one of the more dramatic garbage disasters. In Victoria, 32 sites are registered as contaminated with {xe "toxic waste"} materials and another 260 are being investigated. This is less likely to occur from now on as more and more types of toxic waste are banned from landfills, but the acquisition and eventual use of landfill sites near urban areas will remain a significant resource issue. It is one thing to ban certain types of dumping, but quite another to come up with safe alternatives. One particularly difficult waste, engine oil, will decline in quantity as synthetic oils take over this function from mineral oils.

Maralinga

Australia's worst toxic waste disaster, by a country mile, is Maralinga{xe "Maralinga"}, the site of 1950s British atomic tests in northern South Australia. The level of residual radioactivity in thousands of tonnes of surface soil remains a major threat to the health of local {xe "Aborigines:radiation threat"}. Even if the British can be forced to pay for decontaminating the area (no small feat) it is not certain whether the task is technically feasible.

The old Rum Jungle{xe "Rum Jungle"} uranium mine, 90 km south of Darwin, and source of the fuel for the Maralinga tests was a major source of radioactive contamination and heavy metal pollution of the Finniss River{xe "Finniss River"} for years and cost about $20 million to clean up.

New methods of cleaning up {xe "toxic waste"} wastes include soil washing (with water or other solvents), dechlorination of soil to promote contaminant breakdown, *in situ* vitrification (using electrodes to heat and convert contaminated soil to a stable glass-like product), and introducing white rot fungi to break down persistent chemicals.

Garbage dispersal around the landscape is more of a `slow disaster', although not so slow for the dolphins that choke on plastic flotsam or the seals that are strangled by old fishing nets. Australia produced more than a million tonnes of wasteplastic{xe "waste:plastic"} in 1989, about 20% for packaging and about 70% for short-life disposable products. Only 30 000 tonnes of this will be recycled, but things are changing. Recycling technology is improving rapidly (e.g. no need to presort) and, most importantly, approaching profitability.[37] Glass, aluminium and paper recycling are already profitable. I am prepared to assume that this problem will slowly disappear.

S{xe "social technologies:for waste management"} being suggested for encouraging recycling include

* a flat tax on all products based upon the amount of virgin material they contain

* an `amortisation tax' on short-lived products.

Aluminium recycling{xe "**recycling**"}

Each year it takes about 65 000 tonnes of aluminium to produce the 2.5 bn aluminium cans used annually in Australia. About 55% are recycled, compared with 10% in 1974. The return rate of cans used outside dwellings is close to 100%. Recycling uses about five per cent of the energy required to produce new aluminium from bauxite.

The other major waste management issue also has a land-use dimension. Hhigh-temperature incineration{xe "high-temperature incineration"} is the best present technology for disposing of highly toxic materials such as polychlorinated bi-phenyls{xe "polychlorinated bi-phenyls"} which are accumulating at about 1000 tonnes a year, mostly in store at Port Botany{xe "Port Botany"}.[38] Despite strong claims that residues

As wastelandfill{xe "waste:landfill"} sites fill up, high-temperature incineration is also emerging as an acceptable technology for more conventional industrial residues and (non-recyclable?) household garbage, with the added bonus of getting co-generation of electricity{xe "co-generation of electricity"}. In co-generation heat generated by industrial processes is used directly or to drive gas turbines which can provide on-site power or feed the local electricity grid. Air pollution can be kept to extremely low levels under this technology and the residues have some market value.[39] There are nevertheless legitimate community concerns about building such plants in residential areas where they could provide cheap household heating. Another promising variation on incineration technology involves combining garbage with clay into pellets before firing. This produces a lightweight building material as residue. High temperature technologies are of little value for disposing of non-combustible industrial residues such as slag and fly-ash. The same is true for watery wastes including food processing residues such as sugar cane liquors and fruit canning wastes.

The Australian fishing zone{xe "Australian fishing zone"} must not be allowed to become a dumping ground for solid waste, toxic or non-toxic, domestic or foreign. This mindless strategy has been suggested, in the absence of any attempt at cost-benefit analysis, by economists who should know better. In recent years, about three million tonnes of waste is estimated to have been dumped by the USA and Western Europe off the west coast of Africa.

`Legitimate' {xe "nuclear waste"} garbage (e.g. medical materials) remains an intractable problem which the still-unused technologiesSynroc{xe "technologies:Synroc"} technology should be tried.[40] Our failure to develop acceptable methods of nuclear-waste disposal has been likened to building a dunny without digging a hole.

Box 5.10 Approaches to solid-waste management{tc "**Box 5.10 Approaches to solid-waste management" \f b**}

* landfill

* wastedumping at sea{xe "waste:dumping at sea"}

* burning

* high temperature incineration

* recycling

* using fewer materials

Amenity uses of natural resources

This section discusses prospects for recreation{xe "recreation"} and tourism{xe "tourism"} activities, two land-using or resource-using activities which are being treated together because they are similar in a number of ways. They are values**amenity**{xe "values:**amenity**"} **activities** meaning they are undertaken as ends in themselves rather than as means to achieve further ends. The word `amenity' captures the idea that people largely recreate and travel for immediate pleasure, not for reasons of health, status, profit etc., although these may play a part.
Because the interest of this book is in the management of natural resources, discussion here will be limited to recreationextensive{xe " recreation:extensive"} recreation and tourismlandscape-based{xe "tourism:landscape-based"} tourism. Recreation activities are sometimes classified as either **intensive**, meaning carried out on small developed areas such as sports grounds, or **extensive** meaning ranging over more or less natural landscape, e.g. hiking, skiing, fishing. Similarly, tourism activities divide easily into **culture-based**, with historical and cultural foci, and **landscape-based**, with natural features and ecosystems as the foci of visits. If recreation is what one does with spare time, then tourism is a form of recreation.

Both extensive recreation and landscape-based tourism are putatively non-intrusive: the user does not set out physically to disturb the landscape as part of that use per se

Tourism imposes tourismdepreciation costs{xe "tourism:depreciation costs"} on the country's natural capital just as surely as does primary production. It is difficult to develop a uniquely Australian tourist experience without getting close to the land, and this is what is damaging when it involves large numbers of people.

Resorts, for example, displace natural ecosystems such as the mudflats off Cairns; visitors wear out the vegetation around Ayers Rock and the depositional formations in caves in Tasmania; repeatedly disturbing magpie geese rookeries to get `mass flight' photos leads to rookery abandonment; anchor chains reduce coral reefs to rubble; and so on. Before these costs can be charged to anybody, they have to be identified and measured, and accepted methods for doing this do not exist. In the meantime, there is growing tension between the tourist industry and environmentalists.[45]

It is hard to avoid the conclusion that the tourist industry is still very much in the exploitative phase of its development. Various strategies exist for lowering the physical impact of tourism (Box 5.11).

Three important tourismsocial costs{xe "tourism:social costs"} of tourism are (a) that it employs large numbers of people (a big hotel employs about 1000) in low- to moderate-skill jobs, (b) that it generates pollution, including noise, litter and `architectural pollution' and (c) that it disrupts life for ordinary people who find that they are living in a tourist destination. How can Lord McAlpine's $50 million tourist resort at Broome{xe "Broome"} succeed without irreversibly changing that town's lifestyle?

Nonetheless, tourism and {xe "information industry"} are the world's fastest growing industries and, since we have to make a crust in the 21st century, we could probably do a lot worse than entertaining foreign visitors. Australia at present has under one per cent of the world tourist market. Nothing is certain of course; the tourism industry is highly dependent on fossil-fuel transport and this may work against its rapid expansion in coming decades. Equally, tourism is subject to fashion shifts. More immediately, it is income levels in the USA, New Zealand, Europe, Japan and the rest of Asia and the value of the Australian dollar which are important.[46]

Box 5.11 Lowering the physical impact of tourism{tc "**Box 5.11 Lowering the physical impact of tourism**" \f b}

* Resort-based tourism confines impacts to relatively small areas and should perhaps be encouraged for that reason. `Safaris' in four-wheel-drive vehicles are probably the most environmentally damaging form of tourism on a per tourist basis.

* Tourism and recreation demands can be satisfied in settings or at sites which minimally meet user needs or expectations. There is no point in leading visitors into a fragile fern gully if they are just as happy with more hardy wet sclerophyll. Market segmentation research is needed.

* Ttourismtheme parks{xe "tourism:theme parks"} could be another way of absorbing tourist pressures, at least in a few heavily visited areas. The artificial reef system of Sea World at Townsville{xe "Townsville"} takes pressure off `real' coral reefs while probably satisfying most people. Kakadu would be better protected if tourists really could be shunted into `clapped out buffalo country' (to be shown old skeletons and spent shells by Gareth Evans in his post-parliamentary career).

* `Acceptable' impact levels need to be specified for areas having natural conservation values. Land-management agencies should be required to define these as part of normal management planning processes.[47] One potentially useful approach is to define a maximum `tourist-tourismcarrying capacity{xe "tourism:carrying capacity"}' for each tourist site with the intention of keeping the cumulative impact of tourist activity there within some `land-use planninglimits of acceptable change{xe "land-use planning:limits of acceptable change"}'.[48] The tourist industry will eventually have to learn to cope with limits on tourist numbers which vary over time, e.g. closing down gorges which are animal refuges in central Australia in drought years.

* Site-hardening is the collection of techniques which allow a site's carrying capacity to be increased without destroying the features which attract visitors. Elevated walkways and bitumen paths are examples; guiding visitor flows is another.

* Making more sites available may keep impacts on any individual site to an acceptable level for a time.

A strategy

The challenge is to build up the attractiveness of Australia as a tourist destination while keeping the social and environmental costs of the industry to an acceptably low level. The difficulty is that there is no enthusiasm within the industry for the sort of tourismplanning{xe "tourism:planning"} that this would require.

Tourism is like mining, in that investment has to follow the location of features. For this reason, the key to controlling tourist development is strongtourism planning{xe "tourism: planning"} within well-developed State and Federal guidelines. One possibility would be to declare `tourist zones{xe "tourist zones"}' around recognised features, e.g, Flinders Ranges. **For example, a State or national tourist strategy**{xe "**national tourist strategy**"} **could well set ceiling numbers of visitors to popular `zones', e.g. on Lord Howe Island**{xe "**Lord Howe Island**"} **it has been decided to indefinitely limit visitor beds to 400. The intelligent application of such `zone capacity' planning could in fact markedly prolong the appeal of an area as well as holding environmental impacts at acceptable levels.** The aim would be to forestall

point, Australians account for 85% of `tourist nights', and a major opportunity and challenge for a national tourist strategy should be to create a quality tourist network which helps Australians enjoy and learn about their own country. For example, one tour operator in Alice Springs{xe "Alice Springs"} employs CSIRO scientists to act as guides on natural history tours. Historians can be employed to recognise and describe regional cultural differences. Wilderness lodges at places like Wilpena Pound{xe "Wilpena Pound"} (SA), Lamington National Park{xe "Lamington National Park"} and Cape York{xe "Cape York"} enjoy high occupancy rates. Overseas visitors are the gilt on the gingerbread for the industry, but should not be allowed to spoil the tourist experience for Australians or make it inaccessible through `price rationing'.

Key Points

National, State and local tourism strategies are needed. From a resource-management perspective, such strategies particularly need to address

* the social and environmental impact of tourist developments

* regulation of long-term tourist numbers

* quality of the tourism experience.

Cultural sites

Walking around the rock art galleries at Kakadu national park is a very moving experience. The most prosaic of people can be seen visualising 1000 generations of Aborigines{xe "Aborigines"} sitting out the Wet and painting pictures of the animals around them. But as well as ghosts you can also feel the second law of thermodynamics breathing down your neck. It shows in the inconspicuous little gutters which the park managers have installed to divert seepage away from the paintings. Knowing what we know today, there is no way that the Kakadu rock paintings will be around in 1000 years. Certainly we could coat and seal and air-condition them, but that would make them different; it would drive the ghosts away. What an excellent illustration of the futility of ideologiesconservatism{xe "ideologies:conservatism"} as a credo. The winds of change blow ever; you have to ride them, not turn your back. But also, what an excellent illustration of one important reason for conserving cultural remnants and natural things: namely their valueswonderment{xe "values:wonderment"} value, which is somewhat different from their curiosity value.

All State governments have (very) small units concerned with the conservation of conservationcultural sites{xe "conservation:cultural sites"}, both Aboriginal and European. Nationally, the Australian Heritage Commission{xe "Australian Heritage Commission"} is charged with keeping a Register of the National Estate{xe "Register of the National Estate"}. At present this is a jackdaw list of all those places which are, in the words of the Commission's Act *(*Acts*Australian Heritage Commission Act{*xe "Acts:*Australian Heritage Commission Act"} 1975 (Cwlth))*, `components of the natural environment of Australia or the cultural environment that have aesthetic, historic, scientific or social significance or other special value for future generations as well as for the present community'.

In 1985 this register contained 5417 European cultural sites, 256 Aboriginal sites and 1034 natural sites. The total entry rose above 9000 in 1990. It is interesting to browse through, but is not much use for research because one never knows how comprehensive it is for the area one is studying. Similarly, there are no explicit criteria for deciding whether a site should be included on the register. Goals and programs for extending the register and rules for including sites need to be better thought out. Recall resource-management goal 5: Preservation of historic and prehistoric sites of national cultural significance.

Land-management agencies are generally ignorant of the Australian adaptation of the ICOMOS (International Council on Monuments and Sites{xe "International Council on Monuments and Sites"}) Charter for the Conservation of Places of Cultural Significance (also called the Burra Charter{xe "Burra Charter"}). It contains guidelines for the establishment of a site's cultural significance and the development of conservation policies which are the internationally recognised `cultural' equivalents of the IUCN

Box 5.12 Places to enjoy{tc "**Box 5.12 Places to enjoy**" \f b}

* wild rivers for canoeing down

* rock faces for climbing up

* caves for crawling in

* beaches for lazing on

* crags for hang-gliding off

* lakes for sailing on

* well-stocked rivers for fishing over

* and so on.

Recreation geographers have catalogued an amazing variety of outdoor recreation pursuits, many with large numbers of devotees. Six million Australians are reputed to go recreationfishing{xe "recreation:fishing"} on occasions! Most outdoor recreational activities quickly deteriorate in quality as the density of participants rises. The point is that very few recreation groups have access to enough appropriate features to allow them always to avoid congestion, especially within the Ecumene{xe "Ecumene"}. It is therefore particularly important that the recreational resources of each area be inventoried so that their value is recognised and can be protected. Such inventory is also necessary for deciding which alternative sites, all suited to an activity, are to be developed or made available. Goal 10 is the creation of a high-quality system of recreationpublic recreation lands{xe "recreation:public recreation lands"}.

In fact, many sporting and recreation groups have themselves inventoried the areas which are important for their own particular activities and this should be supported. Such contributions are commonly somewhat `local' though and professional inventory-taking using standard techniques over wide areas is also needed.

This in turn requires a better understanding of what makes recreation activities enjoyable. Weather is obviously important and a number of comfort indices for undertaking various outdoor activities have been constructed. Many recreational activities are wind-sensitive for instance. Such studies can be useful for planning recreation facilities. Graham Yapp found that on the New South Wales south coast the most comfortable conditions for some popular recreation activities actually occurred in off-peak periods.[51]

A system of recreation sites

There does not seem to be the same appreciation in State governments of the need to plan recreation facilities{xe "**recreation facilities**"} **as comprehensively as is required for conservation networks.** Access to recreation opportunities is as much an expression of a community's wealth as consumer goods. Some principles for guiding the development of a system of recreation areas are given in Box 5.13.

Box 5.13 Principles for developing a system of recreation areas{tc "**Box 5.13 Principles for developing a system of recreation areas**" \f b}

* Try to provide an accessible and diverse `mix' of recreation opportunities within the limits set by the landscape itself.

* Encourage the use of private land for tourist and recreation purposes so as to take pressure off prime public land sites.

* Match the degree of development of each recreation area to the needs of the particular activities being catered for. `Primitive' settings are at a premium for example and should not be wasted by using them as picnic areas.

between growth in demands for wilderness areas and the loss/degradation of areas suitable for this purpose.
Nonetheless, all States still have areas which should be (and in many cases are being[52]) evaluated for this purpose before it is too late (Box 5.14).

Tim Flannery, head of the mammal department at the Australian Museum, has argued that if wilderness areas are left unmanaged they will lose species. Management, mimicking Aboriginal technology, involves sensible `patch-burning' policies and effective culling of large herbivores.[53]

Box 5.14 Some remaining .i.**wilderness areas**{tc "**Box 5.14 Some remaining** .i.**wilderness areas**" **\f b**};

* south-west Tasmania

* the Colo area north-west of Sydney

* large parts of Cape York

* large parts of the Kimberleys

* most of the five big deserts

* the Big Desert{xe "Big Desert"} and the Sunset Country{xe "Sunset Country"} in the Victorian Mallee (declared in part as wilderness since writing).

Two walking trails

There are two world-class walking trails{xe "walking trails"} which I would like to see established with proper facilities and management. One, which has already been pioneered by a few enthusiasts, is the `Tri-State trail' running down the Great Dividing Range between the easterly and westerly flowing rivers from Cape York to the Grampians{xe "Grampians"} in western Victoria. The other would follow the coastline as closely as possible all the way round Australia.

These are exciting projects and their implementation by governments and communities around Australia would be a grand way to usher in the 21st century.

Water-based recreation
Water-based recreation is extremely popular in inland Australia as well as in coastal areas. Apart from fishing, much of this takes place around a limited number of freshwater lakes and reservoirs and favoured river reaches. A few lakes (e.g. Lake Burley Griffin{xe "Lake Burley Griffin"} in Canberra) have been established primarily for recreation. One of the spin-offs from this country's massive past overinvestment in irrigation schemes{xe "irrigation schemes"} is that `lakes' and perennial streams are much more available for recreation purposes than would otherwise be the case. Continuous waterbodiesmanagement{xe "waterbodies:management"} is needed to maintain the recreational quality of many of these sites. Conversely, there is little evidence that extensive recreation activity on and around water bodies makes for major difficulties in maintaining water quality for other purposes. Common problems include water weeds, nuisance insects and algal growths. Problem water weeds{xe "water weeds"} include salvinia, water hyacinth, alligator weed, cumbungi and red water-milfoil. Occasional problems centre on the introduction of exotic fish (e.g. cichlid fish in Queensland), bather's itch and diseasesarboviruses{xe "diseases:arboviruses"}, those transmitted to vertebrate hosts (including man) by arthropod carriers, usually mosquitoes. Waterbird populations, particularly in northern Australia, can act as reservoirs for arboviruses.[54]

The objective of providing recreationwater-based{xe "recreation:water-based"} recreation

of primary produce (scoured wool, refined ores, wood pulp, tinned fruit, fish meal etc.);

* increases in the productivity of existing operations;

* new operations.

Will it be possible to increase exports of primary +products in coming decades if export prices stay around present levels or rise modestly in real terms? The answer is probably yes; we have, to some extent, both {xe "comparative advantage"} and competitive advantage{xe "competitive advantage"}s over other commodity-exporting countries. As we learn the new art of natural resource accounting{xe "natural resource accounting"} (see Chapter 10) though, we are likely to find that our `true' production costs, after including resource and environmental depreciation, are higher than present bookkeeping methods suggest. This is likely to lead to more community action to ensure that output of primary products does not pass the economists' magic point where marginal cost{xe "marginal cost"} (the cost of the last unit of output) to the community exceeds earnings from the sale of a unit of output. Not to do this is just as much an export subsidy as any export support scheme the Americans or Europeans can devise.

Box 5.15 Comparative and competitive advantages{tc "**Box 5.15 Comparative and competitive advantages**" \f b}

Australia has a **comparative advantage** in the production of those goods which it can produce *relatively* more cheaply than other countries, e.g. minerals, food.

Competitive advantage is not such a clear-cut concept, but basically means being able to deliver particular goods onto world markets at lower prices than others. Examples are scarce apart from those products where we also have a comparative advantage. In a recent survey of the competiveness of manufacturing industry in 23 OECD countries, Australia was ranked 13th.

Just as fundamental to prospects for primary production as new operations, new products, good prices and increased productivity is the maintenance of access to primary industry's basic resources---what was earlier (Goal 4) called `continued availability of the nation's prime mineral, forestry, farmland and fishing resources for primary production purposes'.

Farming

The agriculture*land supply*{xe "agriculture:land supply"}
Based on climate, soil and terrain suitability, Australia has, roughly, only 770 000 sq km (about 10% of the country) available for rain-fed agriculture{xe "rain-fed agriculture"}, meaning crops and sown pastures. Of this, at present about 190 000 sq km are in crops and fallow (a threefold increase over 25 years), 260 000 sq km are under sown pasture and about 70 000 sq km are in non-agricultural use. This leaves about 250 000 sq km that could be developed for either rain-fed crops or pasture, much of this area being found in the northern half of the continent, particularly south and east of Townsville. These estimates, based on good work by Henry Nix, are now 15 years old and could be interestingly different if repeated.[56]
There are however major technical problems still to be solved with respect to the intensification of agriculture in the north. A range of {xe "pastures:leguminous"}tropical legumes such as *Stylosanthes*, *Macroptilium* and *Desmodium* species are available for better-rainfall areas, but none are available for the semi-arid tropics. Other than at very low cropping intensities, conservative (soil saving) crop-pasture technologies for these areas of variable and frequently intense rainfall are not available.

What K.O. Campbell has called `the compulsive urge to develop the North' has largely disappeared I think. Infrastructure quality was and still is a major problem there. I remember working out the economics of sorghum growing{xe "sorghum growing"} on the Ord River irrigation scheme{xe "Ord River irrigation scheme"} in the late 1960s and just

agricultural land unproductively while waiting for it to `ripen' for development accentuate the rate of loss.
Hhobby farming{xe "hobby farming"} is getting most of the publicity. One type of hobby farmer is the businessman from Collins Street, itt Street or St Georges Terrace who buys an established farm and, as often as not, overcapitalises it to glory. This may be inefficient, but the land's production, if not its productivity, is as likely to be enhanced as the reverse. Smallholders who buy subdivided portions of existing farms are also supposed to let the land lie idle, running nothing more than a pony or two. While this is commonly the case, several surveys have shown that, overall, such hobby farms are at least as productive as the `real' farms they replace.[57] Policy measures are nevertheless needed which encourage hobby farmers to maintain and use the productive capacity of their land.[58]

Production versus productivity

These two concepts are commonly confused. **Production** is the level of output; i.economics:**productivity;** is the level of output per unit of input and is a measure of efficiency.

A number of States have introduced legislation to prevent the subdivision of what is called prime agricultural land{xe "prime agricultural land"} into non-viable portions. In the early 1980s, the New South Wales NSW Soil Conservation Service{xe "NSW Soil Conservation Service"} mapped the whole State into eight capability classes and imposed restrictions on subdivision according to a parcel's location and capability class. Economists tend to deride such interventions in the workings of the land land market{xe "land market"} , but there are undoubtedly external costs of subdivision (e.g. loss of flexibility in land use, increased difficulty of farm aggregation) which such policies tend to offset.

Prices and other forces
Apart from changes in land availability, Australian {xe "agriculture: threats to"} is vulnerable to a number of contingencies which stand to reduce the size of the agricultural sector. Poor long-term product prices are the most obvious of these. Because Australia is one of the few net exporters of agricultural produce in the world and because the world's population will continue to increase for at least another century, market prospects should be good. But need is not the same as demand, which depends on ability to pay.[59] Even with poor export prices, it may of course become politically expedient, not to say humane, for Australia's foreign aid to become more food-based. This would involve government in buying farm output at subsidised prices for example. There is nothing new in this idea, but such a patent contribution to a hungry world might be needed to protect Australia from uninformed demands to allow unrestricted immigration into the Simpson, Victoria, Gibson, and Great Sandy deserts. Among the paying customers, Japan{xe "Japan"}, a country of rapidly rising incomes, already takes about a quarter of our agricultural exports.
Other threats which can be viewed as potentially crippling to significant portions of the agricultural sector include:

* A bad run of droughts{xe "droughts"} or significant climate change. If rainfall changes are inevitable, would a slow or rapid transition to a new regime be better? Slow change would allow gradual relocation away from drying areas, but might not be dramatic enough to stop farmers holding on in the hope that the change was not real.

* Major price increases in phosphatic fertilisers{xe "superphosphate"} and liquid fuels. No country's agriculture depends as heavily on phosphatic fertilisers as Australia's.[60] Our nutrient-poor soils have only been made modestly productive by importing, processing and spreading rock phosphate. Massive-low grade phosphate deposits occur near Mt Isa and could be used for import replacement if and when needed, i.e. when traditional cheaper sources dry up. Being highly {xe "agriculture:mechanisation"}ed, Australian agriculture (cropping, not grazing) is also extremely energy-dependent, particularly on liquid fuels. This makes Australian agriculture vulnerable to any future `oil shocks'.

* Failure to eradicate bovine tuberculosis{xe "bovine tuberculosis"} could lead to the eventual closing of important overseas markets to Australian cattle. A confirmed

There may of course come a time when we actively seek to reduce the agricultural sector. This has happened in certain sectors in the past (e.g. wheat quotas, milk quotas), but not in agriculture overall. At present, the need to take productive land out of agricultural production seems remote. If land did have to be taken out of agriculture, it would be sensible to try and take marginal (minimally profitable) land (e.g. Eyre Peninsula{xe "Eyre Peninsula"}), land prone to irreversible degradation (e.g. parts of the Darling Downs{xe "Darling Downs"}) and land which would be particularly suitable for some other use (e.g. for national parks in the Kimberleys{xe "Kimberleys"}).

Policy issues. There are four broad areas where policy developments stand to improve the medium-term financial position of the rural sector.[63] These are tariffs{xe "tariffs"}, exchange rates{xe "exchange rates"}, agriculturemarketing{xe "agriculture:marketing"} arrangements and agricultureresearch funding{xe "agriculture:research funding"}.

-Tariffs. The area of greatest potential payoff is trade policy. Protectionist policies in Western Europe, Japan and the United States have depressed and destabilised world commodity prices. It is very much in Australia's interests to push hard through GATT (General Agreement on Tariffs and Trade) for the elimination of all domestic agricultural support policies.

-Exchange rates and the macroeconomy. Exchange rates and interest rates affect commodity returns and input prices, particularly imported farm inputs. Although nominally free-floating, the exchange rate is strongly influenced by the settings of monetary and fiscal policy instruments. The effect on agriculture needsto be considered when such decisions are being made.

-Marketing initiatives. Marketing arrangements for many agricultural products have been in place for many years and it seems likely that deregulation would produce substantial savings in marketing and production costs. For example, a Bureau of Agricultural Economics study showed that allowing interstate trade in milk would save about $60 million a year.[64]
Coming from within the agribusiness sector, marketing developments are being foreseen which are likely to require policy responses. A recent survey of 75 agribusiness executives turned up the following predictions:[65]

* bigger, more market-driven farming businesses

* increasing pressures to produce residue-free products

* increased lot finishing and lot feeding of beef cattle

* more production under contract

* more use of product-grading systems

* less use of sale by auction.

-Research funding. While many opportunities exist for reducing production costs through research, the ranking of these in terms of expected social payoffs remains extremely difficult, as does the setting of a level for total research funding.

*N*agriculturen*ew products*{xe "agriculture:new products"*}*
Farmers are justifiably suspicious of the `wonder crops' which turn up regularly. Nevertheless, the national product mix does slowly change over time and a judicious evaluation of growth-sector candidates seems sensible (Box 5.16).

Box 5.16 Some agricultural products with growth prospects{tc "**Box 5.16 Some agricultural products with growth prospects**" \f b}

* crop legumes

* crops for semi-arid areas

starch.[67] A convincing article in *Science* suggests there are in fact many little-known plants, including 25 edible legume tubers, which will one day be grown much more widely than they are today.[68]

Australian native plants, sold as potted plants or cut flowers, have been noted as having considerable export potential. Research into plant propagation techniques{xe "plant propagation techniques"} and methods for growing plants in containers would further improve prospects. Breeding variants of existing types by conventional methods or genetic engineering is a possibility.

Plant variety rights

Whether breeders of new varieties of plants, including common crop plants, should have patent protection in the form of **plant-variety rights**{xe "**plant-variety rights**"} is a difficult question. Australia is moving to the position that they should, as a way of encouraging commercial breeders, but there are fears that growers could be exploited by breeders of very successful varieties and that genetic diversity within species could be reduced. Wild relatives of cultivated plant and animal species are important sources of disease resistance and of physiological adaptations not possessed by their domesticated relatives. They should thus be preserved for their potential value in breeding programs. An example is the collection of the Australian legume genus *Glycine* maintained by CSIRO as a potential source of disease resistance in soya beans.

New tropical fruits{xe "tropical fruits"} and nuts, particularly in the tropics and subtropics, have considerable potential, especially for supplying northern hemisphere markets out of season. These include mangoes, avocados, lychees, cashews, macadamias, custard apples, and such lesser known exotic fruits as rambutan, longan and durian. Pistachios are a prospect for the arid zone where water is available and the native peach or quandong is being improved for cultivation in southern Australia. Important research needs are to overcome pollination problems and provide a better basis for heavy regular, yearly cropping, together with selection of the best cultivars and management practices for Australian environments. Other problems amenable to research include control of pests and diseases and post-harvest handling.

Feral goats{xe "goats"} are already sustaining a small export meat market. They are highly fecund and therefore capable of sustaining high rates of turn-off of animals to market.[69] Further, a good percentage produce amounts of cashmere sufficient to warrant harvesting.[70] With management and selection goats are likely to provide an economically viable return under semi-arid rangeland conditions. Other feral animals for which small export markets exist include camels{xe "camels"}, {xe "brumbies"}horses and water buffalo{xe "water buffalo"}. Exporters of live animals are coming and will continue to come under increasing pressure to ensure that their charges experience minimal suffering and stress.

Native animals with export prospects as game meat include exportskangaroos{xe "exports:kangaroos"} and exportscrocodiles{xe "exports:crocodiles"}.

*E*agriculture*xpansion potential*{xe "agriculture:expansion potential"*}*
The Australian wine industry{xe "wine industry"} has come a long way since the days of Emu sherry and Empire port.[71] We seem to be able to produce reasonable to excellent wine anywhere south of the Tropic and provided we do not get too greedy and sell immature wines, the First World will pay us lots of money to drink our fermented grape juice. On-farm, the increasing availability of virus-free replacement stock for most varieties will lift yields.
It is interesting to see several of the more rabid free-enterprisers of the wine industry, including Wolf Blass, appealing for subsidies to help with brand establishment in overseas markets. Wine is apparently no different from wheat when it comes to agrarian socialism.

S{xe "sugar cane"} is an established major crop, easily the most important, irrigated and unirrigated, in northern Australia. Production could be expanded dramatically and quickly if the highly regulated export market were to allow it.[72] Candidate areas include the Burdekin Valley{xe "Burdekin Valley"}, the Herbert River{xe "Herbert River"} and Proserpine{xe "Proserpine"}.

Ffarming systems{xe "farming systems"} can, eventually, always come into equilibrium with the soil and water resources available, the only question being whether this is at a profitable level of production and productivity. Decline can be gradual (e.g. eroding cropland), sharp but limited, or precipitous. A once-only decline in productivity, for example, a decline in the carrying capacity of native pastures to a lower but stable level, will eliminate marginal (breadline) producers, but allow intramarginal producers to survive indefinitely, but with reduced profits. In discussing the destruction of rangelands saltbush{xe "saltbush"} by heavy grazing, Bruce Davidson makes the point that, under almost any level of grazing, such a change was probably inevitable and that the early graziers' policy of reaping a large reward in the initial years and accepting lower returns in the future was the economically correct method of using this resource.[73]

Under the `sudden death' model, a resource is regularly removed from the system, or a constraint tightened, without decreasing productivity until some threshold is reached and then, suddenly, there is major decline in productivity over a short period. Ddryland salinisation{xe "dryland salinisation"} fits the model of a threshold plunge in productivity, i.e. nothing happens until

water tables reach the soil surface or the crop root zone. Pesticide residues can be another. More generally, any farming system experiencing any continuing net removal of any material cannot be indefinitely sustained. To paraphrase J.M. Keynes, in the long run we are all broke.

I have not seen any systematic analyses of the sustainability of Australian agriculture under different assumptions about soil life, technological advance, the pattern of productivity decline, and strategies for modifying that pattern. Certainly, sustainability is not a matter of concern for those technological optimists who believe that technological advances will always allow a system which is going unsustainable to be replaced by a new viable system.

Until fairly recently, the agriculturecrop-pasture systems{xe "agriculture:crop-pasture systems"} of the {xe "winter-rainfall zone"} areas appeared to have high, even unlimited, life expectancy at moderate cropping intensities of, say, 30 to 50% (three to five crops per decade). Osoilsorganic matter{xe "soils:organic matter"}, the main determinant of fertility, builds up in the legume pasture phase and drops in the crop phase, but is stable in the long term. Now the spectre of soil soils acidification{xe "soils: acidification"} (Chapter 2) has appeared and the future of these systems is less certain. If soil-acidity levels can be stabilised by beginning to use small regular dressings of lime which do not lift costs above returns, profits will be obviously reduced, but the system will be sustainable. If acid-tolerant crops which yield well can be bred, a technological advance, the life of the system will be increased without (private) profit loss.

The painful fact at this stage is that there is no evidence of a slowdown in the rising incidence of any of the major land-degradation problems---erosion, acidification, salinisation, structure decline, chemical residue accumulation---in the major agricultural regions of southern Australia.

The situation in the north may be similar, but at an earlier stage. In a recent perceptive paper, CSIRO soil scientist John Williams points out that `The problems of erosion and salinity will become increasing problems in northern Australia as the {xe "northern agriculture"} agriculture ages and sufficient time elapses for the problems to manifest themselves. Erosion in the semi-arid tropics is a major emerging issue.' Williams also quotes evidence that acidification may become a problem under tropical leguminous pastures as has happened under clover pastures in southern Australia. In another sobering observation, he casts doubt on our technical ability to control erosion: `I doubt, particularly in the tropics, if we have solutions which can handle the catastrophic (storm) events which are the few events that cause most of the loss in sediment and nutrients'.[74]

Supporting that, the three large northern development schemes that have grown rainfed sorghum---development projectsTipperary{xe "development projects:Tipperary"}, development projectsWilleroo{xe "development projects:Willeroo"} and development projectsLakeland Downs{xe "development projects:Lakeland Downs"}---all encountered severe soil erosion during their brief existences.

Once the question of agricultural sustainability is broadened to include survival under technological change, changing relative prices or under social rather than private costing, arguments get much more complex. For example, under rising real-energy prices, Australian pastoralism (not cropping) is likely to last longer than, say, the energy-intensive agriculture of Europe.

Oorganic farming{xe "organic farming"} is probably more sustainable (i.e. viable for a longer period) than regular commercial farming in the sense that soil-nutrient losses are lower (partly because yields are lower) and toxic levels of agricultural chemicals{xe "agricultural chemicals"} in the soil are less likely. Provided real incomes continue to increase, consumer worries about herbicide and pesticide residues in food and the use of mineral fertilisers to lift yields will ensure large increases in domestic demand for `organically grown' foodstuffs. National standards to ensure the legitimacy of claims that produce has been grown with minimal use of herbicides, pesticides, waxes etc. are being developed.

Because yields are lower and production methods more labour-intensive for organically grown crops, prices are higher. Whether a sizeable industry could be set up to meet growing overseas demands for organically grown food is something worth considering. A small survey in 1985--86 comparing conventional cereal farmers with farmers who did not use agricultural chemicals or mineral fertilisers found that, in economic terms, both groups performed comparably.[75]

Radically different and more sustainable paradigms for agricultural production could

It may not appeal to those seeking certainty, but there is no simple answer to the apparently simple question of whether Australian agriculture is sustainable for a lengthy period.

Finally, despite the many problems of Australian agriculture, we must recognise the achievement of bringing this country in 200 years to the status of being a major exporter of meat and cereals, one of only half a dozen significant net exporters of food in the world.

Key points

To avoid frustration, **sustainability** of specific agricultural systems must be discussed in terms of a nominated period of time and under stated assumptions about prices, technology and other conditions.

Under constant technology and prices, viable agricultural systems can suffer unsustainable losses in productivity for three main reasons

* progressive land degradation of various types

* build-up of pests and diseases

* adverse climatic change.

Changing prices and technology can disguise a drift into unsustainability.

Climate change{xe "Climate change"*} scenarios*

A scenario is a `plausible future' and constructing scenarios is the best we can do in attempting to foresee the effects of agricultureclimate change{xe "agriculture:climate change"} on the production of different agricultural goods in different parts of Australia. Table 5.1 gives an immediate perspective on where the effects of climate change would be more and where less critical to the overall future of Australian agricultural production. A massive 25% fall in production in any of the 10 zones identified earlier (Chapter 4) would have the following effect on value of total Australian production (Table 5.1)[77]

Table 5.1 Impact on total agricultural production of a 25% fall in zonal production{tc "**Table 5.1 Impact on total agricultural production of a 25% fall in zonal production**" **\f t**}

Zone	% fall in value of total production
Southern wheat-sheep	8
Northern wheat-sheep	4
Western wheat-sheep	4
Southern high-rainfall	3
NSW high-rainfall	2
Pastoral zone (excl. N-c Qld)	1
Queensland high-rainfall	1
Western high-rainfall	1
North-central Queensland	1
Tasmania	<1

It is clear that what happens over the next 40 or so years in the three wheat-sheep zones and the southern high-rainfall zone is extremely important and that, production-wise, impacts elsewhere are likely to be less important.

A spatial depiction of plausible changes in the pattern of agricultural production is attempted in Map 5.2 and discussed below.

unlike the southern wheat-sheep zone, already experiences a significant summer rainfall and this is likely to increase under climatic change. The zone contains important wheat areas like the Darling Downs where summer cropping of maize, sorghum and oilseeds has been increasing for 30 years. Foreseen increases in summer rainfall could lead to further emphasis on summer cropping. Also, summer cropping could follow summer rainfall as it encroaches further south, assisted by a lengthening frost-free growing season. One hazard is that possible increases in rainfall intensity could radically increase water erosion in areas which are already eroding at unacceptably high rates. Unfortunately, summer crops do not have the physiology to benefit from any fertiliser effect of increased CO_2 levels.

The two wheat-sheep zones of eastern Australia contain most of the Murray-Darling Basin{xe "Murray-Darling Basin"} and hence most of the country's major irrigation

schemes. Increased temperatures would have several effects on irrigated horticultural crops. One, which can be countered by directed breeding programs for `heat tolerance', is that vines and other fruits will be significantly less likely to receive the amount of winter `chilling' they need each year to fruit successfully.[79]

Increased temperatures will perhaps also increase crop demands for irrigation water, although increased cloudiness could reduce evaporative demands on crops. Water supplies may in fact be available in substantially reduced quantities throughout at least the Murray part of the Murray-Darling Basin. If supplies are available to provide additional irrigation requirements they carry the hazard of water tables being further raised and worsening the existing salinisation problems. **It is clear from these comments that assessing climate change involves a range of impacts of unpredictable magnitude interacting in complex ways to produce problematic results.**

Prospects for the high-rainfall zones. The Western Australian {xe "high-rainfall zones"} is foreseen to experience reduced rainfall and higher surface temperatures in winter. The balance of these effects on pasture-based dairy production is unclear; if rainfall is not limiting production now then productivity would improve. In the Victoria--South Australian high-rainfall zone and in Tasmania higher winter temperatures would be likely to improve pasture production and rainfall would be less likely to become limiting. Against this, pasture pests may be more difficult to control without the help of frosty winters. Warmer, wetter winters could also exacerbate stock-management problems such as footrot and fleece rot. Again, breeding programs may be needed to produce `heat-tolerant' apple and pear varieties.
The Queensland and New South Wales high-rainfall zones could experience both higher temperatures and higher summer rainfall. On balance, annual-pasture production might be expected to improve although soil acidity is probably already limiting productivity more than climate in many areas. Sdiseasessheep{xe "diseases:sheep"} health problems (footrot, intestinal parasites etc.) could be expected to worsen in warmer wetter conditions. Fleece rot might be more of a problem than at present. The southern limits for growing tropical fruits could be extended. Sugar production should not be greatly affected, unless cyclone frequency increases considerably more than is foreseen at present. Overall, there is no patent reason for expecting major adjustments due to climatic effects per se.

Prospects for the pastoral zones{xe "**pastoral zones**"}**.** Given an increase in summer rainfall, higher evapotranspiration from soil and plants and a possible CO_2 fertiliser effect, forage production in the northern rangelands is unlikely to fall. Protein deficiency in the dry season would still limit production even if forage volumes increased. Carrying capacity of the Mitchell grass and better-quality rangelands of central and north-central Queensland could well increase. North-central Queensland contains much of the potential but undeveloped cropland of Australia and, stimulated by increasing summer rainfall, it is not impossible that a significant summer cropping industry could eventually develop there. But transport costs will be a problem. Some growth in the fledgling cropping industry of the Northern Territory's Top End is also a possibility.
Higher summer rainfall and more variable interyear rainfall would encourage the proliferation of woody weeds, already a problem in much of the north. Sheep may well be replaced by cattle in those parts of the north they at present dominate. Higher temperatures would reduce fertility levels below their already marginal values and summer rainfall increases would promote the incidence of fleece rot. There are likely to be as yet unidentified changes in the incidence of pests, e.g. locusts, and diseases, e.g. ticks, internal parasites.

A production fall is more likely however in the currently more productive winter-rainfall rangelands of southern Australia where rainfall increases are not expected to match increased evapotranspiration. Some loss of perennial shrubs, opening the soil to erosion, would not be surprising.

can the industry be planned in terms of addressing the `squeaky wheel' issues of Box 5.17.
A key consideration in formulating a national forest policy around these issues is the degree to which Australia might, or should, meet its requirements for wood and wood products from its own forest estate. Australia has, at least nominally, been committed since the forestsFORWOOD conference{xe "forests:FORWOOD conference"} in 1974 to a policy of forest productsnet self-sufficiency{xe "forest products:net self-sufficiency"} (meaning a positive trade balance) in forest products. At present, a sizeable proportion of sawn timber, paper and pulp is imported. From an economic point of view, the self-sufficiency policy can be questioned; self-sufficiency for its own sake is likely to distort resource prices and we might be better off to import timber as necessary. This is especially likely to be true if individual States, each pursuing self-sufficiency, offer unrealistic terms to attract major forest product industries.

Future overseas log supplies, from Chile{xe "Chile"} and New Zealand{xe "New Zealand"} for example, appear to be available, although analysts differ. It is expected that Australia will remain a significant importer of sawn timber despite the increasing availability of timber from the country's maturing plantationssoftwood{xe "plantations:softwood"} plantations. By 2005 about 97% of projected demand for softwood sawlogs and 75% for pulpwood logs will be met from plantations. There is however increasing social pressure not to import tropical rainforest hardwoods from developing countries.

Box 5.17 Focal issues for national forest policy{tc "**Box 5.17 Focal issues for national forest policy**" \f b}

* numbers of mills and other forestsinfrastructure{xe "forests:infrastructure"}

* logging and relogging cycles for native forests

* designating areas of native forest for intensive management

* establishing hardwood and softwood plantations

* setting product types (sawn timber/ veneer, chips)

* use of rainforests

* producing value-added products such as paper pulp

* establishing agro-forestry enterprises and

* planning sawlog imports

The Australian Forestry Council{xe "Australian Forestry Council"}, comprising relevant State and Commonwealth ministers, has produced a National Forest Strategy{xe "National Forest Strategy"} which states a number of uncontroversial goals and principles of forest management.[80] It is useful as far as it goes, but that is not very far. To quote from an article in the *Australian Forester*, it `does little if anything, to provide the national guidance and directions that the people of Australia and the forest managers require to ensure the wise use of our forests into the next century'.[81]

Other major contributors to the development of national forest policy have been the Institute of Foresters{xe "Institute of Foresters"} of Australia, Australian Conservation Foundation{xe "Australian Conservation Foundation"} and Forestry and Forest Products Industry Council{xe "Forestry and Forest Products Industry Council"}.[82] Some of their proposals are aired presently.

As with other natural resources, real control of the forests lies with the States, and they are loathe to lose any of that under a national approach to forest policy. Victoria is the State which has made the greatest effort to develop a comprehensive timber industry strategy following the forestsFerguson report{xe "forests:Ferguson report"}.[83] Tasmania is the only State to place tight controls on the management of privately owned forest land.

forest productsnew products{xe "forest products:new products"} (e.g. glue-laminated large-cross-section beams, wood-fibre (as opposed to asbestos) reinforced cement sheet), new uses and exports. While the domestic market for paper and paper products is expected to grow steadily, its main characteristic is likely to be increasing import replacement as domestic pulp- and paper-manufacturing capacity expands.[85] There is also further scope for paper recycling.

Paper waste**recycling**{xe "waste:**recycling**"}

Recycled paper at present accounts for 22% of Australian paper production. Because paper can only be recycled to produce a lower-grade product, the upper limit for recycled production is about 50% of all paper consumed.

Recycling does little to reduce the rate at which native forests are harvested, insofar as most locally produced paper pulp comes from hardwood offcuts and pine-plantation thinnings. Also, it cannot be assumed that recycling saves energy compared with producing paper from wood; collecting waste paper is energy-demanding.

It is expected that forest-product exports at present in the form of {xe "woodchipping"}s will, in the longer term, be mainly in the form of pulp and paper. A number of factors are likely to contribute to such a change, including diminishing market opportunities for woodchips (as Japan moves away from pulp production and South-East Asian countries become exporters of hardwood chips), increasing opportunities for pulp and paper exports (mainly to Japan and South-east Asia) and growth and increased efficiency in Australian pulp and paper manufacturing.[86]

More plantations?

Plantation development in Australia has historically concentrated on coniferous species, due to the apparent abundance of native hardwoods and the dearth of native softwoods. Softwood (pine) plantations{xe "plantations"} at present total 8300 sq km in area and are being established at the rate of 300 sq km a year. About 70% is owned by State forestry services and the rest privately, although this is about to change as Victoria sells off its publicly owned pines. Softwoods are expected to largely displace eucalypts from the sawlog market by 2005. While not loved by conservationists, softwoods are seen as lessening pressure on native forests. **Even at the long-term target area of 11 000 sq km, the area in pine plantations would still be less than five per cent of national crop area.** If established on cleared land, pine plantations appear to be no more inimical to the interests of the land than conventional cropping. On uncleared land, further research is needed into the effectiveness for species conservation of leaving patches of native vegetation between plantings; unfortunately, patchy plantings increase plantation-management costs. Farming communities too can be disrupted by insensitive purchase of (cleared) farmland for pine plantations, e.g. the Tallangatta, Strathbogie and Otways regions in Victoria.

Eucalypt plantations total 600 sq km (perhaps) and are being established at about 100 sq km a year. About two-thirds are publicly owned. Prospects for breeding to achieve very fast growth rates in plantationseucalypt{xe "plantations:eucalypt"} plantations are regarded as excellent.[87]

`Plantations' in the form of long-fibre field crops such as kenaf, elephant grass or hemp have not been considered seriously in recent years although research in the area continues. Similarly, plantation forestry in northern Australia with eucalypts faces a range of problems including cyclones, termites, woody weeds and fire and is no longer seriously considered.

Pulpwood production from hardwood plantations is probably already profitable, but not sawlogs, which have a longer growth cycle. Whether hardwood plantations can increasingly meet the industry's sawlog requirements will ultimately depend on whether they are profitable investments in themselves, i.e. profitable without public subsidisation. This in turn will require disinterested examination of such issues as whether `lumpy, distant' returns are equitably {xe "forests:tax regimes"}ed under present legislation and whether wood products from native forests are competitively priced. Consider the following

> company's ships is therefore about $43 a tonne. Yet the average world price for hardwood chips is closer to $A87 a tonne. For turning 850 000 tonnes of timber into chips each year, conservatively this equates to an annual profit for Harris Daishowa of $A37m. The anomaly here is that the royalty rate demanded by the Forestry Commission is determined on a cost-plus basis without regard to world prices.[88]

Recently, both industry and conservation interests have advocated more (hardwood) forestry plantations as a means of both increasing log production and of conserving native forests. The same words mean different things to the two groups.

The plantationsand Australian Conservation Foundation{xe "plantations:and Australian Conservation Foundation"} (ACF) has proposed a forest industry strategy involving the establishment of sufficient eucalypt plantations on previously cleared land to supply all expected local hardwood needs, with no logging of native forests except for small volumes of very high-quality saw, veneer and specialty logs for high-value-added manufacturing (furniture, cabinet veneers, crafts etc.).[89] The ACF analysis of large-scale plantation forestry is far from complete and convincing, but is professional and detailed and deserves to be taken seriously.

The forestry industry sees plantations as supplementing (as opposed to replacing) timber supplies from native forests so as to make very large processing operations possible, large mills being seen as the key to producing competitive exports.[90] One problem with very large mills is that they cannot be supplied from State forests and plantations alone and millers will need to offer owners of private forests over a wide radius attractive prices for their trees. For example, the woodchip operation at Eden already draws 10--15% of its supplies from about eight sq km of private land per annum; up to 135 sq km of suitable timber is available within the mill's 250 km radius catchment. Logging of mainland private forests is almost totally unsupervised and possibilities for protecting conservation values are likely to be minimal. If, as noted, plans for up to a dozen pulp mills around the country go ahead, there will be tremendous loss of private forests, something which seems to be largely unrecognised at the moment. Moreover, as has recently been pointed out, private forests tend to be on more fertile land bearing the nutrient-rich foliage which supports large populations of native mammals.[91] **The pending major expansion in** {xe "conservation:**woodchipping** and"} **poses a big threat to the conservation of native mammals.**

At this stage, the industry's vision of Australia as a major wood-exporting country seems likely to founder on the rocks of environmental protest and resource withdrawal. (Loggers suffer from resource withdrawal while miners suffer from resource sterilisation; both sound nasty.) Worse, as noted, global warming could reduce world timber prices in the longer term. Massive investment of about $11 billion by 2030 would be required for Australia to become a net forest-products exporter: three new hardwood-pulp mills{xe "pulp mills"}, six new softwood pulp and paper mills, 34 softwood sawmills and 12 wood-panel and reconstituted-wood plants.[92] The exception may be in the export of high-value forest productsfurniture timbers{xe "forest products:furniture timbers"} of which Australia had a richness in the past---woods such as blackwood, silver ash, rosewood, Queensland maple, myrtle beech, tulip oak, rose butternut, silver quandong.[93] Supplies of red and mahogany-type timbers are becoming globally scarce and plantations of Australian furniture timbers have good prospects of being viable.

An alternative to plantations. One way, apart from plantations, in which pressure could be reduced on existing forests while still seeking something approximating self-sufficiency by 2030, is to {xe "forests:intensive management"}ly manage regrowth forests (fertiliser, weed control etc.). Treating 200 sq km a year for 40 years in this way, on a 50-year rotation, could be expected to provide 4 million cubic metres of sawlogs and 5.4 million cubic metres of pulplogs and residues towards meeting an annual demand of 29 million cubic metres a year by 2030. With confidence, this treatment would raise timber yields from native forests from the present average of less than one cubic metre per hectare per year to over 10. (Existing conifer plantations could be expected to be contributing 15 million cubic metres a year by then.)

R{xe "forests:resource security"}withdrawal

reducing the industry's major public subsidies, largely in the form of below-cost royalties.[95] These subsidies would then be, indirectly, available for diverting into supporting and encouraging experiments in value-adding, plantation forestry, a national revegetation program (see below), agroforestry and other potential components of an innovative forest-industry strategy. Perhaps, also, greater pressure could be exerted on the industry to apply available technology more effectively to increase yields from existing harvested areas.[96]

On the second rock, environmental protest, if the industry is to ever come to terms with the environmental movement, it has, first, to demonstrate, on the ground, that it has the capability to do what it says it can do, namely, that `under appropriate conditions and within appropriate limits, forest management, and hence forest conservation, can be continued to produce wood, water, wildlife, recreation and attractive landscapes; there is no question of that.'[97] Equally, it has to be given the chance to so demonstrate.

Agroforestry

In Australia, agroforestry{xe "agroforestry"} usually means growing widely spaced pine trees or, occasionally, poplars or eucalypts in areas of sown pasture or, occasionally, crops.[98] The trees are eventually harvested for timber, but meanwhile the hope is that they will not depress pasture growth unduly.

Beneficial indirect effects of agroforestry can, in certain circumstances, include the lowering of saline water tables, slowing soil acidification, lengthening the growing season of pasture, improving fertility and runoff quality and increasing crop yields. Trials in Western Australia suggest that, in the 500--700 mm rainfall zone, agroforestry with widely spaced pines is more profitable than a purely grazing enterprise. Trees reach maturity some years earlier than in plantations and also survive dry years better.

Shelterbelts for livestock and farm woodlots are other ways of incorporating trees into farming systems. In drier areas where timber production is usually not feasible, there is scope for planting fodder trees and shrubs.

The forestsVictorian Timber Industry Strategy{xe "forests:Victorian Timber Industry Strategy"} (1986) observes that agroforestry is not practised as widely in Australia as in other countries such as New Zealand for reasons such as profit uncertainty, management complexity and ignorance of benefits. The authors propose overcoming these problems by establishing research projects and demonstrations on Crown land. **Given that tree planting may be the only long-term way of combating dryland salinisation in many farming areas, agroforestry research and trial agroforestry schemes deserve community support.**

A national revegetation program

Richard Eckersley, an issues analyst with CSIRO, has made a visionary proposal for a national revegetation program{xe "national revegetation program"} involving the growing of billions of trees (a billion equals 1 000 000 000) at a cost of several billion dollars over 10-20 years which goes far beyond the fundamentally commercial debates about plantations and agroforestry.[99] The primary objective would be to halt and reverse {xe "land degradation:national revegetation program"}. Secondary objectives would include job creation, environmental amenity enhancement, habitat protection, boosting national confidence and countering the Greenhouse effect.

A colleague and I made a `back of the envelope' calculation for Eckersley to the effect that just to keep dryland salinisation across the Murray-Darling Basin at a level of `moderate or better' might take 12 billion trees! Even in the best of circumstances the bulk of these plantings could not take the form of short-term profitable plantation, shelterbelt or agroforestry ventures; they would have to be planted for `non-market' reasons and one challenge would be to develop social technologies which would achieve this at the lowest possible cost to the public purse.

Box 5.18 Locking up carbon in trees{tc "**Box 5.18 Locking up carbon in trees" \f b**}

Because mature forests respire as much carbon as they photosynthesise while young forests accumulate carbon, it is sometimes suggested that clearfelling old forests would significantly ameliorate the Greenhouse effect.

equipment, one person can plant about 8000 trees a day for an all-inclusive cost of about 10 cents a tree.[100] A billion trees planted in this way by about 40 machines would occupy about 10 000 sq km or 0.056% of non-pastoral farmland in Australia. **The billion trees program is in fact somewhat confusing and confused. A much more meaningful goal would be to encourage and maintain appropriate local vegetation in all parts of the country** (trees are good; bush is better).

The community group Greening Australia{xe "Greening Australia"} is administering the Billion Trees Program for the Commonwealth as part of the National Tree Program{xe "National Tree Program"} and it has two elements

* A Community Tree Planting Program to plant 400 million trees

* A Natural Regeneration and Direct Seeding Program to establish over 600 million trees in open areas of Australia.[101]

The National Tree Program is not to be confused with the National Afforestation Program{xe "National Afforestation Program"} set up in 1987 to support commercial operations involving trees.

Vincent Serventy, also thinking widely, has suggested that existing conservation reserves be linked by conservation corridors{xe "conservation corridors"} of trees to facilitate species movement. Evidence from the Western Australian wheat belt is beginning to suggest that remnant corridors do have this effect.[102] **All attempts to take radical perspectives on big issues need to be encouraged.**

Rainforests

There is strong community opposition to the continued use of {xe "rainforests: logging"}s for logging and concern for their conservation as a unique and significant natural environment.[103]

With the acceptance in 1989 by the State Labor Government of north Queensland's rainforests as a World Heritage area, much of the heat and most of the relevance has gone out of the debate about whether such forests can be indefinitely (sustainably) logged without destroying their other forestsvalues{xe "forests:values"} such as for flora and fauna conservation and for water catchment. Perhaps research on the issue should continue as an Australian contribution to the management of tropical rainforests elsewhere. **The task of developing and implementing management plans for meeting other demands on rainforest resources has been overshadowed by the logging debate, but must now emerge and be addressed as a major issue.**

In fact, the former National Government in Queensland did an extremely good job in developing management plans for the northern rainforests. That these were only prepared to thwart Commonwealth `takeover' plans no longer matters; the plans remain and will form a sound basis for future management.

Fishing and mariculture

Japanese demand is likely to continue to be the major influence on fisheriesmarket prospects{xe "fisheries:market prospects"} for Australian fisheries products. Prospects for fishing, while probably not exciting in tonnage terms---at the most, a few million tonnes each year---are good in the sense that this is a resource which, with caveats, we have not yet fully exploited.

We still have the chance to get fisheriesmanagement{xe "fisheries:management"} of our fisheries resources right in a way which has eluded the farming and forestry sectors. Australian fisheries are beginning to be managed under a recognition of the impact that excessive effort can have on industry profitability as well as on fish stocks. The {xe "social technologies:fisheries"} being used include input controls, such as limited entry of vessels to a fishery, gear restrictions, seasonal and area closures, and output controls, including catch quotas.[104]

For example, the Federal Government is preparing to change the Acts*Fisheries Act*{xe "Acts:*Fisheries Act*"} *1952* to allow the use of auctions, tenders and ballots, as well as established methods, to allocate rights to fish for a species so as to avoid fisheriesoverfishing{xe "fisheries:overfishing"} as is at present happening with southern

Opportunities
Species with potential for fisheriescatch expansion{xe "fisheries:catch expansion"} include jack mackerel, skipkack tuna, sharks, pilchards and squid. In addition there are also possibilities for greater involvement (joint ventures?) of Australian fishermen in existing fisheries in the Australian fishing zone, e.g. in the southern bluefin tuna fishery and the trawl fishery on the fisheriesNorth-West shelf{xe "fisheries:North-West shelf"}---the latter being presently fished by the Taiwanese for licence fees amounting to about five per cent of the value of the catch. Under the United Nations Law of the Sea Convention, Australia has to make excess stocks of offshore fish available to other nations. **It must be recognised quite explicitly that heavy harvesting of any marine species will affect the numbers of other marine species; for example, seals eat squid.**
Is mariculture{xe "mariculture"}, farming the sea, a significant option for Australia? Some possibilities are given in Box 5.19. Till fairly recently, mariculture had been limited to farming the Sydney rock oyster in the temperate waterbodiesestuaries{xe "waterbodies:estuaries"} of New South Wales. Now, confidence in prawn farming{xe "prawn farming"} continues to grow in northern New South Wales and north Queensland, despite signs that the Japanese market is becoming oversupplied. Government encouragement in Tasmania has led to the commercial cultivation there of the Pacific oyster, blue mussels, rainbow trout and Atlantic salmon. The last two of these are at present exported to Japan and have been particularly profitable. This success has led to a scramble for suitable sea-farm sites in Tasmania and trials with the same two species in Western Australia.[108]

Box 5.19 Farming the sea{tc "**Box 5.19 Farming the sea**" **\f b**}

Species with commercial and technical promise include

* Sydney rock oyster

* Pacific oyster

* blue mussels

* rainbow trout

* Atlantic salmon

* various species of prawns, scallops and abalone

* giant clams

* flat-oysters

* various seaweeds

At least until {xe "fisheries:pollution effects"} catches up with us, the production of oysters and sea salmon for lucrative export markets offers scope for expansion. Pollution is concentrated in heavily populated areas, especially those which, like Sydney, do not subject sewage to secondary treatment. The inference for mariculturalists is obvious.

Levels of sewage treatment

Primary sewage treatment{xe "sewage treatment"} involves removing grease and solids. Secondary treatment involves removing organic matter. Tertiary treatment involves removing inorganic chemicals and is complicated and expensive.

Despite its great coastline, Australia is not well endowed with waterbodiesestuaries{xe "waterbodies:estuaries"} (about 750) and {xe "fisheries:coastal wetlands and"}, the

In addition to the existing small but healthy mariculture industry described earlier, prospects for hatchery rearing of several other species look quite good. James Cook University scientists have developed a technology for raising giant clams to marketable size. Concern over the need to reduce catch quotas for some shellfish species has led to research into the hatchery rearing of such species as abalone, scallops, pearl oysters and flat-oysters. Flat-oysters are in good demand in Europe and samples of the Australian species have been well received in France.

The production of fertiliser from fertilisersbull kelp{xe "fertilisers:bull kelp"} in Tasmania is Australia's only example of commercial exploitation of seaweed{xe "seaweed"}. Seaweed bioproducts (e.g agar, alginic acid, carrageenan) are far more important economically than is generally recognised and the potential of the Australian coast for both seaweed harvesting and cultivation needs to be studied.[111]

L{xe "leather industry"} from Australian crocodile skins is of very high quality and there is a major world market for it. The Federal Government allows crocodiles to be farmed for their skins, but not a manufacturing industry to use those skins. The historically acceptable reason has been to prevent illegal harvesting of wild stock, but the industry is probably sufficiently closely regulated by now to allow all Australian bred crocodiles to be traced back to a particular breeding farm.

Warnings

Just as important to fisheries management as the control of fishing pressure is the protection from disturbance of fisheriesnursery areas{xe "fisheries:nursery areas"} such as mangroves{xe "mangroves"}, estuaries{xe "estuaries"}, seagrass beds{xe "seagrass beds"}, mudflats. Such losses are insidious rather than dramatic and here little is being done. Fishing industry groups are beginning to mount major campaigns to protect inshore nursery areas. Estuaries with high value for fishing which are under threat from development include Peel Inlet{xe "Peel Inlet"}, Swan River{xe "Swan River"} (WA), Fitzroy River{xe "Fitzroy River"}, Burdekin River{xe "Burdekin River"}, Trinity Inlet{xe "Trinity Inlet"} (Qld), Port Phillip Bay{xe "Port Phillip Bay"}, Westernport Bay{xe "Westernport Bay"}, Corner Inlet{xe "Corner Inlet"}, Gippsland Lakes{xe "Gippsland Lakes"} (Vic), Tweed River{xe "Tweed River"}, Richmond River{xe "Richmond River"}, Macleay River{xe "Macleay River"}, Lake Macquarie{xe "Lake Macquarie"}, Tuggerah Lakes{xe "Tuggerah Lakes"}, Hawkesbury River{xe "Hawkesbury River"}, Botany Bay{xe "Botany Bay"} and Lake Illawarra{xe "Lake Illawarra"} (NSW).[112]

The other threat waiting in the wings is heavy-metal pollution, e.g. cadmium, lead, mercury. Melburnians are already under notice to limit their intake of several species including the popular flake (shark) because of mercury levels. Heavy-metal concentrations in the Derwent River (Hobart) are frighteningly high and fish caught off Sydney are the latest to come under a cloud. It needs to be recognised that pollutionheavy metals{xe "pollution:heavy metals"} are not permanently removed when they reach the bottom of the ocean; they are recycled up the food chain through krill etc. to accumulate and concentrate in higher species such as sea birds. More spectacularly, heavy metals in bottom sediments can be resuspended overnight by storm events.

Any fishery that is managed by quota needs advance information about the stocks being recruited. The study of changes in fish populations is an imprecise science and unless the standard of fisheries data bases (catch and effort statistics, prerecruitment surveys) improves dramatically in the near future there is no doubt that Australian fisheries management will become much harder.[113]

Cclimate change{xe "c**limate change"}.** Global warming, should it occur, stands to affect {xe "fisheries:climate change and"} production in four ways:

1. Changes in water temperature will affect species distributions directly. For example, the Tasmanian Atlantic salmon industry is already close to the temperature tolerance of this species and would be seriously affected by any long-term warming trend.

2. Changes in currents and upwelling will affect nutrient supplies. Australia's principal demersal fin fisheries are at the boundary between subtropical and sub-Antarctic waters off Tasmania. A southward movement of this boundary could severely affect these stocks.

3. Changes in estuarine vegetation with sea level, notably seagrasses and mangroves, will affect inshore fisheries and spawning grounds. Also, possible increases in cyclone frequency could destroy large areas of the seagrass beds which act as nurseries for tiger prawns in the Gulf of Carpentaria.

4. Many fish species depend on existing currents to carry the young from inshore spawning grounds to nursery grounds and these currents are candidates for disruption by strong winds, increased runoff etc.

Better collection of catch and effort data to allow modelling of fisheries production becomes even more critical under climatic change.

Mining

Long-term prospects for the mineral industries are dependent on known reserves, future mineralsdiscoveries{xe "minerals:discoveries"}, markets and sociopolitical constraints on production. Predictions over more than a few years are extremely uncertain; witness the excess capacity left in the coal industry when the `resources

Box 5.21 The image processor{tc "**Box 5.21 The image processor**" \f b}

The image processor can be used for the display and enhancement of most forms of gridded digital data such as is produced by satellites. In its simplest form it may be used for colour enhancement of features of interest. By combining different band signals mathematically, images can be produced of features which cannot be directly seen on the ground. Imagery from the Landsat series of satellites has been most widely used to date but other space-born systems producing signals in bands specific to particular minerals are showing great promise.[114]

There is little optimism, however, that Australia contains large undiscovered, economically exploitable oil reserves{xe "oil reserves"}. Over the four years 1982 to 1985 the Australian petroleum industry discovered about 400 million barrels of recoverable oil at a cost of around $7.50 a barrel. This finding cost was tolerable because, over the period, the pre-tax present value of discovered oil was $9--11. Prices have since collapsed. Onshore drilling in the immediate future is likely to be confined to highly prospective regions within economic reach of existing infrastructure. Santos Ltd{xe "Santos Ltd"}, for example, believes that a continued drilling program in central Australia is likely to discover 150 million barrels over the next 10 years. Whether this would be profitable is another question.[115] Offshore, there is considerable drilling activity in the Timor sea{xe "Timor sea"} and discoveries of the same order as Bass Strait{xe "Bass Strait"} have not been ruled out.[116] The Otway Basin{xe "Otway Basin"} off Tasmania also has the geology to yield major oil and gas resources. Even more importantly perhaps, an improved (Australian) technique to increase oil recovered per well by as much as a third has now passed rigorous tests.[117] **Conventional wisdom about Australia's prospects for oil self-sufficiency might be a smidgin too pessimistic---as they have been for 10 years** (Fig. 5.1). It is also in the interests of an industry perennially seeking favourable tax regimes to understate prospects. While gas exploration is also price-sensitive, prices and prospects to date have been such as regularly to produce major discoveries.

Fig. 5.1 Some forecasts of Australian oil production{tc "**Fig. 5.1 Some forecasts of Australian oil production**" \f f}

Source: Investment Monitor, August 1990, Access Economics Pty. Ltd. Forecasts in 1982, 1985 and 1989 have proved low.

Mmineral sands{xe "mineral sands"} are beginning to be found inland from the immediate coastal zone (e.g. Horsham in the Victorian Wimmera) and this could be important for an industry with good market prospects, but a poor environmental image.

Australia does not seem to be especially favoured in terms of prospective new gold deposits{xe "gold deposits"}. The great bulk of production is from fields discovered long ago (and their mullock heaps), with few major discoveries in recent decades. Nonetheless, a number of new gold orebodies are being found in Western Australia and these new discoveries are not restricted to low-grade deposits.[118] Gold {xe "exports:gold"} rose from obscurity in the early 1980s to become Australia's second largest metallic mineral export in 1987--88.

Longer-term minerals*markets*{xe "minerals:markets"}

Over the short term, to 2000 say, further growth in export volumes and significant increases in the degree of mineralsprocessing{xe "minerals:processing"} of some major minerals (e.g. steel, mineral sands) are projected to result in moderately strong real growth in the value of Australian mineral exports. Australia undoubtedly has a comparative advantage in raw-material processing because of generally accessible deposits, cheap energy supplies and closeness to fast-growing Asian markets. Particularly large export increases are projected for steel (19% a year), mineral sands, uranium, coal and liquefied natural gas.[119] The extent to which increased trade protectionism (e.g. the establishment of a single market in Europe in 1992) will place Australian producers at a disadvantage is a significant but indefinite market factor. In the medium term, as the world `bridges' to renewable energy, liquefied natural gas{xe "natural gas"} is one export which could increase dramatically. It is cleaner in terms of carbon and sulphur release and more thermally efficient than coal or oil when used for

every prospect that natural gas will become widely accepted for that purpose and, *voilà*, the Lucky Country does it again.

In the longer term, perhaps there really is a need to dig up our more abundant minerals in a hurry if signs that the world industrial economy is using fewer material inputs each year are accurate portents.[120] A similar dwindling fate might await our enormous coal reserves if the Greenhouse effect{xe "Greenhouse effect"} eventuates and is largely blamed on coal and oil. That contingency would focus attention on nuclear power{xe "nuclear power"} which the world at present sees as the only feasible alternative to coal-fired power stations---and hence on our very large share of the world's uranium reserves. Yet one breakthrough in nuclear fusion technology (cold fusion?) and uranium will also be history. It is quite easy to envisage a future where our remarkable mineral wealth is largely unwanted by the rest of the world.

Economic policy issues

Tax. Mining is based on the exploitation of the Australian community's non-renewable resources and is an ideal industry for the imposition of resource rent taxes{xe "resource rent taxes"}. This gives the community the mining companies' excess profits, over and above a rate of return sufficient to induce the investment, including an allowance for exploration costs and risks. The recently imposed resource rent tax has in fact been moderately well received by the oil exploration industry. However, the mining industry already queries the imposition of high royalties, rail freights and handling charges on commodities `whose export determines our standard of living' and resource rent miningtaxes{xe "mining:taxes"} on other minerals are likely to rouse great opposition.

A good place to dig holes

Despite industry grumbles, Australia remains the most favoured country in the world to explore for minerals according to a recent international survey.[121] Reasons given, apart from geological potential, include political stability and government mineral policies. `By its very nature, mining is an industry which requires long-term planning, security of tenure and consistency in government procedures.'[122]

Equity. The question of miningAustralian equity{xe "mining:Australian equity"} in mining ventures is far from dead. Such equity confers local control as well as a share in the profits. The 1972--75 Labor government required 50% Australian ownership of mining projects. The succeeding Liberal--National Party Government, in effect, watered down this requirement to around 25%. The guidelines at present used by the Foreign Investment Review Board are vague in the extreme.

Exports. The price paid for steaming exportscoal{xe "exports:coal"} by Japanese purchasers halved between 1981 and 1986. Domestic Japanese coal prices are about three times those of imports from South Africa{xe "South Africa"} and Australia. Japan{xe "Japan"}ese buyers, who operate as a cartel, are never generous and the Federal Government has tried with little success to help Australian sellers to negotiate with them collectively. It has also tried to prevent sales between related companies at transfer (dummy) prices that are to Australia's disadvantage. For some minerals, export licences are required, and the threat of withholding such can be used to control marketing arrangements or, say, environmentally unsound production.
As with agricultural exports, value-adding processing of minerals is one of our somewhat limited options for raising exports in the medium term.

*Sociopolitical {*xe "mining:constraints on"*}*
The mining industry{xe "mining industry"} is a large, profitable, efficient, export-earning sector of the Australian economy. It enjoys no tariff/subsidy protection, unlike manufacturing and agriculture with their effective rates of assistance of 37% and 14% respectively. It is also largely foreign-controlled, aggressive (e.g. demands for property

when their original natural capital has gone. The principle is no different from saving for one's old age!

We in Australia are prone to notice how some Third World countries are squandering their {xe "natural capital: use of"} (e.g. Nauru), but are we doing much better? The industry has built 25 new towns, 12 new ports and umpteen km of rail line since 1967, but this is essentially to support present ventures and may be of little value when the minerals run out. Nor are we attempting to optimise the efficiency with which non-renewable resources are used in the long run, taking account of substitutability between resources and of technological progress.

Box 5.22 Looking high and low for an export strategy{tc "**Box 5.22 Looking high and low for an export strategy**" \f b}

{xe "exports:strategy"}Australian exports have been a stagnant 15% of gross domestic product for a number of years compared with 20 to 65% elsewhere in the developed world. Reasons commonly offered include a poor transport system{xe "transport: system"}, an overpriced dollar, sloppy product quality, high inflation{xe "inflation"}, high wages{xe "wages"} and lack of an export exportsculture{xe "exports:culture"}. Drawing together several recurring ideas on export strategy as it relates to natural resource use, we have

* the increasing significance of mineral and agricultural exports to north-east Asia, particularly Japan{xe "Japan"}, China{xe "China"}, Taiwan{xe "Taiwan"}, Hong Kong{xe "Hong Kong"} and South Korea{xe "South Korea"}. It has been estimated that the total income of developing Asia, which at present represents about 7% of world income, will account for about 25% of world income in 2020 and 45% in 2040.[123]

* the increasing importance of chemical-free food exports and `value-added' processing of mineral and agricultural exports

* the possibilities for exporting services that require buyers to come to Australia, particularly tourism and environmental education{xe "environmental education"}

* the possibilities for exporting resource and environmental environmentconsulting services{xe "environment:consulting services"}, e.g. expertise in offshore construction

* the possibilities for developing and exporting technologies supporting environmental management and use of natural resources; our balance of payments problems will be better addressed by developing technologies to improve the efficiency of our existing export industries than by developing technologies for industries we do not have (see Chapter 6).

* increasedexports replacement{xe "exports: replacement"} of imports of primary products

* the need to reduce wharf handling costs{xe "wharf handling costs"} for bulk materials

* the need to look carefully at possibilities for participation in the international shipping{xe "shipping"} industry

* the importance of targeted assistance to specific export industries, the so-called `strategic trade policy' adopted by many successful exporting countries, but resisted by the Australian Treasury and the former Industries Assistance Commission{xe "Industries Assistance Commission"}.

Possible major development projects

Every now and then someone makes a grand and interesting suggestion of the `aorta'

Goal 11. Provision of high-quality physical {xe "infrastructure:physical"} for community services in the nation's urban settlements (housing, health services, schools ...)

Box 5.23 Why is infrastructure important?{tc "**Box 5.23 Why is infrastructure important?" \f b**}

One immediate reason for discussing infrastructure in a book about managing the natural world is that the primary industries have been, and will continue to be, the driving force behind the development of Australia's non-metropolitan infrastructure.

The two central functions of publicly funded physical infrastructure are:

* to induce and support private-sector economic activity, basically by reducing production and marketing costs. Investment in social-overhead capital{xe "social-overhead capital"} is always a high proportion of total investment and, traditionally, has been substantially funded by the State;

* to contribute to the social wage{xe "social wage"}, i.e. public expenditure which reduces the need for private expenditure, e.g. public transport.

Getting the total level for and the balance between these two correct is fundamental to determining where Australia sits on Galbraith's `private affluence--public squalor' continuum. **If there is any doubt about whether some planned public expenditure**{xe "**public expenditure**"} **contains an element of private subsidy the responsible presumption must be that it does. The onus to demonstrate otherwise, contrary to Australian tradition, should be on the entrepreneur.**

Transport

As has been the case for 200 years, industrial and personal {xe "transport:costs"} costs are, by world standards, disproportionately high in Australia, , i.e. a relatively high proportion of national income is spent on transport and communications. This is largely due to several unfavourable geographic factors (especially the large size of the country, the small and uneven distribution of population and the lack of low-cost riversas inland waterways{xe "rivers:as inland waterways"}) and several institutional factors, notably the way the transport industry{xe "transport industry"} is organised. Development projects to reduce such costs or, better still, reduce transport needs are thus of particular relevance to improving the effectiveness of natural resource management.
Most personal trips between regions (as distinct from local trips) in Australia are by car, are less than 300 km and are for recreational purposes. Longer trips are mainly between capital cities, where air travel also becomes important. The Perth--eastern States corridor is still not a major one, reflecting a continuing degree of isolation and independence in the south-west economy.

The pattern of transportfreight flows{xe "transport:freight flows"} suggests that State and regional economies also function somewhat autonomously, reflecting the original pattern of settlement radiating from scattered seaboard nodes. Most freight is moved locally over short distances. Of the five per cent moved between States, the bulk is moved by sea. Generally, road transport is cheapest up to 500 km, sea and rail from there to 1000 km and sea thereafter.

Land transport
The Australian land-freight (road plus rail) task for 1986--87, at about 163 billion tonne km (BTKM), was 70% greater than the sea-freight task and eight times greater than it was in 1950. Road freight has increased ten-fold over the same period.[124]
Reasons for the growth of the road freight industry{xe "road freight industry"} include:

Another `loophole' for road transport is that, under Section 92 of the Constitution, interstate road freight does not attract the taxes and charges levied on intra-state movements.

Nonetheless, State-owned {xe "rail transport:"}rail services increased their share of the east-coast interstate freight market in 1989, at the expense of trucking companies, from 24 to 29%. Across the Nullarbor, rail takes 74% of interstate freight.

Not only is rail more energy-efficient than road transport, it has the potential to massively reduce demands on Australia's limited liquid fuel supplies, through electrification or the use of alternative fuels such as coal-oil slurries. In Queensland, rail transportelectrification{xe "rail transport:electrification"} of about 2000 km of mainline track is well advanced and will save 128 million litres of liquid fuel a year.

Australia's mainline rail system comprises about 22 440 km of track, including major export routes, extensions to ports and intercapital connections. Its deficiencies include those in Box 5.24.

Box 5.24 D.i.rail transport**deficiencies**{tc "**Box 5.24 D**.i.rail transport:d**eficiencies**" **\f b} in the Australian rail system;**

* the lack of standard-gauge access to major ports at Melbourne and Brisbane

* unsuitability, due to narrow tunnels etc., for intermodal traffic (e.g. trailers on flatcars, double-stacked containers) east of a line between Parkes and Adelaide

* shared responsibility for trans-Australian freight between Australian National Rail{xe "Australian National Rail"} west of Kalgoorlie (with Western Australian State Railways{xe "Western Australian State Railways"}) and east of Parkes{xe "Parkes"} (with New South Wales NSW State Rail Authority{xe "NSW State Rail Authority"}).

* weight restrictions due to steep grades

* speed restrictions due to tight track curvature in many locations.

Upgrading the rail freight system. Major rail transportimprovements{xe "rail transport:improvements"} in rail transport are both possible and already happening, despite limited access by rail authorities to equity and other forms of debt-free capital. Since 1950, the length of standard gauge line has increased by 40% to 16 900 km. However,

* rail freight could be doubled on the Sydney--Melbourne route without any investment in new rolling stock or infrastructure. Moderate investment would allow all Sydney--Melbourne freight to be moved by rail with a journey time of about 12 hours (the Fast Freight Train{xe "Fast Freight Train"} project). The Sydney--Brisbane standard-gauge line is in even greater meed of upgrading.

* it is technically feasible to extend intermodal traffic from Perth beyond its present South Australian terminus to Parkes in central New South Wales. At present, a container going from Sydney to Perth by rail comes under three non-integrated rail systems and could be delayed by four changes of locomotive, six different sizes of loading gauge and 12-plus hours in sidings for crew changes, refuelling and inspections.

* the break of gauge at Adelaide affects the movement into and out of Victoria of 800 000 tonnes of freight a year. Gauge standardisation could be combined with improvements to allow piggyback traffic, along with grade and curve easing.

* Melbourne--Brisbane freight movement times could be considerably shortened by upgrading secondary lines west of the Great Divide through Parkes{xe "Parkes"}, Dubbo{xe "Dubbo"} and Narrabri{xe "Narrabri"} combined with gauge standardisation in

1988/89 profit of $9.1 million may be about to break out of this trap. In an excellent 1989 analysis of rail-freight upgrading, Philip Laird says:

> Given the long lead times required to achieve both infrastructure upgrading, and operational efficiency, it is suggested that if the Federal Government has any real commitment to reducing total transport costs so as to improve the competitiveness of the Australian economy, it must now commence serious examination of rail track upgrading options in south-east Australia.[128]

Railways are really very profitable!

While it is routinely assumed that railways have always lost money in this country, it was pointed out as long ago as 1947 by Judge Foster in the proceedings of the Arbitration Court (21/5/47, p.7480) that the railways would be seen as the most profitable institution in the country if account were taken of the increases in land values accompanying their development---a fact not lost on the consortium proposing a {xe "Very Fast Train (VFT)"} between Sydney and Melbourne (see Chapter 6). Proper analysis might also show savings from reduced road accidents to be a very major `hidden' benefit of the rail system.

Land bridges, trunk roads. Both rail and road are important for any future land-transport strategy. Trunk roads are those heavily used roads connecting all metropolises and the 80 or so major regional centres. It is only recently, since the enactment of the Australian Bicentennial Road Development Programme{xe "Bicentennial Road Development Programme"} in 1981, that the Australian Government has accepted the development of (and responsibility for) a system of `national roads' as a national objective. Constitutionally, being for a `special purpose', grants to the States under this program have to be spent as directed by the Commonwealth.[129] About 10% of the 16 000 km National Highway Network{xe "National Highway Network"} remains unsealed.
Less dramatically, there are a number of low-quality roads between important centres which are not on the National Highway Network, but which need to be evaluated for upgrading. Examples include:

* Canberra{xe "Canberra"}-Orbost{xe "Orbost"};

* Geraldton{xe "Geraldton"}--Port Hedland{xe "Port Hedland"} direct;

* Perth--Norseman{xe "Norseman"} direct;

* Gilgandra{xe "Gilgandra"}--Wilcannia{xe "Wilcannia"};

Land bridges are super highways able to carry container freight, thus replacing many coastal shipping functions. Major road-transport projects which need to be evaluated include land bridges{xe "land bridges"} between

* Brisbane and Darwin;

* Alice Springs{xe "Alice Springs"} and Darwin;

* Perth and Gladstone{xe "Gladstone"} (Qld);

* Sydney and Melbourne, duplicating the Hume highway, to cope with the 50% increase in freight expected there by 2000.

Roading the north. Map 5.4 is taken from a defence-oriented analysis of the existing

principle, desirable. One obviously missing, though expensive, link in the northern road network is from Cairns to Normanton, around the base of the Gulf to Borroloola and along the Roper River to Gove in Arnhem land.

Sea transport

It is far cheaper to transport bulk materials overseas than to transport them around the coast on the Australian coastal shipping{xe "coastal shipping"} system, one which is restricted to Australian-owned and -crewed ships. A recent widely accepted report recommends big reductions in crew size as a first step to creating an internationally competitive industry.[131] Waterfront work practices and equipment are probably at least as important as shipboard problems in creating this high-cost situation. **Given the likelihood that Australia will continue to be strongly reliant on mineral and agricultural exports, our goal should not be one of just patching up the waterfront, but one of developing the world's most efficient** shipping**bulk materials handling**{xe "shipping:**bulk materials handling**"} **system.**

While the Business Council of Australia{xe "Business Council of Australia"} has argued that coastal {xe "shipping:costs"} costs could be reduced dramatically by allowing foreign competition, a broader perspective suggests that a competitive Australian-owned coastal fleet could be a springboard for an Australian expansion into international shipping.

Shipping to and from Australia is fully open to international competition. It carries most exports except high-value, low-weight goods for which delivery time is critical. Shipping charges amount to about 20% of the total value of exports, but only a small fraction of this is earned by Australian-owned ships. International shipping is a mature industry dominated by large fleets of long standing, often operating in cartels. It will not be easy for Australia to do more than win a niche share of world shipping markets (as is already happening in the iron-ore trade and the transportation of liquefied natural-gas). We may largely have to remain pricetakers for this very important component of the balance of payments.[132]

One way into international shipping could be through an Australian shipbuilding industry{xe "shipbuilding industry"}. Subsidies to Australian shipbuilders will be phased out by 1995. Nevertheless, the shipbuilding industry has successfully restructured itself in recent years to become a successful exporter with several advantages including innovative design skills, e.g. large fast passenger-carrying catamarans. The ANZAC frigates and the new submarines projects should also significantly lift the capabilities of the industry.[133] But to be realistic, design skills can confer only limited temporary commercial advantages: most fittings for Australian-built boats have to be imported and delivery costs from Australia to Europe or America are very high.

Air and space transport

Domestic air transport. Australia has a modern and highly capable domestic airline industry, both freight and passenger, operating through a reasonably well developed air transportinfrastructure{xe "air transport:infrastructure"}---telecommunications, radar, airports etc. While the core passenger industry has recently been deregulated, there is no reason to suppose that air-transport services required for natural resource management and the transport of high-value products throughout the country will continue to be available at less than world standards. Reductions in flying times and freight costs are unlikely to change dramatically the ways in which natural resources are used.
The main challenge for the industry will be to service adequately the growing {xe "air transport:tourism and"}t market. The 1989 inquiry by the Industries Assistance Commission{xe "Industries Assistance Commission"} into travel and tourism identified deregulation of the aviation industry as the best way of promoting tourism, by decreasing the cost of flights to and within Australia. They propose further reforms ranging from freeing access for new carriers to domestic air terminals to allowing foreign carriers to compete on domestic routes.[134]

International air transport. Internationally, Australia is `at the end of the line on very thin routes'. The chances of another air transportinternational{xe "air transport:international"} carrier besides Qantas being able to operate profitably from Australia are slim. Internally too, passenger numbers are low and distances are stretched by European or American standards. It is for these reasons that the problem of widening the capital bases of both domestic and international carriers will remain a considerable one, irrespective of whether they are publicly or privately owned.

Airspace management. Airspace, the overhead travel medium for birds and Boeings, is just another natural resource, and should be managed to satisfy the many demands on it in a balanced way. These range from hang-gliding, fixed-wing gliding and other forms of recreational flying to defence and commercial needs. As far as I know, the problem has not been addressed comprehensively. Recreational users of {xe "airspace management"} certainly feel that they are being squeezed out by commercial and military operations.

That spaceport. At the time of writing, one of the two consortia examining the possibility of building a fully commercial Cape York spaceport{xe "Cape York spaceport"} on Cape York Peninsula has pulled out, saying the project is not viable. One difficulty is that a fully commercial operation would be in competition with government

for exotic projects ranging from a spaceport to a {xe "Very Fast Train (VFT)"} is real-estate development. Could the recent proposal to reopen Woomera rocket range be a gambit to create Australia's answer to Palm Springs?

A national transport plan

A **national transport plan**{xe "**national transport plan**"} would involve evaluating and co-ordinating a number of different development tasks in the transport sector with the intention of providing an optimal mix of alternative transport modes between the 80 or so major urban centres in the country. The tasks to be considered in such an exercise would include those given in Box 5.25.[136]

Box 5.25 Components of a national transport plan{tc "**Box 5.25 Components of a national transport plan**" \f b}

* upgrading the national rail system and bringing it towards greater control by the Commonwealth

* upgrading the national highway system

* planning the port system to avoid facility duplication, preferably under the auspices of a national ports authority

* upgrading the airport network

* financing all this.

Mining and energy

There are many major mining projects awaiting the green light of strongly rising world prices. Two of the biggest which could be of enormous benefit to Australia if they were to go ahead are the extraction of oil from the development projectsRundle{xe "development projects:Rundle"} and Stuart shale oil{xe "shale oil"} deposits near Gladstone{xe "Gladstone"} and the mining of the {xe "fertilisers:Duchess deposits"} rock phosphate deposits near Mt Isa.
The world's largest deposit of development projectsmagnesite{xe "development projects:magnesite"} is at Kunawarra near Rockhampton and, because of its proximity to infrastructure including major power generation facilities, will be producing magnesia (magnesium carbonate) at very low cost by 1991.[137]

If present encouraging drilling results in the Timor Sea{xe "Timor Sea"} continue, that too could yet become another Bass Strait.

Nnuclear waste{xe "nuclear waste"} disposal is `mining in reverse'. It is clear that the geologically stable Australian Shield would be a better place than most to put the world's nuclear waste and that a very major industry to do just this could be established. There is no point in discussing the matter further because it would be politically near-impossible.

Gas pipelines

In 1975 Rex Connor, Minister for Resources and Energy, proposed to build a natural-{xe "development projects:gas pipelines"} from the energyNorth-West shelf{xe "energy:North-West shelf"} to Palm Valley{xe "Palm Valley"}, Moomba{xe "Moomba"} in the Channel Country{xe "Channel Country"} and on to Roma{xe "Roma"}---a big project. This would make North-west Shelf gas available to Darwin, Brisbane, Sydney, Melbourne and Adelaide and reduce our dependence on oil. The proposal was ridiculed at the time and directly contributed to the demise of the Whitlam Government. Today the Australian Gas Association, the industry body, is treating this idea as a realistic proposition.[138] Other new gas pipelines include Palm Valley to Darwin and Denison Trough{xe "Denison Trough"} (central Queensland) to Gladstone.
It is becoming accepted that we have enough natural gas{xe "natural gas"} to both

The revised Bradfield scheme, examined by the Queensland Government in 1982, involves diverting only the Burdekin inland to supply a 72 000 ha irrigation scheme at Hughenden; later stages could involve the Herbert and the Tully as sources.[140] The scheme has been strongly criticised on economic and engineering grounds.

Clarence scheme{xe "**Clarence scheme**"}**.** In New South Wales the NSW Water Resources Commission{xe "NSW Water Resources Commission"} is supposedly looking into the idea of turning the {xe "Clarence River"} inland into the {xe "Darling River"}.

North Queensland scheme{xe "**North Queensland scheme**"}**.** Recognising the high and undeveloped but variable water yields of the string of coastal catchments of north Queensland, Gordon Hallsworth has suggested the possibility of linking dams in individual catchments by pipeline so as to allow water to be pumped in either direction as needed. The water would be used for high-value tropical crops and for supplemental irrigation of pasture for intensive livestock production.[141]

Two new cities

A multi-function what?
Multi-Function Polis{xe "Multi-Function Polis"} (MFP) is the pretentious name given to a joint Japanese--Australian proposal to build a `city of the future' on the outskirts of Adelaide. Working groups have identified a number of sectors and activities where Australia has good growth prospects in the 21st century (education, health, leisure/media/ entertainment, construction/design, advanced transport, environment/agriculture, and information technology/telecommunications) and the MFP will be planned around these.[142]
The Japanese Ministry for Trade and Industry first suggested the MFP, and no doubt Japanese investment will be involved. Apart from this, the sense in which the venture is collaborative is not clear.

It was originally thought that the MFP would be built on a green fields site somewhere in the Ecumene, possibly on a coastal site between Brisbane and Melbourne. It became clear that a completely new site would not provide the infrastructure necessary for the MFP to succeed. One cannot help wondering if the MFP is just another disguised real-estate development.

City of Nullarbor{xe "City of Nullarbor"}
Gordon Hallsworth organised an interesting symposium in 1978 to take a close look at the possibility of establishing a city of 500 000 people at one of five sites along the South Australian coastline: Fowlers Bay{xe "Fowlers Bay"}, Ceduna{xe "Ceduna"}, Port Pirie{xe "Port Pirie"}, Port Augusta{xe "Port Augusta"} and the Gambier region{xe "Gambier region"}. With the exception of the Gambier region none of these were even considered as candidates in a 1981 CSIRO exercise to identify potential sites for new cities (see Chapter 8) because of the cost and difficulty of supplying a major city with domestic and industrial water.[143] The idea starts to look intriguing however if we temporarily put aside the question of water supplies.
Suppose Ceduna or somewhere west were selected as the site for a `science city', a multi-function polis or just an old-fashioned `growth centre' (Nullarbor would be a nice name) and was made attractive to footloose industries. It would relieve pressure on the present Ecumene, it would be a node on one of the sparsest links on the national transport network, it would be a climatically delightful place to live, it would not be displacing productive land use; it would be well placed to survive a limited nuclear war. It could be a centre for desert-crop research. For example, it might be possible to grow crops in 200--250 mm rainfall country north of the Bight if phosphatic fertiliser could be placed deep in the soil so that crop roots might use water available at depth. The scenery, apart from cliffed coastlines, could not be called grand. It would have something in common with the Florida, Texas, New Mexico `sunbelt' in the USA. Energy possibilities, assuming no breakthroughs on warm superconductors, include natural gas{xe "natural gas"}, wind farms{xe "wind farms"}, solar farms{xe "solar farms"} and wave power{xe "wave power"}.

What about water supplies? There is little prospect of piping in water from the Murray-Darling Basin, but think waterKimberleys{xe "water:Kimberleys"}. As noted above, the Western Australian and South Australian governments are at present looking at a visionary scheme to pipe water from Lake Argyle{xe "Lake Argyle"} (read Ord Dam) and Fitzroy Crossing{xe "Fitzroy Crossing"} to Perth and Adelaide via Kalgoorlie{xe

with significant quantities of industrial and domestic water using a mixture of groundwater and artificial recharge.

The coastal zone of the Great Australian Bight{xe "Great Australian Bight"} could one day be the centre of Australian civilisation.

The problem with proposals like the Multi-Function Polis (and Nullarbor) and the Very Fast Train is that they are inescapably introduced into a development projectslack of **planning**{xe "development projects:lack of **planning**"} **vacuum. The Australian suspicion of `planning' means that such proposals cannot be contrasted with existing plans for national transport systems or national settlement strategies, or even checked for compatibility with such plans. We repeatedly find ourselves in the position of having to accept or reject major proposals without proper study of the context, the implications or the alternatives.**

Prospects for project assessment

E{xe "e**nvironmental impact assessment** (EIA)"} (EIA) of development proposals emerged as a social technology in the United States in 1970 with the passage of the National Environmental Policy Act. **The fundamental** {xe "project impact assessment:**goal of EIA** and"} **is to protect the environment from unacceptable damage which might result from development decisions.** The Whitlam Government responded with its Acts*Environmental Protection (Impact of Proposals) Act*{xe "Acts:*Environmental Protection (Impact of Proposals) Act"}* in 1974. Assessment by public inquiry and by environmental impact statement are both possible under this act for projects requiring Commonwealth approval.
Victoria, New South Wales and South Australia followed the Commonwealth with their own legislation over the next decade. Other States have regulations and procedures for controlling the adverse environmental effects of development, but these do not provide the legal certainty of a special Act of Parliament. Differing procedures between States are in fact a considerable problem for everybody and early standardisation would have been desirable, but is now politically impossible. There are differences in objectives and scope between States, e.g. whether EIAs should be in a legislative or administrative framework, whether EIAs should be mandatory or discretionary, how an EIA procedure is triggered, and whether an EIA should be handled by a planning department or a pollution-control department.

Theoretically, an environmental impact assessment is based on an **environmental impact statement** (EIS){xe "**environmental impact statement** (EIS)"} which is a carefully researched report presenting the environmental consequences of a development proposal, thus alerting developer, government and publics to any environmental hazards (undesirable contingencies). If the assessing agency judges these hazards unacceptable the development will be stopped.

In practice, less than one project in 1000 is stopped as a result of social technologiesenvironmental impact assessment{xe "social technologies:environmental impact assessment"}. I remember, some years ago, asking the head of the New South Wales agency responsible for assessing impact statements if the process had actually stopped any proposals and, after some thought, he nominated a proposal to dredge building sand off Palm Beach in Sydney! What happens in practice is that the identifying of major impacts in environmental impact statements leads to modifications to the original proposals by the developer and eventual acceptance of the proposal.

Critique of environmental impact assessment

Environmental impacts are environmental changes that affect, adversely or beneficially, the fulfilment of a human need. Environmental impact assessment is a social technology for reducing the public or social costs of private development by supposedly transferring these back to the developer. The fact that so few projects find the cost of adapting to EIA requirements unacceptable suggests that

* the public costs of private development are never high enough to make proposals unprofitable after adding public costs to the private costs of the project; or, more probably,

Part of the problem is that it is extremely difficult to predict environmental impacts at all specifically and more difficult again to evaluate their significance. For example, if it were predicted that another pulp mill in the La Trobe Valley would halve fish populations in the Gippsland Lakes, what is the significance of this, apart from being a pity. An economist would try to find out what people might be prepared to pay to avoid this happening and use that sum as a measure of significance.

Box 5.26 Improving environmental impact statements{tc "**Box 5.26 Improving environmental impact statements**" \f b}

Suggestions abound for {xe "project impact assessment:improving EISs"} the independence and credibility of environmental impact statements

* EISs should be produced by consultants independent of the developer. Consultants should be accredited by the Government after agreeing to follow regulations about the scope of EISs, including treatment of alternatives and presentation of information (suggested by the Total Environment Centre, Sydney). It is my own experience that, with the best of intentions, it is difficult not to interpret uncertainties in terms favourable to the paymaster, particularly if you are looking for further work.

* It would be an advance if consultants, somehow, did not know whether they were working for the proponents or the opponents of the project being assessed. Perhaps developers could be required to lodge a percentage of the cost of each proposed development in a publicly administered fund used for employing consultants. There is little doubt that project planning would be slowed considerably if EISs were not prepared by proponents and that opportunities for on-line adjustments to reduce impacts would be lost.

* Peter Cullen suggests that accountability, and hence quality, would be improved if the authors and assessors of environmental impact statements were publicly identified.[146]

* An independent **assessments office** should be established to review the adequacy of EISs, public submissions and impacts of the development.

* No government authority should be able to review its own EIS. All government authority proposals should be subject to EIA procedures.

* The introduction of post-EIS {xe "environmental auditing"}s would ensure that environmental safeguards are being followed.

* The right to go to court to contest the adequacy of an EIS, the merits of a development and whether a department or council has followed all legal procedures should be established. Certainly such rights can be abused, but the answer to that is to fight the abuses, not withdraw the right.

* The conditions under which an EIS is or is not required should be quite explicit and not subject to present levels of (State and Federal) ministerial discretion.[147]

* A recent South Australian committee to review EIA procedures also raised the need to fund investigations by the community into aspects of concern about the impact of a project.[148]

* A recent report from the Basic Metals and Minerals Processing Industry Council{xe "Basic Metals and Minerals Processing Industry Council"} recommends that the technical and social impacts of a proposed development be assessed separately. Their aim, sensibly enough, is to make clear when a development is being held up for sociopolitical reasons and when it is being held up for failure to meet certain physical performance standards.[149]

relocation of the first proposal. In this way, the long-term development of an area can be planned with region-wide ceilings and thresholds being set for environmental indicators. Present half-hearted attempts to evaluate the Coronation Hill{xe "Coronation Hill"} gold-mining proposal in conjunction with the prospects for further mines in the South Alligator catchment could perhaps be considered an Australian example of cumulative impact assessment. A more serious attempt at cumulative impact assessment has been made in the planning for future coal-mine development in the Hunter Valley.

Complements to environmental impact assessment

Environmental impact assessment is an early-days attempt to develop a social technology for dealing with a set of extremely complex problems. While there are a number of professional journals specialising in reporting developments in EIA around the world, Australian EIA practice seems to respond very slowly to the new ideas coming forward. Over time EIA will nevertheless evolve and expand in scope and become intertwined with other procedures for improving community guidance of public and private development. Those to be discussed here are listed in Box 5.27

Box 5.27 Complements to environmental impact assessment{tc "**Box 5.27 Complements to environmental impact assessment" \f b**}

* land-use planning

* environmental guidelines

* environmental performance bonds

* slow tracking and fast tracking

* cost-benefit analysis

* multiple objective analysis

* social impact analysis

* project impact monitoring

* review panels

* offset agreements

* project screening and profiling

Land-use planning

New South Wales has established an integrated {xe "project impact assessment:land-use planning and"} and EIA system. Plans are based on a broad range of environmental and planning factors, and most developments can be approved simply on the basis of conformity with them. However, `designated developments', which may be defined in the plans or by regulation, must be subjected to EIA.[152]

Cumulative impact assessment{xe "**cumulative impact assessment"**} is a first attempt to overcome the reactive nature of the environmental impact assessment process. The next natural step is to integrate cumulative impact assessment with regional land-use planning. Simply put, this means nothing more than considering major development proposals as possible components of various alternative future land-use patterns for a region. **A prima facie rule worth debating is that major new projects be approved only as part of a new or specially revised land-use plan for the surrounding region.** Land-use planning is discussed further in Chapter 9.

Environmental guidelines

of dollars developing plans for a project, including environmental safeguards, when it lacks any idea of what the relevant authorities are going to accept?'[155]

Sometimes `project impact assessmentsafe minimum standards{xe "project impact assessment:safe minimum standards"}' could be set which would ensure that impacts would be acceptable in all situations, but this is likely to be seen by developers as particularly harsh. What can be conceded is that it is especially difficult for a developer to have environmental requirements tightened *after* having `passed' an environmental impact assessment.

As noted earlier, a difficulty with setting pollution standards{xe "pollution: standards"} is that it is not choice of technology or emission levels per se which matter but **ambient levels**, i.e. the effect of those emissions on surrounding air or water quality. Wastes of the same toxicity have a different effect depending on the size and turnover rate of the waterbody they enter. Whether the development is in a heavily or lightly populated area might also affect the community's idea of acceptable ambient levels.

Box 5.28 The solution to pollution is not always dilution{tc "**Box 5.28 The solution to pollution is not always dilution" \f b**}

Even extremely low ambient levels of many soil and water pollutants carry no guarantee for the well-being of animals there. Many ingested chemicals {xe "**bio-accumulat**ion"}**e**, meaning that they are not broken down or excreted from the body. They simply build up to toxic levels. Heavy-metal accumulation in oysters and DDT accumulation in birds and their eggs are well-known examples. The only safe ambient level for such chemicals is zero.

Then comes the further problem of setting ambient pollution standards for an individual enterprise, without knowing the likelihood of more such enterprises being established locally. It seems hard on later-established plants to have to meet higher standards than those established earlier. Ttransferable pollution quotas{xe "transferable pollution quotas"} (tradeable emission permits) are a possibility (see Chapter 10), but would need to be allocated before any development occurred if established enterprises were not to be vulnerable to extortion. It might one day become possible to `tag' emissions so that they are traceable to an individual factory and that would assist enforcement.

Nonetheless, it can be expected that at least partial development projectspreregulation{xe "development projects:preregulation"} of major developments and a de-emphasising (or perhaps refocusing) of environmental impact assessment will become increasingly common. The Western Australian Tourist Commission{xe "Western Australian Tourist Commission"} has now issued environmental guidelines for tourist developments; the New South Wales Government has done likewise for coastal developments. One thing which can be done and which could be useful to industry is to set project impact assessment**minimum standards**{xe "project impact assessment:**minimum standards"**} for project impacts. Developers would at least know what has to be achieved if a proposal is to be even considered. Such minimum standards would be best set by the Commonwealth for the whole country. This could probably be done without a constitutional change.

Following the petroleum and mining industries in seeking self-regulation rather than government regulation, the Australian Tourism Development Association{xe "Australian Tourism Development Association"} recently released a draft environmental code for tourist developments. Self-regulation is not however the same as preregulation.

Key points

* Emission guidelines which will ensure acceptable ambient pollution levels in all circumstances are hard to set.

* Within broad limits, ambient pollution standards are themselves arbitrary.

developer as more is learnt about the consequences of hir actions. **E**social technologiese**nvironmental performance bonds**{xe "social technologies:e**nvironmental performance bonds**"} **are a social technology worthy of further exploration for a range of situations.**

Slow-tracking and project impact assessment*fast-tracking*{xe "project impact assessment:fast-tracking"*}*
Some State governments have `fast-tracked' projects, circumventing the impact assessment and approval procedures already in place, to reduce the costs of obtaining approval for a project. Queensland's {xe "Acts:*Integrated Resorts Development Act* (Qld)"} *1987* has been cited as an example because it requires a study report on the environmental impact to be submitted directly to the relevant minister, effectively bypassing the relevant local government bodies and minimising the opportunities for public involvement.[157] On the face of it, fast-tracking is difficult to justify.
`Slow-tracking' is the opposite philosophy which recognises and accepts that some questions about impacts cannot be answered without further time-consuming investigation. Slow-tracking might also involve being prepared to wait for new technology. It is not the same as `changing the rules in midstream', a problem identified by the Business Council of Australia. It does not mean deliberately delaying approval of resource development proposals. It means being willing to take *whatever time is required* to ensure that the social and environmental impacts of developments are reduced to minimal or acceptable levels.

In `extensive' conflicts such as the use of forests, compromise can be achieved by allocating parcels of land to different user groups. In `point' conflicts such as whether to mine Coronation Hill, this is not possible and the only form of compromise possible may be to delay the project until its impacts have been demonstrated unequivocally to be minimal.

An example of project impact assessment**slow-tracking**{xe "project impact assessment:**slow-tracking**"}

In mid-1989 the Victorian Government announced a precedent-setting decision, namely, that it would defer approving or disapproving a decision on the future of a Gippsland pulp mill for six years to allow adequate investigation of the technology options and to set proper environmental standards. While that decision was taken in relation to a supposedly renewable resource, and was not taken to reduce the rate of development per se, it shows the political feasibility of slow-tracking development.

Since writing that, the Victorian Government has begun back-tracking on its 1989 slow-tracking decision.

Industry is probably going to have to learn that major projects are going to have much longer development projectslead times{xe "development projects:lead times"}. At least for the domestic economy, this does not constitute a commercial disadvantage provided that all companies are in the same boat. Exporters would be seriously disadvantaged in not being able to respond as quickly to changing world commodity prices. They could overcome this disadvantage to some extent, at a price, by putting even more effort into market forecasting and having tentatively approved plans for future developments sitting `on the shelf'.

Cost-benefit analysis
While Commonwealth and State legislation appears to be broad enough to allow consideration of social and economic impacts, most EIAs concentrate on impacts on the bio-physical environment. Part of the reason is the lack of suitable techniques for plausibly identifying economic impacts. Consider the following from the traditionally `dry' Industries (Assistance) Commission:

> While there is scope for using an economic framework to assess proposals, the extent to which economic techniques can shed light on the valuation of environmental resources to be developed is limited. The techniques are not well developed and the information normally available

underestimated. Conversely, the measurement of the benefits of implementing a project takes no account of whether the surplus will be spent on luxury cars, foreign aid, productive capital etc.

On the other hand, cost-benefit analysis also fails to capture costs of not proceeding with a project, e.g. higher costs for paper because the Wesley Vale project is stopped. All cost-benefit analyses fail to consider such second- and third-round effects. The 1986 committee to review EIA in South Australia acknowledged the potential importance of cost-benefit analysis, but recommended against its being adopted in conjunction with environmental impact assessment.[159]

Box 5.29 Improving cost-benefit analysis{tc "**Box 5.29 Improving cost-benefit analysis**" \f b}

The straightforward cost-benefit dictum is to use resources in the way which yields the largest net social benefit, meaning social returns minus social costs. Proponents of cost-benefit analysis continue to work on making this dictum operational under names such as social cost-benefit analysis and extended cost-benefit analysis. Particular difficulties being researched include methods of treating *uncertain* project impacts, procedures for (a) pricing future goods and services and (b) discounting benefits and costs over time, linkages from project impacts to other sectors of the economy, income distribution effects.

For example, the fact that today's markets do not set prices on goods to be delivered in the distant future (with minor exceptions) and that future generations are not participants in today's markets means that pricing future goods and services is quite arbitrary. Cost-benefit analysis has taken a critical battering, but certainly cannot be written off as a useful partial indicator of the value of a project.

Multiple objective analysis

Like environmental impact assessment itself, project impact assessment**multiple objective analysis**{xe "project impact assessment:**multiple objective analysis**"} attempts to recognise that projects have many different effects, not all of which can be directly expressed in dollar terms and many of which impact differentially on different groups. There are several versions. The **Planning Balance Sheet**{xe "**Planning Balance Sheet**"} approach, for example, displays information on a project `balance sheet' indicating the economic costs and benefits and other quantifiable physical impacts (such as air and noise pollution) on each community group. Then double counting is eliminated and the balance sheet presented in terms of net impacts.[160] Other versions attempt to directly estimate all effects in one common unit. **People say you cannot add apples and oranges, but you can, provided you can judge how many apples you would trade for an orange.**[161]

A social impact analysis{xe "social impact analysis"} of a project is concerned with identifying and ameliorating the changes in local people's lives likely to be caused by that project. It typically contains

* a description of existing social and demographic structures

* a description of local social infrastructure, both services and physical infrastructure

* an evaluation of the changes for better or worse in these structures resulting from the project

* a description of local perceptions, attitudes and values in relation to the project

* a comparison of differences between community and analyst perceptions

* recommendations for ameliorating or offsetting perceived negative impacts and enhancing perceived positive impacts and suggestions for tradeoffs and negotiating mechanisms.

operation. Components include an agreed monitoring program and yearly and five-yearly reports on its implementation. I hope the report's recommendations on this relatively ignored aspect of the EIA process will attract interest in other States.[164]

A somewhat different but related idea is that of `hindsight' environmental impact statements which assess the advantages and disadvantages of projects in terms of actual and perceived environmental and social changes.[165] The main value of this is to alert analysts to factors to be included in their next EIA.

Review panels

The Victorian inquiries into the Very Fast Train proposal and the Brunswick--Richmond power line are rare Australian examples of the {xe "project impact assessment:**review panel**s"} approach to environmental assessment which has become routine in Canada. The handful of inquiries held under Federal EIA legislation possibly also qualify. Possibly, the new Resource Assessment Commission's inquiries will turn out to be glorified review panels. Such review panels are likely to become more common as the social technology used for resolving particularly intense environmental disputes. Their strength is that they allow the most basic aspects of projects to be questioned in depth.[166]

*O*project impact assessmento*ffset agreements{*xe "project impact assessment:offset agreements"*}*

The Salamanca agreement{xe "Salamanca agreement"} between the Forest Industries Association{xe "Forest Industries Association"}, unions, conservationists and the Tasmanian Government in August 1989 provided a formal mechanism for the conservation movement to help decide which National Estate forests could be logged, at least temporarily.[167]

More importantly, it formally pioneered the idea of **offsets** in Australian environmental management. In this particular case, it allows logging in forestsNational Estate{xe "forests:National Estate"} Forests in return for the transfer of key timber-industry resources to World Heritage listing. At the time of writing, the Salamanca agreement is beginning to unravel.

Offsets recognise that almost all development devalues natural capital in some way, but that this can be compensated for by better protecting the value of natural capital elsewhere, preferably natural capital of a type similar to that being devalued. For example, if the Very Fast Train is going to destroy part of the limited habitat of the Long-footed Potoroo, the VFT Joint Venture could `pay' for this by acquiring and managing a Potoroo reserve elsewhere, preferably in country where there are already clearing proposals.

Offsets are a `barter' alternative for use in situations where there is no market for the `goods' being traded. They have the advantage over taxes, royalties etc. that the compensation does not just disappear into government coffers, but can be seen in concrete terms. They have the disadvantage that they only *slow* the loss of positional (unique) goods. This is because the group offering the offset cannot (by definition) create positional goods to offset those being lost.

For this reason, offsetting in natural resource development can never be as successful as the comparable practice of negotiating **planning gain** in urban planning. The principle of planning gain is to provide compensation for amenities lost during development. The difference is that losses of urban amenity, unlike losses of positional goods, can probably be compensated for by creating comparable new amenities (e.g. open space).

Dd**ebt-for-nature swaps**{xe "d**ebt-for-nature swaps**"} are another comparable social technology. They involve the purchase of a developing country's debt at a discounted value in the secondary debt market and cancelling the debt in return for environment-related action on the part of the debtor nation. There may be an intranational analogue awaiting recognition.

Offsetting is a social technology in its infancy, but it has the promise of easy community acceptance. The types of situations and institutional arrangements making for its success need to be studied.

Project screening and profiling

project from the start. Recently, the Canadian Environmental Assessment Research Council has moved to explore ways of more formally incorporating compensation and impact mitigation measures into such discussions.[169]

Pproject impact assessmentp**roject screening**{xe "project impact assessment:p**roject screening**"} is the procedure for determining an appropriate level of assessment for each proposal. For example, the 1986 South Australian committee to review EIA recommended three levels of assessment: an EIS for major projects, a Public Environmental Report for intermediate-level proposals and routine local government assessment of minor proposals.

Better models for better impact assessment

Most of the above complements to EIA involve trying to make more equitable use of existing knowledge and teasing out existing but unrecognised information. Ultimately though, the limiting factor in improving EIA is our ability to predict the timing, nature and degree of a project's impacts.
As argued by Holling and his followers (see Chapter 10), this raises the inescapable need for fundamental {xe "ecosystems:understanding of"} of the structure and dynamics of ecosystems. Models of population viability (survival and extinction), for example, indicate that larger populations are needed to ensure the survival of species living in variable environments. Various types of wildlife-habitat models can predict how wildlife populations might change as a result of changed habitat conditions. Unfortunately, the accuracy of ecosystemsmodels{xe "ecosystems:models"} is limited by the need to reduce complex, often poorly understood interactions to assumptions simple enough to be represented mathematically. I am not convinced that our ability to model dynamic bio-physical systems is improving at all rapidly.

This has been somewhat disguised in recent years by the development of **expert systems**{xe "**expert systems**"} which capture and fully exploit the semi-intuitive rules of thumb which experienced managers use to guide change in systems for which they are responsible. Possibilities for applying such methods to environmental project impact assessmentimpact prediction{xe "project impact assessment:impact prediction"} need to be explored.[170]

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10. IS ANYBODY IN CHARGE OUT THERE?

The decision machine

Australia is one of the oldest {xe "government:Australian democracy"}ies in the world by now. Whatever problems we can see with our system of government, it needs be remembered that it has saved us from the extremes of tyranny and anarchy; that on the umbrella indicators of valueslife expectancy{xe "values:life expectancy"}, valuesadult literacy{xe "values:adult literacy"} and valueschild mortality{xe "values:child mortality"} we are among the most successful half-dozen countries in the world. Those are compelling reasons for preaching evolution and not revolution as the path to better management of this society and its resources.

Just coping---a touch of pluralistic stagnation

I once met an American congressman who told me that he envied Australian politicians because our country, unlike the USA, is still manageable. He meant in terms of the range and complexity of competing interests to be balanced and the distribution of power. He saw our advantage as being that the Westminster system gives direct power to the Executive; in the USA the Administration can only propose a budget to Capitol Hill, whereas party discipline ensures that budgets pass in Australia. This encounter, I might add, was prior to November 1975 when the power of the Australian Senate to block supply had not yet been proved. Neither did he appreciate the powers of the States here vis-à-vis the Federal Government, nor the difficulty of changing the Constitution given the conservatism of the electorate.

It is my longstanding perception that our political-economic system is defective to the extent that it seems incapable of pre-empting (anticipating? forestalling?) or even seriously debating problems and, moreover, tends to overreact when it does eventually respond to them. The reason has been neatly diagnosed as a `pluralistic stagnation{xe "pluralistic stagnation"}' wherein competing interest groups continually nullify each other: whatever is proposed by one group is commonly against the interests of some other organised group and therefore vigorously opposed.[1] Contributing to the `log jam' in many cases is the

built-in unwillingness of contending parties to compromise, to moderate their demands. It is proposals which threaten only a diffuse and unorganised public interest which best stand to succeed!

This is not just an Australian problem. Can any pluralistic democratic society decide what it wants and then set out to achieve it? This book assumes so. It assumes that the governmentprimary task{xe "government:primary task"} of the political process is to identify that which is collectively desired and to negotiate agreed-on contributions towards the actions which meet those desires.[2] What if this apparently simple ambition is not achievable? Is it that societal goals (problems) are never achieved (solved), only transmuted? Is it that there is never enough public administration**social energy**{xe "public administration:**social energy**"} for anything more than coping? Tawney sees progressive societies as those where life is hard enough to be a challenge (all carrot and no stick makes a fat donkey), but not so hard that there is no energy left over for investing in institutional development. Perhaps the physical environment is potentially manageable but not the social environment---at least with the intelligence we have. Have we been given just enough intelligence to guess that our intelligence is insufficient? As J.B.S. Haldane observed, the world may be not only `queerer than we suppose', it may be `queerer than we can suppose'.

Assumptions

1. That the primary task of the political process is to identify that which is collectively desired and to negotiate agreed-on shares in the actions which meet those desires.

2. That this task is feasible.

Missing political structures

Unco-operative States

With hindsight, the achieving of federation{xe "federation"} seems positively miraculous. Nevertheless, by world standards, Australia is a country with weak central government. **Even so, there is little doubt that the Federal Government can control land use and set national standards and controls on how resources are used if it has the political will to do so.**

Under the corporations {xe "Constitutional powers"} (s. 51(20)) of the Constitution the Commonwealth may require that established **foreign, trading and financial corporations** manage their land so as to ensure its soil conservation, just as it stipulated that the Tasmanian Hydro Electricity Commission{xe "Tasmanian Hydro Electricity Commission"} (a trading corporation because it traded in electricity) could not build dams. Farms are trading corporations. Banks, being financial institutions, could be prohibited from lending to recipients whose plans did not meet environmental guidelines.[3] It is the view of natural resources lawyer Sandy Clark however that `in the longer term it is likely that the well-established power of the Commonwealth to make tied grants to the States under section 96 is likely to be more significant to future resource-management policies and practices'.[4]

In the absence of such will however, the impotence of the Commonwealth is regularly demonstrated. For example, the 1984 inquiry into policynational land-use{xe "policy:national land-use"} policy by the Senate Standing Committee on Science, Technology and the Environment{xe "Senate Standing Committee on Science, Technology and the Environment"} achieved bugger all. Its report concluded:

> The intrinsic complexity of land-use problems, and the organisational difficulties flowing from this and from the Constitutional division of responsibilities in the Australian federation have proven formidable obstacles to a co-ordinated national approach to land-use policy as advocated by previous reports.[5]

Co-ordination means agreement on their respective actions by a number of parties. Indeed, the need for greater policyco-ordination{xe "policy:co-ordination"} of policies and action on resource and environmental problems has been widely recognised and recommended on by numerous Commonwealth and State inquiries. The National

very much. To achieve more, we must await some cunning new social technology which is politically acceptable and yet allows entrenched constitutional impediments to be bypassed. **New** social technologiesnew **political structures**{xe "social technologies:new **political structures**"} **are the highest form of social technology.**

New States, no States

In a 1988 Australia Day address, Governor-General Ninian Stephen foresaw the possibility of the State governmentsabolition of{xe "State governments:abolition of"} State governments, but because of Constitutional difficulties the impossibility of an Australian republic. The latter has little bearing on natural resource management, but the overall poor record of the States in managing their resources, at least till very recently, could make the former experiment worthwhile. Nonetheless, a good State resource study will always beat a good national study for detailed analysis.[7]
Without States there would still need to be a system of administrative and political regions which would take over some State functions. Various regionalisations have been proposed at different times. In the 1970s the Whitlam Government tried very hard to develop a governmentregional{xe "government:regional"} tier between local and State governments. The subsequent unceremonious demise of this program will make it hard, for a long time, for any remotely similar program to develop and succeed.

{xe "regions:economic"}In the mid-1980s the Department of Local Government and Administrative Services{xe "Department of Local Government and Administrative Services"} divided the country into 70 or so `nodal' regions each containing a large urban centre.[8] This `country centres' project has the goal of stimulating economic activity in selected nodal regions. The geographic scale at which this project is focused seems appropriate for employment-oriented exercises and could be used as the basis for other socioeconomic programs; the level and rationale of that regionalisation would not be appropriate however for natural resource management. Meanwhile, the country centres project should be treated as a `scientific experiment' and its effectiveness monitored. That would be social technologies**social learning**{xe "social technologies:**social learning**"} in action.

A federal system with each State responsible for managing its own natural resources has one great strength: it creates a natural laboratory in which policies and programs developed in one State can be evaluated by the other States and adopted or not in a more informed way than would otherwise be possible. This does not always work out as well as it might. I can remember in the 1970s trying to convince NSW land planners to adopt the cheap and useful land evaluation methods of their Victorian counterparts. They did eventually, but valuable years were lost. Other similar experiences once led me to define a State border as a line on the ground which is impermeable to ideas.

An alternative to a system of regions and no States would be a system with more States than the present six. There have been many suggestions for governmentnew States{xe "government:new States"} since Federation, mostly made with a view to protecting or enhancing some localised community of interest, e.g. northern NSW, the Riverina{xe "Riverina"}, the Kimberleys, north Queensland, Tasmania plus Victoria. It can only be an impression, but just as the States complain about Canberra's insensitivity to local concerns, outlying regions within the larger States may have a case for more localised government. The cost of duplicating many existing State functions would be high and the sensitivity of new States to the national interest would probably be low.

One sensible idea for a new State is `Arizona' or `Centralia{xe "Centralia"}' embracing the whole of the arid zone and implying the inclusion of parts of the Northern Territory and of all States except Victoria and Tasmania. As noted earlier, there are good resource-management reasons for treating the arid zone as a unit. However, given the tourist potential and the possibility of further major mineral deposits in the arid zone, there is little likelihood of the States relinquishing control of these areas.[9]

Still, continuing the daydream, perhaps the States of `North-west Australia' (with Darwin as capital) and `North-east Australia' (with Townsville{xe "Townsville"} as capital) could be carved out along with `Centralia'. This structure would reflect the socioeconomic links between the Kimberleys and the Victoria River district{xe "Victoria River district"} and the links between the Barkly Tableland{xe "Barkly Tableland"} and north Queensland{xe "north Queensland"}.[10] `South-west Australia' (with Perth as capital) would still be larger than western Europe.

Tidying up the bureaucracy

umbrella departments. For example, in Victoria the Forestry Commission, the Lands Department and the National Parks Service are now divisions within one department; in Western Australia the Department of Conservation and Land Management now encompasses forestry and national parks. Queensland is in the process of doing something similar. This movement represents the triumph of a `common-purpose' theory public administrationtheories of bureaucracy{xe "public administration:theories of bureaucracy"} over a `dedicated representation' theory. The former sees departmental integration as a way of achieving more balanced, disinterested treatment of sectional interests. The latter sees progress in resource management as coming from bureaucrats who identify strongly with one `client' sector or industry and fight for it in the corridors of power; it holds the danger of the agency being `captured' by the client sector and becoming insensitive to the public interest. The NSW Forestry Commission{xe "NSW Forestry Commission"} has sometimes been cited as just such a case.
The Brundtland Commission{xe "Brundtland Commission"}, the United Nations' most recent attempt (1987) to argue the compatibility of conservation and development, sees a need to extend the common-purpose model even further so that agencies that are responsible for resource management are also responsible for environmental protection:

> The other great institutional flaw in coping with environment/development challenges is governments' failure to make the bodies whose policy actions degrade the environment responsible for ensuring that their policies prevent that degradation.[11]

In Canada{xe "Canada"}, a task force planning implementation of the Brundtland report has already recommended that central economic ministers, along with energy, agricultural and other key sectoral ministers, should be made responsible and held accountable for ensuring that their policies and budgets support development that is economically and environmentally sustainable.[12]

Calls to arms

The production of social technologies**community goal statements**{xe "social technologies:**community goal statements**"} has become increasingly common in recent decades as a social technology for clarifying and, some hope, reworking dominant social values. Particulars differ, but usually, some public body with an interest in changing community values commissions a group of relevant people to produce a document arguing what society's goals in some particular area should be and, in broad terms, how these can be achieved.
Most community goal statements suffer the criticism that they are vague and bland and `do not address the real issues'. True usually, but critics are also often unable to see that goal statements{xe "goal statements"} can only, at best, achieve marginal changes in community values and perceptions and even that depends on avoiding controversy. To the good, the very act of criticising such statements can often focus and deepen the `real' debate. In short, the *process* of producing community goal statements is at least as important as the *product*.

The matter of communal goals and guiding values for the use and conservation of natural resources has been the target for a number of these exercises, including the three discussed below, i.e. the **National Conservation Strategy**{xe "**National Conservation Strategy**"}, the **Brundtland Report** and *Our country, our future*. From 1950 to 1970 was probably the greatest period of sustained economic growth the world has seen. It is the subsequent fallout from this in the form of fears of a world running out of energy and minerals, of environmental pollution and of loss of ecosystems which have found expression in these documents of the 1980s.

National Conservation Strategy
All Australian governments have adopted the **World Conservation Strategy**{xe "**World Conservation Strategy**"} developed by the International Union for the Conservation of Nature in 1980. In 1983 a **National Conservation Strategy**{xe "**National Conservation Strategy**"}, with objectives as in Box 10.1, was developed and endorsed by most States. Several States have since developed their own conservation

Box 10.1 Objectives of the National Conservation Strategy{tc "

Box 10.1 Objectives of the National Conservation Strategy" \f b}

The strategy has four `objectives'

* to maintain essential ecological processes and life-support systems

* to preserve genetic diversity{xe "genetic diversity"}

* to ensure the ecosystemssustainable use{xe "ecosystems:sustainable use"} of species and ecosystems

* to maintain and enhance environmental qualities.

`Objectives' has been placed in quotes because they are more like goals than goalsvs objectives{xe "goals:vs objectives"} if we accept the useful distinction that an objective is something stated in measurable terms so that progress towards it can be monitored.

Economic concepts are relevant to conservation

Oo**pportunity cost**{xe "o**pportunity cost**"}**:** Whenever you do something, you forgo the chance to do something else.

Meconomicsm**arginality**{xe "economics:m**arginality**"}**:** When adjusting whatever you are doing, what matters is whether the last (marginal) unit of activity is still worthwhile---not the first.

Seconomicss**ubstitutability**{xe "economics:s**ubstitutability**"}**:** You have never really run out of something as long as there is something else around which will more or less do the job.

Clearly, the strategy does not say much. Whether it has delivered any indirect benefits such as encouraging debate I do not know. No one talks about it, but somewhat incestuously it sometimes gets mentioned in more recent community goal statements like *Our country, our future.*

A central assertion of the strategy is that any economicsdevelopment{xe "economics:development"} undertaken should be sustainable, meaning that `the social and economic benefits it creates should be available for as long as they are desired'. Development, unqualified, is itself a complex concept and the subject of innumerable texts. Assume that it somehow means an increase in living standards. Sustainable development could then be sensibly defined as an ongoing increase in living standards.

However, recognising that no process is indefinitely sustainable, modify that definition to make valuessustainable development{xe "values:sustainable development"} mean an ongoing increase in living standards over a long period. Fine. Now what? Like a state of grace, developmentsustainable{xe "development:sustainable"} development is clearly `a good thing'; this book is written on the premise that sustainable development, so defined, is achievable. But the premise is in fact extremely complex and how it could be operationally substantiated I do not know. Nor do I know what question to ask to check if a development project is sustainable.

All in all, it is probably better to regard sustainable development as an incantation rather than as something measurable and precisely meaningful. It is an acknowledgement that any associated depreciation and degradation of the natural resource base is likely to be significant and will need to be valued and considered when a development proposal is being judged.

Alternatively, it is an acknowledgement that future generations have a right to inherit a (natural) resource base of undiminished value. If that is not possible, the resource base should be treated as though jointly owned by all generations. This would mean that representatives of the future would have to agree to exchange a certain quantity of reproducible (manufactured) capital for the loss of {xe "natural capital:loss of"} today. If I were a representative of the future, I would be driving a very hard

the world's people, given that environmental degradation seems to be an inescapable accompaniment to increased production of goods and services.[16]

Box 10.2 The complexities of sustainable development;

Fig. 10.1 shows informally some of the interactions which need to be considered if the `tank' of economic activity is to continue to deliver a `shower' or a `bigger shower' of pollution-free consumer goods and services. The figure shows that the more the action in the tank of economic activity, the more waste entering air and water sinks. These overflow as pollution when sink capacity is exceeded.

Looking upwards, the tank of economic activity is itself supplied from tanks of renewable resources, exhaustible resources and manufactured capital (which has to be continually replenished by pumping up investment). Unless all the taps and pumps are working correctly, people get a dirty shower or no shower at all. When the number of people wanting a shower keeps increasing, taps and pumps have to be continually adjusted. Altogether more fun than running a Tokyo bathhouse.

Box 10.3 What is a conservationist said Alice?;

C{xe "conservationism"} (ism) is an attitude of mind said the Queen, one of agreeing only reluctantly, and for much greater immediate rewards than a non-conservationist would ask, to use up the irreplaceable and near-irreplaceable, especially natural capital. A conservationist is one with well-developed conservation values; that means a person who, for example, wants more than one Coronation Hill{xe "Coronation Hill"} mine as compensation for a threat to the Kakadu wetlands{xe "Kakadu wetlands"}. Someone who would not exchange a threat to the Kakadu wetlands for King Solomon's mines is a **preservationist**. Someone who would accept *any* productive mine as compensation for the wetlands threat is a *vandal*.

Where people fall on the preservationist--vandal spectrum for an issue will partly depend on how the decision affects them personally. For example, it is commonly *local* conservationists who lead the fight to protect environmental goods and it is the company shareholders who most vocally identify the economic goods flowing to the community from a development project.

The report is rapidly becoming best known for reviving the World Conservation Strategy's concept of **sustainable development**{xe "**sustainable development**"}, this time with star billing. If you read the report, as distinct from imagining what might be in it, sustainable development is the name given to the Commission's preferred and supposedly feasible means of achieving the goal of providing the whole of the present and future world population with the necessities of life.

My own candidate for this accolade, this magic bullet, is **conservative development**{xe "**conservative development**"} aka trying to have your cake and eat it too. It is development which would still be profitable if one were charged a high royalty for any accompanying depreciation of natural capital. Conservative development involves maximising the net benefits of economic development, subject to maintaining the services and quality of natural resources over time, as far as possible. This implies using resourcesrenewable{xe "resources:renewable"} resources at rates less

than, or equal to, the natural or managed rate at which they can regenerate, and non-renewable resources efficiently (which probably means a high level of recycling). Expressed this way, conservative development, apart from sounding more sensible, is not greatly different from Turner's economist's definition of sustainable development.[17] **The main difference is that conservative development is a recipe without guaranteed results and sustainable development is a goal without guaranteed means.**

The basic thrust of the Commission's sustainable development strategy (sic) is to achieve a `new era of economic growth' characterised by the implementation of development projects which meet the criteria in Box 10.4{tc "The basic thrust of the Commission's sustainable development strategy (sic) is to achieve a `new era of economic growth' characterised by the implementation of development projects which meet the criteria in Box 10.4" \f b}

Box 10.4 Brundtland's sustainable development strategy{tc "**Box 10.4 Brundtland's sustainable development strategy**" **\f b**}

* use renewable resources `within the limits of regeneration and natural growth' (although ` every ecosystem everywhere cannot be preserved intact')

* use non-renewable resources at rates which `take into account the criticality of that resource, the availability of technologies for minimising depletion, and the likelihood of substitutes being available'.

* conserve plant and animal species

* minimise ` adverse impacts on the quality of air, water, and other natural elements'.

What I would very much like to see is a list of Australian developments which the Commission regard as sustainable.

The report goes on to identify the **values** required in particular sections of society valuesfor sustainable development{xe "values:for sustainable development"} to be achieved

* `a political system that secures effective citizen participation in decision making

* an economic system that is able to generate surpluses and technical knowledge on a self-reliant and sustained basis

* a social system that provides for solutions for the tensions arising from disharmonious development

* a production system that respects the obligation to preserve the ecological base for development

* a technological system that can search continuously for new solutions

* an international system that fosters sustainable patterns of trade and finance

* an administrative system that is flexible and has the capacity for self-correction'.

It is easy to see why groups such as the Australian Mining Industry Council{xe "Australian Mining Industry Council"} have embraced the Brundtland report. It gives the green light for development *projects*{xe "development *projects"}* (not quite the same thing as development) subject to their satisfying loosely defined qualitative constraints on the level of impact on a number of environmental goods; in fact, it recognises that some developments which do not even achieve these standards may be legitimate. In short, it can easily be seen as a resounding defence of the status quo.

The authors of the Brundtland Report probably meant well and I have no disagreement

Last word on Brundtland

The worst that can be said of the Brundtland Report is that it simply diverts attention from the world's fundamental problems---population growth and the inequitable distribution of wealth.

Our country, our future

The highly public release in July 1989 of policy*Our country, our future{*xe "policy:*Our country, our future"},* a 60-page prime ministerial statement on the environment, was a political triumph for the Labor Government. The stage management was clever, media coverage was intense, the reactions of mainstream interest groups were basically positive. The statement contained at least one politically brilliant decision, namely, the appointment of Sir Ninian Stephen as Ambassador for the Environment. It is his task to push the Australian view on climate change, rainforest logging{xe "rainforest: logging"}, driftnetting{xe "driftnetting"}, species conservation etc. in international fora. And the medium is still the message. The effort that went into the preparation and launching of *Our country* signaled clearly to the electorate that the Government was going to take policyenvironment{xe "policy:environment"}al issues much more seriously in future (while simultaneously asserting the near-heroic level of past and present environmental initiatives).

But what of the substance? It is certainly a document which has to be taken seriously. This is no six-page policy statement cobbling together a handful of pork-barrel programs. Until gnawed away by events, this must be regarded as the definitive statement of the Federal Government's considered plans for making good use of the place.

For a helpful start, it throws a concrete girdle round the nebulous concept of `the environment'. The range of topics which it addresses under the broad headings of natural ecosystems, atmosphere, land and the urban environment is comprehensive enough to give the public a sound idea of what `the environment' is in practice. This educational and {xe "environment:defining"}tional achievement is important if Australians are to understand each other during the coming debates.

The statement takes each topic in turn, gives a capsular version of the issues and then presents the Government's past, present and intended responses, together with excuses and explanations.

A grab-bag philosophy. If there is a philosophy of valuesenvironmental management{xe "values:environmental management"} underlying all of these we would expect to find it in **`Principles and objectives'**. What do we find?

1. A value judgement that we have a responsibility to preserve Australian ecosystems;

2. A commitment to economic development and growth (so that everyone `can enjoy a better standard of living');

3. A statement of belief in the possibility of, and a commitment to, `developmentecologically sustainable{xe "development:ecologically sustainable"} development';

4. A statement of the need to include {xe "development projects:social costs of"} when evaluating development proposals;

5. An acceptance of the rare possibility that an ecologically damaging technology may have to be banned;

6. A recommitment to the four objectives of the National Conservation Strategy{xe "National Conservation Strategy"};

7. Three decisionmaking guidelines:

* early recognition of both conservation and development aspects of proposals;

* support for educationenvironmental{xe "education:environmental"} education

* support for Commonwealth--States co-operative action.

Role of the Commonwealth. The section on the governmentrole of the Commonwealth{xe "government:role of the Commonwealth"} in all this acknowledges the primary responsibility of the States for environmental matters. The role of the Commonwealth is described as including

* environmental legislation enacted under the Commonwealth's foreign affairs, trade and foreign investment powers, e.g. ActsWorld Heritage Act{xe "Acts:World Heritage Act"};

* legislation enacted to regulate environmental aspects of activities in the Commonwealth's areas of direct responsibility, e.g. assessment of Commonwealth development proposals, quarantine, fishing in the Australian fishing zone{xe "Australian fishing zone"};

* a co-ordinating, consultative, leadership role on global, national and trans-State problems, e.g air, water and noise pollution pollutionstandards{xe "pollution:standards"};

* an information-provision role, e.g. National Resource Information Centre{xe "National Resource Information Centre"}, Resource Assessment Commission{xe "Resource Assessment Commission"}, Australian Biological Resources Study{xe "Australian Biological Resources Study"}, National Wilderness Inventory{xe "National Wilderness Inventory"}, National Forest Inventory{xe "National Forest Inventory"}, National Estate Register{xe "National Estate Register"};

* a research and program funding role, e.g. National Water and Land Research and Development Corporation{xe "National Water and Land Research and Development Corporation"}.

Most of the document is an exposition of how the Commonwealth has developed, or plans to develop, these roles. Unfortunately, hamstrung by the Commonwealth's limited constitutional powers, the statement can say very little about specific places which are not under direct Commonwealth control. Take the coastline and national parks as two examples:

> Through co-operation with the States, the Government will continue to work towards a conservationnational strategy{xe "conservation:national strategy"} to ensure all ecosystems are represented in a reserve network.

> The Government has decided to refer coastal-zone issues to the Resource Assessment Commission{xe "Resource Assessment Commission"}. [It] will also establish a National Working Group on Coastal Management{xe "National Working Group on Coastal Management"} with representatives from all levels of government and industry and community groups to facilitate dialogue on coastal-zone issues.

A good test of the government's environmental credentials is to look at what it has done in areas where it has undisputed control. An example is the 200 nautical mile Australian fishing zone. Stocks of a number of species (e.g. southern bluefin tuna, gemfish, orange roughy) have been very severely depleted under Commonwealth management, admittedly beginning well before the present government. While the story is complicated by licensing agreements with foreign boats, the {xe "fisheries:Commonwealth control"} has not been very active in monitoring fish stocks to produce data vital to proper fisheries management. Against that, however, the government recently has moved vigorously to implement sophisticated catch-allocation methods. Recent moves against driftnetting and mining in Antarctica have very little political downside and cannot be counted. Preparations for a major oil spill are not well advanced, nor are arrangements for a national network for monitoring open ocean pollution.

The authoritarian way, the anarchic way

It is a not uncommon belief in Europe and North America that environmental problems affecting common property resources (air, water, soil) are already so pervasive that only draconian societal supervision and regulation of economic activity, possibly supranational, can stop the tragedy of the commons being writ large.[21] Provided there is reasonable public support for such regulation, it is legitimate and cannot be tagged valuesauthoritarian{xe "values:authoritarian"}. Authoritarian decisions are those which promote values commanding little community support. They may be taken with good intentions (paternalism) or bad (totalitarianism). **The practical argument against authoritarian decisions involving the commitment of resources on a large scale is that they carry considerable risk of creating disasters comparable with those they seek to avoid,** e.g. Soviet collectivisation, the Great Leap Forward, the madness of the Khmer Rouge.

At the opposite end of this ideological spectrum lie the `eco-anarchists' with a hatred of hierarchy and with ideals of power devolving to decentralised low-energy village-based human-scale communities.[22] R{xe "ideologies:radical ecology"}ists see environmental crises, not class war, as capitalism's ultimate contradiction. Irrespective of the integrity of this vision it is politically irrelevant in Australia in the shorter term.

Legitimacy in the public mind is not everything. **However, governments which see a need to take authoritarian decisions in the long-term interests of the environment and the natural resource base have a responsibility (not to mention a political imperative) to attempt to build** values**legitimacy**{xe "values:**legitimacy**"} **for their decisions.** There is a place for selective authoritarianism, but not for **social engineering**{xe "**social engineering**"}, which I take to mean the attempt to replace widely held community values in a wholesale way. I do not regard the `Life, be in it' campaign as social engineering! (Some restrictions on real property rights---the right to affect others--- is one area where we could stand a little authoritarianism.).

It can in fact be argued that in a pluralist society centrally concerned with resolving conflicts between private interests, the valuespublic interest{xe "values:public interest"} (if there is any such thing distinct from private interest) can only be served by a government prepared to take authoritarian decisions. **Ppluralist planning**{xe "p**luralist planning**"} **assumes that people's preferences represent their best interests. This is only so if people know what all the options are, what outcomes they will have, and are able to calculate the costs and benefits of various actions.**

The Hughmorgans

The only ideology which at present stands to significantly affect resource-management activities here is ideologiesultra-conservatism{xe "ideologies:ultra-conservatism"}, a *weltanschauung* characterised by a strong commitment to an authoritarian social order, minimal government and to the marketplace as a necessary and sufficient social technology for allocating goods and resources to producers and consumers. ideologies**Hughmorgans**{xe "ideologies:**Hughmorgans**"}, as I will tag this group in tribute to one of their standard bearers, seem oblivious to the allocative weaknesses of markets as taught to first-year economics students. In contrast to being socially conservative, Hughmorgans are ecologically radical, i.e. they believe development is a `good thing' and tend to place a low value on the loss of `natural' ecosystems when deciding on the viability of development proposals. Like Karl Marx, they view the material environment as a stock of commodities for the use of man.[23]

Perhaps the recent rise of Australian ultra-conservatism is a reaction to the collectivism{xe "collectivism"} of the {xe "Whitlam Government"} era (1972--75), but it also appears to be part of a worldwide swing to the right in politics. ideologiesReaganism{xe "ideologies:Reaganism"}, for example, was the doctrine that government is part of the problem, not of the solution. We can be thankful that our Australian brand of ultra-conservatism is merely greedy and short-sighted rather than evil in the mould of fascism; **ideologies are nearly always rationalisations of self-interest**.

Ultra-conservatism will continue as a potent ideology at least until it wins political power and is tried and, sooner or later, found wanting. Beyond that time, the pendulum will swing back and there will be a period when the proper role of government intervention is once again recognised. One must hope that the coming long night of unbridled entrepreneurial fulfilment does not irreversibly destroy resources and environments at a rate such that our grandchildren curse our stupidity.

the decayed economic fabric of the Middle Ages. The eventual result of its somewhat imperfect implementation however has been to substitute a new privileged class for the old.

My disquiet with the prominent role accorded `economicsfree-market{xe "economics:free-market"}' economists (or `market-oriented' economists as they sometimes call themselves) in formulating natural resource and environment policy is their cultural imperialism (beware of the man who has found the truth; everything is just an aspect of economics) and the easy cognitive dissonance with which they can both acknowledge and ignore major weaknesses in economic models. While willingly admitting the weaknesses of, say, cost-benefit analysis{xe "cost-benefit analysis"}, they quickly add that it is a much better guide to what should be done than alternative evaluation procedures and therefore should be used as a first approximation. They say this even though they have no way of estimating just how bad, relatively or absolutely, that first approximation is.

What is it about the use of economic analysis which, despite its well-documented deficiencies, gives it delphic status as a decision aid for natural resource management in the eyes of many politicians, bureaucrats, entrepreneurs and other influential people?

First, many economic concepts, usually simple ones, are extremely useful for thinking about a wide range of problems---economicsbasic concepts{xe "economics:basic concepts"} like supply and demand, marginal cost, opportunity cost, fixed costs, user pays, polluter pays etc., etc. This means that economics cannot be dismissed out of hand like, say, astrology, which has no redeeming features.

Second, the main conclusion of neoclassical economic analysis, that so-called free markets produce something highly desirable called efficiency (a normative concept), is lauded by numerous entrepreneurs who do not give a damn about efficiency, but who can earn higher profits in unregulated `free' markets. Support for economic analysis and efficiency is often a smokescreen for support for higher profits.

Efficiency

Allocative or Pareto efficiency{xe "Pareto efficiency"} is that situation where nobody's lot can be improved without worsening someone else's lot. The theoretical conditions for allocative efficiency to be achieved are so demanding that it can safely be said that, chance aside, all markets clear at prices incompatible with efficiency.[24]

Third, economic analysis, say cost-benefit analysis, ranks alternative courses of action quite unequivocally. The fact that any economic analysis of any policy issue can only be a partial analysis gets ignored. The costs of {xe "values:social disruption"}dislocation, for example, are usually ignored in economic analysis as are the implications for social evolution. Precision gets confused with accuracy; precision inspires confidence. Conversely, the analyses of `opposition' disciplines such as political science{xe "political science"}, political economy{xe "political economy"}, sociology{xe "sociology"} etc. do not rank alternatives precisely and unequivocally and are therefore deemed less persuasive.

The appeal of economics

* economic concepts are helpful for analysing many many problems

* neo-classical economic analysis appears to support unfettered capitalism

* economic analysis appears to produce unequivocal recommendations for action

It is in the professional interests of economists not to blow the whistle publicly on this deification of their modest but useful achievements. It would however be very much in the interests of this country for some eminent establishment economists to forcefully remind the community of the limitations of their expertise. The material is already there in the professional literature, indeed in the textbooks, but needs to be popularised. The model I have in mind is the Bishop of Durham, I think he's the one, the one who goes round denying the divinity of Christ. In a discussion with Helen Hughes, the `establishment' development economist who gave the Boyer lectures in

inescapably play in the work of professional economists. Fred Gruen recently quoted the eminent Joseph Schumpeter to the effect that economics is an observational and interpretive discipline, meaning that the room for differences of opinion can be narrowed, but ultimately not be eliminated.[26]

The market must be disciplined, not deified

Mm**arket capitalism**{xe "m**arket capitalism**"} **is a very good core system for organising the production of goods and services. Through mutually beneficial and voluntary exchanges validated by the price mechanism, it rations the use of scarce resources into producing goods which people are willing and able to pay for. With the promise of profit it fosters innovation to meet unsatisfied needs and, conversely, moves resources from where they are no longer required. It avoids the crushing burden experienced in centralised economies of trying to calculate relative prices for everything such that shortages and surpluses are minimal.** But what are the flaws, the failures, that mean the market has to be disciplined? What is the case for government intervention in market operations?

Real markets are no good at producing goods for poor people or unborn people or incompetent people or minority groups. Such is rarely even claimed since the discrediting of the idea of the `trickle down' effect, i.e. if we make a bigger pie, everyone will get a bigger slice. The ultra-subtle doctrine that self-interest works to the common good has long been blown out of the water. Markets produce goods according to an implicit equity principle that it is fair that people should get what they can pay for here and now; that it is fair for 1(10)% of adult Australians to hold 25 (55)% of private wealth.[27] Society has great need for the contributions of `interventionist' economists willing to advise on how to best implement *a priori* equity goals. Those economists who regard such activity as non-professional should at least ask if they have a professional duty to alert the public to the distributional consequences of their recommendations.

The market cannot produce **positional goods**{xe "**positional goods**"} (unique goods like the Mona Lisa or rainforest or beachfront allotments) in increased quantities. This is not a criticism, since no economic system could. The criticism is that the market rations positional goods by price, which I find inequitable. What if we decided to price-ration entry to Kakadu to protect its ecosystems and Australians could not afford the 1000 yen entry fee? Even with non-positional goods, the extent to which the preferences of consumers are transmitted to producers through the market process has been questioned by a long line of critics.[28]

Real markets will rarely produce **pure public goods**{xe "**public goods**"} like attractive landscapes, at least deliberately. Public goods are those freely available to all and costless to use more. Markets tend to undersupply **mixed public goods** like toll-roads where additional users do impose additional (e.g. congestion) costs on existing users. Services from **natural monopolies** (like utilities) are provided at decreasing average cost and are unlikely to be provided efficiently by the private sector.[29]

Real markets, especially in Australia and especially in manufacturing industry, rarely achieve competitiveness. Prices are routinely distorted under oligopolistic and collusive market structures.[30]

Real markets set `incorrect' prices for many if not most goods. Eeconomicsexternalities{xe "economics:externalities"} (unpriced side effects on third parties) and economicsimperfect information{xe "economics:imperfect information"} (different people perceive different ranges of choices) are two common causes. Governments are commonly major price distorters through their use of taxes and subsidies (e.g. accelerated depreciation allowances). Furthermore, it takes only one incorrectly set price to distort the prices of all other goods. What is more, `corrected' prices cannot even be calculated in (second best) theory, much less in practice. Externalities which pervade several sectors and affect a diversity of people are more difficult again.[31] Contrary to the present onus, every market should be assumed significantly imperfect unless demonstrated otherwise.

Even in equitable, competitive, externality-free {xe "markets:perfect"}, prices would still only be imperfect indicators of social value in the sense of being measures of buyers' (sellers') willingness to purchase (sell) the quantities of goods that they do. At best, as cost-benefit analysis attempts to recognise, prices can only be useful for valuing small changes in quantities of goods traded, because, simplistically, large changes in quantities traded would lead to price changes.

have been characterised by considerable government `strategic co-ordination' of private sector activity to create national comparative advantage.

The drunk who lost his keys

The problem for economists in accepting that all markets are significantly imperfect is that this leaves them without formal models to answer `what if' questions. Like the drunk who preferred to look for his keys under the streetlight, even though he had lost them down the road, many economists prefer to answer the wrong question confidently rather than the right question tentatively.

P{xe "political economy"}ists (cf. market-oriented economists) start with the plausible view that many crucial prices are set by extra-market negotiations between big business, big unions and big government. Unfortunately, this theory does not produce much in the way of useful predictions.

Tax/subsidy approaches. In attempting to compensate for in{xe "markets:correcting"} prices, economists have a textbook penchant for advocating solutions based on taxes and/or subsidies, e.g. taxes on soil loss, subsidies for tree retention and regeneration. The theory is to withdraw the de facto right to generate external costs and impose a tax equal to the true social cost of the externalities generated---the so-called `social technologiespolluter pays{xe "social technologies:polluter pays"}' principle. Similarly, if the landholder can create a social but not personal benefit (e.g. an aesthetically pleasing landscape) by some action, it is in the community's interest to subsidise it---an example of the `user pays' principle. The problem with such `market' solutions to market deficiencies is that, apart from necessarily being wrong if other prices are wrong, as they usually are, they are difficult and expensive to implement because of the supply--demand information needed to set tax/subsidy levels and the time required to verify their correct levels by `trial and error'.[32] None of this stops the economics fraternity from trotting out the same set of largely untried, impracticable solutions in response to every issue from tourism to agricultural chemicals. The most recent is a Treasury discussion paper to be used to brief particpants in the working groups being established to develop policies for sustainable development.[33]
Support for tax/subsidy solutions is, in fact, one of the few positions espoused by mainstream economists which the wider community largely rejects. Direct {xe "regulations"} backed by legal injunctions seems to have greater appeal to both voters and governments as a way of correcting the invisible hand when it starts clumsily knocking pieces off the economic chessboard.

It is true that regulatory solutions to pollution-type problems (probably the main externalities in resources management) may not bring output to levels where the marginal value of output equals the marginal social cost of the externality (Box 10.5).

Box 10.5 D.i.regulationsd**isadvantages**{tc "**Box 10.5 D**.i.regulations:d**isadvantages**" **\f b} of regulatory solutions to pollution problems;**

* they often do not allow the individual to choose the lowest-cost response

* they do not ensure that the task of reducing environmental damage is allocated to those who can do it at least cost

* they generally provide no incentive to do better than the prescribed standard.

Regulations do not have to be rigidly uniform of course, e.g. land use can be regulated in accordance with its bio-physical land capability{xe "land: capability"}, pollution can be allowed according to population density. However, given the difficulty of valuing unpriced economicsexternalities{xe "economics:externalities"}, and that real-world prices are a dog's breakfast, the alternative of taxing emissions or whatever to reduce them to the `optimal' level is pie in the sky.

Even then, the method cannot cope with income differences among interviewees, strategic (equals dishonest) responses and the sensitivity of answers to additional knowledge or to being presented with additional options.[35]

Box 10.6 Approaches to valuing non-market goods;

* estimation of production losses associated with increased levels of non-market goods

* estimation of earnings lost

* estimation of `defensive' spending to protect a resource

* estimation of repair costs

* estimation of hedonic prices (which involves the use of statistical methods to isolate the contribution of one partial price determinant (e.g. air quality) to the overall market price of some good (e.g. a house))

* estimation of `willingness to pay' to enjoy unpriced goods, e.g. by assuming travel costs to a site measure the value of visiting it

* estimation of **option values**{xe "**option values**"} and **existence values**{xe "**existence values**"}, what people might be prepared to pay to avoid the destruction of a resource they might wish to use at some future date, or might simply wish to see preserved

* estimation of `contingent values'

Space precludes any detailed discussion. All of these approaches have obvious limitations, but equally all have some value as `indicators' of the magnitude of environmental benefits or (mainly) costs. The cost of doing such calculations in any encompassing fashion, coupled with their inadequacies, makes their routine use unlikely.

Supporters of `extended' cost-benefit analysis{xe "cost-benefit analysis"} argue that if admittedly imperfect measures of valuesintangible{xe "values:intangible"} values of alternatives are not included in information made available to decisionmakers these values will be more readily ignored.[36] The counter-argument, since such measures are likely to underestimate rather than overestimate intangible values, is that this practice will regularly lead to the approval of projects having negative net social benefits. **Perhaps the resolution of this argument is to accept that a project should probably be rejected when `extended costs' exceed `extended benefits', but that the converse result should constitute only weak support for accepting a project.** The other obvious requirement is that decisionmakers must be educated (by disinterested teachers) in the strengths and weaknesses of cost-benefit analysis.

Pproperty rights{xe "p**roperty rights**"} **approaches.** One approach to meeting pollution goals which has the relative certainty of direct controls and some of the cost-effectiveness of taxes is being used overseas and warrants consideration in Australia too. It involves the Government issuing firms with transferable permits (called social technologiestradable emission rights{xe "social technologies:tradable emission rights"}) which add up to some maximum permissible level of pollution. In other words, government regulates the total level of pollution, but leaves it open to the market as to which firms do it.[37] The contrary position is that some social technologiesproperty rights{xe "social technologies:property rights"}, the right to clean air, say, belong to the public and are not for `sale'.
A full `property-rights' solution to {xe "pollution:social technologies"} problems is likely to be of limited relevance for several reasons (monitoring would be just as necessary as under a regulatory approach). One is that pollution is likely to be undervalued by the `market' when present at low levels; it is only beyond certain threshold levels that pollution impacts escalate. Another is that the `transaction costs{xe "transaction

Whether Sweden{xe "Sweden"}, with its strategy for using `wage earner funds' to progressively transfer economic power to the labour movement, also offers a `post-capitalist' model is more problematic (Table 10.1). In the longer term, a paradigm shift will undoubtedly occur rapidly if a comprehensive new alternative to market capitalism, and its handmaiden, mainstream economics, appears.

Table 10.1 Comparison of three economies{tc "**Table 10.1 Comparison of three economies**" \f t}

+	USA	Sweden	Australia
GDP per capita (as % of USA)	100	76	70
Aver. ann. growth per capita 1965--86 (%)	1.6	1.6	1.7
Productivity	+0.7	+1.2	+1.0
Real wage rise 1986--88 (%)	-2.5	+7.8	-9.0
As % of GDP (1986)			
Taxes	31.3	61.5	34.7
Govt. spending	36.9	63.5	38.3
Private consumption	66	52	61
Savings	15	21	21
Investment	18	22	22

Sources: OECD, World Bank, *The Economist*

Meanwhile, the simple and practicable way of dealing with external costs (e.g. pesticide residues in food) is to directly regulate them to acceptable levels.[38] In the longer term, the internalisation of such costs through a more developed culture of rights and obligations would not be surprising.[39] The long-term measure of a successful social technology in this area will be declining pollution per unit of output.

Heavy {xe "**taxes**:heavy"} **on profits and firm regulations do not make for a very**

applies no such concept to natural capital. As natural capital is used up, national accounts include no charge to reflect the fall in future potential production. **Natural resource accounting** is the attempt to include such values in the national or regional accounts. The effect of treating natural capital as `free' is, generally, to overstate increases in national income.

Depreciation of a productive natural asset is no different in principle from asset depreciation{xe "asset depreciation"} of a manmade asset; it is the reduction in use value, measured today, of the stream of future profits which the asset can earn. It shows out as the use of increased inputs and/or decreased outputs. For many assets it can be assumed to be much the same as fall in market price over time. This is inapplicable however for the many natural assets which are not traded in competitive markets, or indeed any market.

Unfortunately, it is both conceptually and empirically difficult to cost, say, air pollution, which is clearly a depreciation in the value of an asset called the atmosphere. Making rules for depreciating exhaustible stock assets{xe "stock assets"} like soil and oil and even renewable stock assets like forests is likely to be easier than making rules for depreciating flow assets like polluted air and water.[40]

To date, natural resource accounting has not focused on quantifying changes in the value of natural resources resulting from productive use for purposes other than further productive activity, e.g. quantifying changes in existence values, survival values, enjoyment values, some sorts of option values. Rules for depreciating environmental goods where this takes place in ways which do not affect any production costs (e.g. loss of attractive landscapes) are likely to be particularly difficult to develop. One approach is to ask people what they would be prepared to pay for clean air (or accept as compensation for dirty air), unspillable oil tankers etc., but, as noted earlier in relation to valuing species survival, there are major difficulties in doing this. What can be said is that developing natural resource accounting is going to require some very clear thinking.

It is important to distinguish two stages in depreciating natural capital. The first is to document physical change in the asset over time and the second is to put a dollar value, sometimes called the **marginal opportunity cost**{xe "**marginal opportunity cost**"},[41] on that change. Even if it is difficult or even impossible to do the second, it may still be extremely useful to do the first and also identify the activity causing the physical change.

One calculation which can sometimes be made is a **breakeven depreciation**{xe "**breakeven depreciation**"}. For example, if seven tonnes of topsoil is valued at more than the conventional profit on a tonne of wheat, then wheat-growing on the Darling Downs{xe "Darling Downs"} is unprofitable, irrespective of the size of the profit as conventionally calculated. This does not answer the question of what value to put on seven tonnes of lost soil, but it does display the required judgement very clearly. Should Australia value seven tonnes of soil at more or at less than the `profit' on a tonne of wheat? If more, then that tonne of wheat should not be produced.

How would conventional economics begin valuing an increment of topsoil?

* If losing a small amount of soil does not affect yields or increase production costs, now or in the future, it has zero value to the individual farmer.

* If costs and returns are affected, all changes to future profits have to be given a present value{xe "present value"} (what one would pay today for next year's etc. profit changes) and then added up to get a lost-soil value.

* If the cost of saving that increment of topsoil today is less than the present value of future profits gained plus terminal capital losses in land value thus avoided, then a conventional economist would advise doing so, i.e. saving the soil. And vice versa.[42]

The economics is straightforward provided that effects on third parties, including future generations, can be ignored; the problem is getting the physical data.

Miners, loggers and fisherpersons get very coy when it is suggested they might like to bid for the {xe "resources:use rights"} to use up public natural assets---but at least it is suggested. Farmers, on the other hand, have bluffed the community into accepting that the only charge for using up topsoil should be indirect, through loss in land

This is most likely to have an effect on internalising erosion costs when remaining soil life is down to a few decades. Markets tend to value marketsvaluing natural resources{xe "markets:valuing natural resources"} at levels which might save them only when those resources are nearly gone.

Alternatively, we perhaps need a market in `erosion rights' to help set values for lost topsoil. The farmer would then grow wheat only if it were profitable after buying the right to allow the erosion accompanying cropping. Depending on the price of marketsfor erosion rights{xe "markets:for erosion rights"}, cropping would tend to gravitate to low-erosion areas. Monitoring the use of such rights would be very demanding.

Another example. Logging a forest is basically a matter of turning one form of asset, standing timber, into another, namely cash. Unless that cash is used to build up some other form of productive capital (and not spent on consumption), the forest owner becomes poorer. Unless net capital formation{xe "net capital formation"} is larger than natural resource depreciation, the economy's total assets decline as resources are extracted or degraded. Setting up a market in marketsfor logging rights{xe "markets:for logging rights"} is obviously one way of getting an estimate (probably a low estimate) of the depreciation that accompanies logging. I am reminded of Kruschev's joke that, when Russia had conquered the capitalist world, they would keep one tame capitalist economy so as to know what to charge for everything.

What is the practical value of estimating depreciation in natural capital? There are two benefits. The first is that it will give a more accurate idea of how well the economy is performing and whether some apparently profitable enterprises should be abandoned. The second is that when hidden costs are identified we can decide who pays them. Users? Beneficiaries? Polluters? Taxpayers?

The Australian Bureau of Statistics{xe "Australian Bureau of Statistics"} announced plans in mid-1990 to attempt to calculate **sustainable net domestic product**{xe "**sustainable net domestic product**"} for the economy each year. This will comprise gross domestic product less depreciation of man-made capital (giving net domestic product) less depreciation of natural capital less pollution**defensive expenditures**{xe "pollution:**defensive expenditures**"} on combating pollution, soil degradation etc. (Fig. 10.2)

Fig. 10.2 Sustainable net domestic product{tc "**Fig. 10.2 Sustainable net domestic product**" **\f f**} While net domestic product is increasing, sustainable net domestic product may be increasing or decreasing depending on the levels of natural capital depreciation and expenditures on ameliorating pollution, degradation etc.

The other side of the resource-accounting coin is that we need to have a much clearer idea of the use value of the portfolio of capital assets we are building up---not just from the proceeds of the sale of natural capital but more generally. Certainly the National Accounts identify and classify investment activity, but what alternative development**national capital-building strategies**{xe "development:**national capital-building strategies**"} are available and what are their pros and cons? In the long run? Is Robert Solow correct in arguing that a constant real income can be maintained by increasing the use of manmade capital goods to offset increasing natural resource scarcity?[43] Probably not; substitution of manmade for natural capital has very definite limits. I see this as a neglected but very rewarding question to explore. An analysis which views capital as more than `machine tools and houses' is needed.

Idea of the steady-state economy{xe "steady-state economy"}

Debate over the hidden costs and the sustainability of economic growth, defined as increasing gross national product, was intense in the early 1970s. E.J. Mishan in *The costs of economic growth* talked about the `carpet of choice' rolling up behind the consumer as fast as it unrolled in front in a growing economy.[44] There were no winners in this debate because no one knew how to value what was being lost in relation to what was being gained. **The focus of the** development**debate on economic growth**{xe "development:**debate on economic growth**"} **at that time was on whether it must eventually be limited by material shortages and rising energy costs. The comparable debate today assumes that supplies of minerals and energy are unlikely to prove directly limiting and focuses on whether growth must eventually be limited by the waste-assimilation capacity of soil, air and water resources.**

The idea of a **steady-state economy** emerged to encapsulate the values of those convinced that conventionally defined economic growth was not in the long-term interests of the community. It has however never become an idea in good currency. Like `sustainable development' (with which it has much in common) or, indeed, `economic growth', the concept of a `steady-state economy' has no clear-cut meaning. Certainly, a steady-state economy is not characterised by zero growth in gross national product; neither does the idea imply constant technology, nor constant distribution of wealth and income.

The two central goals of a steady-state economy are that the rate of throughput of matter and energy be reduced to the lowest feasible level and that the total stock of matter tied up in (manmade) capital and consumer goods should be roughly constant. Some depletion and dispersal of materials (pollution) is inevitable of course and the goal of minimising pollution per unit of output becomes increasingly important.

The **conservative economy**{xe "**conservative economy**"} would be a better name than the **steady-state economy** for this sort of economy, just as **conservative development**{xe "**conservative development**"} would be a better term than **sustainable development**{xe "**sustainable development**"}. The steady-state economy is in fact comparable to the more recent idea of the conserver society which

* promotes the design of {xe "systems:design"} which use fewer materials

* promotes re-use and recycling of materials used in production of goods

* questions increased production per head of consumer goods

* promotes experimentation in seeking solutions to problems.

The distinguished and now venerable H.C. Coombs has discussed how an Australian economy with a stable population and a commitment to `sustainable' pollution levels and to minimally depleting non-renewable, particularly scarce {xe "non-renewable resources"}, resources might function.[45]

Growth, in the sense of net investment or increased output, could only derive from more effective use of known resources and from the development of new goods and services employing few or no scarce materials. Growth from such sources need not be insignificant says Coombs; it would derive from the more effective use of capital, from increasing knowledge, from improved organisation and from imaginative entrepreneurship---the capacity to recognise and effectuate new opportunities to combine resources for human benefit or enjoyment.

Scarce resources could be economised to whatever degree was thought desirable by the effective use of the price mechanism. For example, prices of goods produced by especially polluting activities would jump through the imposition of excise taxes{xe "excise taxes"}, lowering the `standard of living' of those using them---at least until changes in social values became `{xe "values:internalisation"}ed' and made such goods less desirable. The `quality of life' however would rise as pollution fell and the natural environment recovered. The full effects would be complex and comparison with present living standards problematic. Relative price changes would begin to stimulate technology change and change the relative profitability of different industries. Having quantitative limits on materials usage would force qualitative improvement in goods and services. Savings levels might increase in some communities, but there would be little fear of running out of worthwhile investment projects.

What are the arguments for a steady-state economy? It is not enough to say that eventually we will have no alternative when the cupboard is bare; that might be 1000 years away. As it happens, the Western world could be moving, without it being planned, in this direction anyway. To quote a recent study on the changing American economy, `optimal use of new technology could result in a 40 to 60% *decline* in the use of natural resources, even when there is rapid economic growth'.[46] Also, the drive to reduce {xe "carbon dioxide pollution"} emissions must show out as decreasing or slowly increasing energy consumption. The question now is one of the extent to which this unplanned trend should be actively pushed along.

Herman Daly, the economist who popularised the idea of the steady-state economy, gives several supporting arguments.[47] First, high rates of resource depletion allow ultimately unsustainable stocks of people and goods to be built up; the danger in this is

The second argument, which I find more relevant, is that high rates of depletion of non-renewable resources seem to lower the availability of renewable resources, e.g. mining pollutes water, smelting pollutes air, coal-burning kills trees, soil erosion reduces plant production. There must be a tradeoff point where the social benefits of using non-renewables equal the social costs of decreasing/degrading the flow of renewables. We have little chance of formally identifying that point though, and, if we did, market mechanisms which would bring it nearer do not exist. **What we do know is that this `optimum' lies in the direction of decreased** resourcesoptimum **use rates**{xe "resources:optimum **use rates**"} **for non-renewables, simply because market forces are valuing the benefits but not the (external) costs.**

A similar argument holds even more directly for renewable resources. Rates of harvesting of plant and animal species which exceed critical levels cannot be maintained. The problem is to know what is too high.

Slowing throughput. Direct methods of slowing throughput or turnover rates include setting aggregate social technologies**depletion quotas**{xe "social technologies:**depletion quotas**"} on each basic resource and auctioning the quota rights to individuals or firms; various taxation schemes are also possible. Property rights to quotas could be subsequently traded in a marketplace. Government could create further rights or buy in existing rights in appropriate circumstances.
While it might soon be politically feasible to work actively towards a ceiling level of ceiling energy consumption{xe "ceiling energy consumption"}, it is at present politically impossible, and it would be economically disastrous to significantly slow the rate of depletion of other non-renewables. At this stage, however, a commitment to `getting it right' environmentally, no matter how long that takes, before starting development projects is a reasonable goal.

Here, a social technology which is politically feasible, and which attacks the throughput problem directly, is to `slow-track' major resource developments. This does not mean deliberately delaying approval of resource development proposals. It means being willing to take whatever time is required to ensure that the social and environmental impacts of developments are reduced to minimal or acceptable levels. The example of the Victorian Government deferring a decision on the future of a Gippsland pulp mill for six years was quoted earlier.

The search for legitimacy

The essence of legitimacy for government decisions is public acceptance or, less actively, absence of gross public rejection. Not total acceptance of course. A government's decisions do not require unanimous approval any more than they require consensus or adjudication in order to be judged legitimate. Most people are unaware most of the time of the host of decisions being made (nominally) on their behalf, and the question of the legitimacy of these unperceived decisions does not even arise. This is legitimacy by default. It is only decisions on issues in the public consciousness which need to be overtly and actively legitimised. Pragmatically, legitimacy depends heavily on the ability of resource planners to `deal with the issues'.[48] But how? Box 10.8 suggests how.

Box 10.8 Achieving legitimacy in public decisionmaking{tc "**Box 10.8 Achieving legitimacy in public decisionmaking**" \f b}

While legitimacy is a fragile mantle for any decision to wear, most people are prepared (grudgingly and tacitly perhaps) to accept decisions which are shown or perceived to have involved[49]

* non-trivial efforts to identify relevant issues and facts bearing on those issues

* a competent evaluation of the range of alternative decisions which could be made

* fair valuestreatment of competing{xe "values:treatment of competing"} values

There are no right answers

A judgement that a decision is equitable is, inescapably, personal and subjective.

Equity is a difficult concept; consider it further. Operationally, we say that a cake has been fairly shared when we feel that no one deserves a bigger slice and no one deserves a smaller slice. In simple situations like slicing a cake, equity{xe "equity"} is often the same as equality{xe "equality"}; handing out equal-sized slices would be an equitable solution to most people. What happens however when the size of the slices cannot be adjusted? When two children have to divide up the indivisible, say, a bike and an encyclopaedia? Can any decision be fair in such circumstances? If it is not fair, how unfair is it? We have no calculus of equity and inequity.
While it in no way provides a scale for measuring equity, John Rawls, an American philosopher, has created a powerful intellectual device for helping people make fair decisions.[50] His idea is to think yourself in turn into the shoes of the different beneficiaries (victims) of a decision and decide which you would rather be (conversely, which ones would feel envy). If you cannot decide, then the decision or state of affairs under scrutiny has been fair (or more information is needed). Try it out by thinking through whether you would rather be born a black or a white Australian. Or, to quote a nice example from John Paterson, we, as valuesRawlsian{xe "values:Rawlsian"}s, should be seeking an allocation of resource entitlements between States in the Murray-Darling Basin{xe "Murray-Darling Basin"} that would satisfy all the premiers if each of them were told `Tomorrow you could be running one of the other States and we won't tell you which one'.

Allocation decisions on the right to use natural resources are never as simple as sharing cakes; the full consequences of different possible allocations are never apparent or never known with confidence. Think of the unknowns surrounding the Wesley Vale{xe "Wesley Vale"} pulp mill proposal. It is difficult therefore for a politician trying to be fair to think hirself into the shoes of the different affected parties.

Often of course it is quite unnecessary to measure equity levels per se. When only a marginal change in a situation is possible, it is enough to be convinced of the direction in which change should occur to know how to increase equity. The political scientist C.E. Lindblom has in fact argued that very few situations can be changed other than marginally in democratic societies and that a philosophy of `public administrationmuddling through{xe "public administration:muddling through"}' by making frequent small changes in the `right' direction without particular reference to ultimate destinations is in fact an optimal strategy for managing society---not terribly effective but optimal.[51] It is worth recalling that evolution works the same way. The point must be made however that muddling is a slow process, not suited to tackling urgent problems.

There are other maxims around to assist planners, politicians, bureaucrats etc. in making more equitable decisions. Rupert Crawshay-Williams has suggested the importance of identifying one's own values and bending over backwards to ensure that these are not preconsciously favoured.[52]

Box 10.9 What are values?{tc "**Box 10.9 What are values?" \f b**}

Values{xe "Values"} are criteria on the basis of which personal preferences are formulated; things which one takes into account when choosing among alternatives, e.g. the Bustard is worth conserving; the Bustard is not worth conserving. Values, like goals and decisions, are tools, off-the-shelf criteria, for achieving one's purposes without having to think every action through anew.

Entities which are commonly recognised as having value include material goods and services and potential experiences for self or others. All values are arbitrary or, less harshly, acts of faith. We hope, but cannot prove, that actions which satisfy our values will produce a sense of goal achievement, of purpose fulfilled. We acquire values from our elders and peers and, occasionally, create our own. **It is because values held by different people cannot be added up that there are no right answers to resource-management problems, quite apart from the difficulty of identifying what values of which people are to be considered.**

solutions. Gazetting a discrete area such as Coronation Hill{xe "Coronation Hill"} as either national park or mining province creates clear winners and clear losers. But allocating numerous tracts in one large region, some to parks and some to mining allows all parties to have some wins and some losses. The Victorian {xe "Land Conservation Council (Vic)"} successfully did just that, region after region, for some years. Certainly there were protests, particularly over their allocations in the Aalpine region{xe "alpine region"}, but people basically accepted that this was an attempt to do the job properly.

*The changing face of due process{*xe "due process"*}*
Part of the problem of achieving legitimacy is that most agencies use allocation methods which are quite informal, even intuitive, and these do not allow their planners to see what sort of input it would be genuinely helpful to seek actively from the {xe "public participation"} or how to process it.[53] In many cases they are still learning to cope with the requirement that natural resource areas legally require management plans{xe "management plans"} (in itself a response to a perception of changing legitimacy demands).
Then there are those who assert that some form of economic cost-benefit comparison of alternatives is a requirement for legitimacy. Some of this group would go further and assert that to be legitimate nothing more nor less than a cost-benefit analysis{xe "cost-benefit analysis"} is required. That is, economic efficiency as calculated by available technologies is regarded as the be-all and end-all of decisionmaking---simplism indeed.

Cost-benefit analysis is just one (probably the first) of an increasing range of social technologies which concentrate on processing information into some form which will directly support decisionmaking and, in appropriate circumstances, help to confer legitimacy on decisions. Many of these have already been discussed: {xe "environmental impact assessment (EIA)"}, technology assessment{xe "technology assessment"}, risk assessment{xe "risk: assessment"}, management planning, land-use planning{xe "land-use planning"} and setting environmental standards{xe "environmental standards"}. Eenvironmental mediation{xe "environmental mediation"} is one which has not yet taken root in Australia. It involves the use of a trained neutral mediator to identify and secure agreement by opposed interest groups to compromise positions.[54]

In coming decades the use of a wide variety of (ever-improving) social technologies which deliver decision-supporting information to all parties is going to become more and more central to the idea of due process in natural resource management. Whether such social technologies will just evolve or can be consciously designed as required is discussed below.

Explaining changes in social organisation

Even in conservative societies trying to resist change, social structures will evolve. When it comes to *explaining* change however(Why did that happen?), it is difficult even to postulate criteria which a theory of social change{xe "social change"} `should' satisfy. While they in no way constitute a comprehensive theory, I have found the writings of Donald Schon and Geoffrey Vickers on the process of social change illuminating in a descriptive sense and those of Edgar Dunn helpful in a prescriptive sense, i.e. with respect to developing `recipes' for guiding societal evolution.[55]
In what follows I am attempting to develop the view that

(i) significant changes in the way natural resources are managed follow the emergence of **social technologies** which allow **ideas in good currency**{xe "**ideas in good currency**"} to be implemented. A good example is the improved management of the Great Barrier Reef{xe "Great Barrier Reef"} following the design of a social technology in the form of a joint Great Barrier ReefState-Federal management authority{xe "Great Barrier Reef:State-Federal management authority"} as a response to the widespread perception (idea in good currency) that the Reef needed to be better managed.

(ii) the emergence of successful social technologies cannot be scheduled, but will be enhanced by (a) a policy of active social experimentation{xe "social experimentation"}, (b) a program of research into the *design* of social technologies, and (c) the ongoing development of material technologies{xe "material technologies"}.

Ideas in good currency

** I wrote that six months ago. With the decision not to put the Very Fast Train through Gippsland, the poor old Long-footed Potoroo has lost ground to the night parrot{xe "night parrot"} which has turned up after being unseen for decades.

Memes, culturgens and the spread of ideas

Relating Schon's work to more recent thinking, his `ideas which are beginning to surface in the mainstream' seem to fit Richard Dawkins' concept of **memes{**xe "**memes"}** or E.O. Wilson's similar concept of **culturgens{**xe "**culturgens"}** (cultural genes).[57] A meme is an idea which spreads from person to person in the community. The meme concept is evocative rather than precise, but from the plethora of memes which begin life a few are somehow selected to grow into ideas in good currency. To quote Edgar Dunn, who anticipated some of Wilson's and Dawkins' thinking

> Like biological mutation, human `idea mutation' does not always generate relevant ideas. Those idea inventions or behavioural innovations that are not consistent with the interplay between operating environment and operating goals tend to lose force. Those that promote a convergence between environment and social goals are reinforced.[58]

Ideas whose time has come have to be implemented. Sometimes the means will be obvious, perhaps nothing more than the use of increased budget allocations in already-established programs. At other times implementation will require the invention of one or more social technologies, built around **ideas for implementing ideas.**

> The solution of social problems lags behind technology because we have not organised the same sharp search for ideas to deal with them.
>
> J.R. Platt
> *The step to man*

In *The city in history*, Lewis Mumford points out that while the technical foundations of the industrial revolution were the exploitation of the coal mine, the vastly increased production of iron, and the use of the steam engine, the large-scale use of these technologies depended upon the invention of new forms of corporate organisation and administration.[59] These inventions, what I call **social technologies**{xe "**social technologies**"}, following Geoffrey Sawer (I have lost the reference), included the joint stock company, the limited liability investment, the delegation of administrative authority under divided ownerships and the control of production through budget and audit.

It is easy to think of dozens of such social technologies**social inventions**{xe "social technologies:**social inventions**"}, John Platt's name for them: the alphabet, standard time, credit cards, the research and development team, pay-as-you-earn tax, debt-for-nature, the Constitution, policy instruments such as transferable fishing quotas, milk quotas and so on [60]. The `Torrens' Torrens land-title system{xe "Torrens land-title system"} is a highly successful Australian social technology which rests on the fact that the State guarantees the information in the titles register book.

Social technology: recipe for increasing the effectiveness of a class of interactions or transactions between people.

Rules and roles

Social technologies appear in various guises. Some work, metaphorically, by creating roles for people and then issuing stage directions for playing those roles; think of the legal system. Such social technologies are the practical implementation of ideas for structuring classes of purposive (directed) interactions between people and parties, `rules of the game' if you prefer. They are institutional changes in the sense of either changing these rules or setting up new `games'.

In other social technologies, corresponding to social technologies**decision-support**{xe "social technologies:**decision-support**"} **technologies**, the emphasis is on ideas for collecting and processing specified information so as to reach some useful conclusion, e.g. public participation in land-use planning. A further large group are what Ian Lowe calls `social mechanisms for handling the results of technological change', (e.g. road rules), but equally large numbers have a minor or no technological trigger (e.g. the Federal Constitution).[61] Others are specifically designed to exploit new {xe "social technologies:material technologies and"} (e.g. teleconferencing, credit cards).

The commonplace observation that technological change{xe "technological change"} is a social process is confusing. It is the *diffusion* of a new (material) technology through a community which is a social process (and social technologies may well be devised to facilitate the use of new (material) technologies), but the new recipe should not be mistaken for the feast.

All social technologies are recipes developed to solve a social problem, meet a social need or achieve a social objective. Some are developed for profit, others by government in the public interest. Some day I will find the time to think through a taxonomy of social technologies. One potential misunderstanding that should be pre-empted however is that social technologies are just another name for {xe "social technologies:**social engineering** and"}. Social technologies work *with* people's appetencies; social engineering tries to *change* them. **If there are worries that social technologies might condition or indoctrinate people in unacceptable ways, the solution is to establish clearly just what people's rights are and ensure that these are respected, not to take the attitude that a society can never attempt to change**

The idea of social technologies is powerful and extremely useful, and one of the central questions of this book must be whether it is possible to create deliberately successful social technologies, in particular, social technologies which contribute to the process of learning how to reach our 15 natural goalsresource-management{xe "goals:resource-management"} goals. **Flowering social technologies are the marks of a learning society.**

Some particular successes

It would be difficult and of limited value to make a long list of successful Australian social technologies relevant to natural resource management. The half-dozen in Box 10.10 are simply those which first spring to mind.

Box 10.10 Some successful Australian social technologies{tc "**Box 10.10 Some successful Australian social technologies" \f b**}

* the Torrens land-title system

* the Victorian {xe "Land Conservation Council (Vic)"}

* the Great Barrier Reef Marine Park Authority{xe "Great Barrier Reef Marine Park Authority"}

* the national park system{xe "national park system"}

* rural adjustment scheme{xe "rural adjustment scheme"}s for helping debt-ridden farmers leave agriculture

* Aboriginal Aboriginesland rights{xe "Aborigines:land rights"}.

Improving the social learning rate

Key Points

Among the most important tasks for which new, revamped or re-directed institutions are needed are

* learning how to purposively generate ideas for new social technologies which solve problems and exploit opportunities

* developing a political framework within which alternative approaches to solving major resource-management problems can be seriously debated, tried and compared.

Among writers who have rejected simplistic ideological approaches to reaching social goals and solving social problems there are an impressive number who, more or less independently, have seen the task as one of developing skills in social learning{xe "social learning"}, i.e. have seen the task as one of a society *learning* to manage itself. This insight is reinforced by the further widespread perception that social, technological, and now natural environments are changing so rapidly that behaviour based on successful past experiences is likely to be irrelevant or even misleading.

But can we, *as a society*, learn how to learn? To develop a system for deliberate social learning requires establishing at least the following subsystems:

1. An **appreciation system**, to use Geoffrey Vickers' term, one that identifies which tacit or explicit goals of the society are not coming any closer or, more urgently, are retreating. These can then become the focus for the learning process.

2. An **options system** for identifying existing social technologies which stand to ameliorate each problem, or, finding none such, for developing new candidate social

Box 10.11 Components of a social learning system{tc "

Box 10.11 Components of a social learning system" \f b}

* an **appreciation system** for identifying priority threats and opportunities

* an **options system** for identifying and/or building candidate social technologies

* an **implementation system** for applying selected social technologies

* a **monitoring and evaluation system** for checking progress

Appreciation comes first

The declaration in Chapter 1 of 15 land-management goals constitutes one person's synoptic appreciation of the task of managing Australia's natural resources. But, less personally, what might be demanded of a publicly funded agency charged with devising an social changeappreciation system{xe "social change:appreciation system"}? Is it difficult, for example, to implement an `early warning' system which flags emerging major problems well in advance of their receiving IIGC status?
While society is regularly caught napping by the totally unforeseen (AIDS is a good example), the fact is that almost all major problems (and opportunities) are identified by someone well before they become threatening (are lost). The Greenhouse effect{xe "Greenhouse effect"} has been foreseen for decades by scientists. Rachel Carson wrote *Silent spring* in 1969. Agriculture departments in Australia have been warning about soils erosion{xe "soils: erosion"} for more than 100 years. And so on.

Producing candidate lists of (land-management) goals is not too difficult---but with the caution that there are always many ways of disaggregating complex problems and the foci which seem obvious may not be the most effective basis for problem analysis. What is more difficult is nominating the goalsrevising social goals{xe "goals:revising social goals"} which, over time, will (a) increasingly and (b) decreasingly need to be addressed. There are no free lunches and pursuing one goal more vigorously normally necessitates withdrawing resources from other areas.

It is particularly important that matters thrown up by any formal appreciation system be placed on a public agenda. Here we have an ideal task for the Commission for the Future{xe "Commission for the Future"}. They would draw all sorts of flak, particularly in identifying waning priorities, but could nevertheless make a major contribution to our perception of what we are trying to achieve as a nation. Besides, much as I appreciate what the Commission for the Future is attempting, it needs a significant concrete task to protect itself from being seen as just a talkfest. As an addendum, perhaps it could also take on the task of keeping a dynamic listing of what it sees as the likely `big issues' in Australian society 10, 20 years on.

Idea

The Commission for the Future should maintain and regularly update a ranked list of national land-management priorities.

How to social technologies*design{*xe "social technologies:design"*} social technologies*

> The loss of the stable state requires that we shift from the rational model to a model of learning, both personal and public. Our concern, then, becomes not only that of finding right answers or solving problems but of developing continuing processes by which problems can be solved and answers found.
>
> D. Schon,
>
> *The technology of public learning* (p. 000)

organised the same deliberate search for them. Perhaps CSIRO needs a CSIRO Division of Social Technologies{xe "CSIRO Division of Social Technologies"}! Or, in the present context, a Division of Social Technologies for Resource Management.

A major benefit, merely from establishing such an organisation, would be to make the idea of social technologies familiar and recognised as the class of solution needed for middle-sized social problems. **To know that one is looking for something called a social technology is, in itself, a flying start.**

The first task of an organisation set up to develop social technologies for ameliorating major social problems would be the meta-task of learning how to do just that. There are no textbooks. An inductive search for patterns in successful existing social technologies would obviously be worthwhile. For example, it is clear that many resource-management problems stem from just a few classes of causes, including ignorance of consequences (e.g. rabbit introduction), delays between cause and effect (e.g. dryland salinisation), externalities (e.g. pollution) and open access to resources (e.g. fisheries decline).[63]

It would be important not to let such an organisation fall into the hands of any one established discipline such as applied systems analysis{xe "applied systems analysis"}, political science{xe "political science"}, public administration{xe "public administration"}, law, economics, sociology{xe "sociology"}, sociobiology{xe "sociobiology"}, environmental sociology{xe "environmental sociology"}[64] or social psychology{xe "social psychology"}. These disciplines would each have something to offer in the way of useful precedents, but none has a sufficiently broad conceptual framework for the task being set. **One of the strengths of the social technology concept is that it is not associated with any particular discipline.**

Some principles

It is not possible to anticipate the details of any procedures which might be developed for designing social technologies, but the search and social technologiesdesign{xe "social technologies:design"} principles behind those procedures might well include, for example:

* the need to develop separate technologies for small parts of large problems (the `adaptive muddling' principle[65]);

* the possibilities for blending existing social technologies into new integrated technologies (the `belt and braces' principle[66]);

* the importance of developing procedures which are accepted because they constitute `instant carrot'. Things like the alphabet, the credit card, standard time, penny postage were successful because it was in the immediate interests of people to adopt them (the `instant feedback' principle);

* the importance of making maximum use of non-monetary values to motivate behaviour; conversely, the need to avoid solutions based on just throwing money at the problem (the `leather medal' principle);

* the importance of harnessing self-interest to pursue public interest (the `invisible hand' principle);

* the importance of viewing the problem from many perspectives (the `alternative realities' principle[67]);

* the need for {xe "social change:new institutions and"}. I incline to the view that, frequently, you will not be able to change embedded social procedures without changing the lead institutions, i.e. it is not enough to change the rules, or even the game---the players must also change. The reason is the psychological one that new organisations are perceived to be free of accumulated baggage (obligations, animosities etc.) and to embody the energy to force change. Thus, one candidate component when designing a new social technology must always be a new institution. As Donald Schon has said, the structure of government is perpetually out of date, a `series of memorials to old problems' (the `new broom' principle);

* the need to redistribute resources among the stakeholders (the `power sharing' principle);

cannot be immediately judged correct. These are an obvious source of ideas for developing a structured approach to designing social technologies. Two of the more interesting of these with relevance to natural resources management are **Adaptive Environmental Assessment and Management**{xe "**Adaptive Environmental Assessment and Management**"} (AEAM) and **Analysis of Interconnected Decision Areas** (AIDA). More generally, the field of **applied systems analysis** has developed insights which must be taken into consideration.

Adaptive Environmental Assessment and Management is a Canadian social technology, a collection of collaborative problem solving methods, which can be used to attempt to improve[68]

* the design of resource-management policies;

* environmental impact assessment;

* research planning;

* project integration and synthesis.

It is all a bit mystical, but usually includes bringing scientists, managers and policymakers together in a workshop where they do such things as

* build simulation{xe "simulation"} models of the system being studied;

* make plans which recognise principles such as the pervasiveness of uncertainty and the need `to learn on the run'.

An {xe "adaptive processes"} is one governed by the flow of information.

The originators of AEAM argue that available data and theories are never adequate for making plans, and that conditions change rapidly and unpredictably. In this uncertain environment it is best to take an incremental and experimental approach to problem-solving, a program of continuous monitoring and readjustment.

The key features of AEAM that make it useful for tackling complex environmental problems have been summarised as

* providing an unfamiliar mix of expertise and interests which brings together different approaches and views of the world;

* providing a forum within which people with different roles (e.g. scientists, managers, policy advisers, key constituents etc.) can interact;

* drawing from experience in other areas and issues that relate to the problem at hand;

* promoting understanding of the behaviour of complex, dynamic systems.[69]

AEAM has not really taken off in the 20 or so years it has been around. I suspect that it partly hangs on because the ecologists who originally suggested it (Holling and Walters) have excellent reputations as mainstream scientists and nobody wants to accuse the Emperors of becoming unclad in moving from science to management.

Nonetheless, AEAM is an example of trying to do what I am advocating and that is to attempt to deliberately design a social technology. It is obviously something which would have to be reviewed as part of any attempt to set up formal machinery to design social technologies. It has in fact been tried with some success in Australia on the problem of managing the Macquarie Marshes{xe "Macquarie Marshes"} in New South Wales.[70]

Analysis of Interconnected Decision Areas{xe "**Analysis of Interconnected Decision Areas**"} (AIDA) is the core of what its developers call the **strategic choice approach to**

conservative solutions, but that is not necessarily always unacceptable.[72]

Conservative solutions---solutions not very different from the status quo.

Emerging and improving social technologies

Irrespective of whether or not the process can be formalised and routinised, social technologies *are* being created regularly and established social technologies are being improved or are evolving. A number have started in the business world and have been subsequently adapted to assist resource management in the public sector. Among the {xe "social technologies:emerging"}newer social technologies with promise for environmental and resource management are those in Box 10.12[73]

Box 10.12 Emerging social technologies{tc "**Box 10.12 Emerging social technologies**" \f b}

* active conflict resolution, including multi-party planning, environmental mediation and environmental arbitration

* systematic public consultation/participation

* formation of community action groups

* issue management

* technology assessment

* decision conferencing[74]

* social impact assessment{xe "social impact assessment"}

* environmental auditing{xe "environmental auditing"}, which can take many forms, but is essentially concerned with identifying changes to an existing enterprise's operations standing to reduce the environmental impact of those operations

All of these have a general goal of improving the equity, the distributive justice, of decisions. Mediation can be either passive, simply assisting the parties to reach an agreement, or active, which involves directing the search for an equitable and technically sensible outcome. In either role, the mediator helps to identify data gaps and ways of filling them, facilitates joint evaluation of data and the drafting of an eventual agreement.[75]

Because the focus is on the conflicting interests of the immediate stakeholders in a mediated dispute, the interests of the broader public can get neglected. Social impact assessment, on the other hand, specifically considers the interests of third parties. None however particularly consider the interests of what I will call fourth parties, namely, future generations.

Among more established social technologies which are enjoying recognisable improvement, I would include those in Box 10.13.

Box 10.13 Improving social technologies{tc "**Box 10.13 Improving social technologies**" \f b}

* Environmental impact assessment
---extension of environmental impact assessment from assessing just physical development projects to assessing a wide range of government policies, regulations and programs seems a likely development at some stage.[76]
---cross-impact assessment{xe "cross-impact assessment"} allows a group of people systematically to identify a set of key variables to be considered in environmental

Implementation

The essence of experimentation is to try several ways of doing something and select the most successful. The **implementation phase** of solving problems in a learning society would involve simultaneously initiating several (usually) social learningparallel programs{xe "social learning:parallel programs"}. Each would focus on a different social technology identified as potentially capable of ameliorating the problem or exploiting the opportunity.
In practice, because the concept of social technology is not recognised by most bureaucrats, programs are normally designed at a preconscious, intuitive level. Also, the idea of simultaneously trying out more than one approach to a social problem, while not unknown, is unusual. `Pilot' programs are more common. For some problems the States and Territories adopt different approaches and comprise a natural laboratory. That is not enough howeverand new ideas are needed for making active experimentation overtly acceptable (the `open mind' principle).

Monitoring and evaluation

Where have we been?
The need to **monitor and formally evaluate** all newly introduced social technologies (the `but did it work?' principle) seems obvious enough. The difficult parts of a monitoring{xe "monitoring"} program lie in setting values for indicator variables at which ameliorative action will be triggered; so-called **backoff and threshold criteria**. Sunset clauses are a useful backup in case monitoring fails badly.

Ssunset clauses{xe "s**unset clauses"**} in the legislation or regulations setting up a government program state that the program will routinely cease at a certain date unless special action is taken to prolong its life.

Fundamental to learning from a mistake is recognising and admitting it. While a Maoist approach of public self-criticism might not be the social technology we are seeking, **our** {xe "government:**adversar**ial"}**y system of government means that mistakes have to be denied and this makes self-delusion easy**. A vigorous intelligentsia remains our best safeguard for ensuring that the successes and failures of emerging social technologies will be identified and evaluated. Ssocial critics{xe "social critics"} like Hugh Stretton and Donald Horne, to name but two, are necessary. Unfortunately, today's thin intellectual atmosphere is not conducive to deeply informed critiques of social processes. The searing winds of economic fundamentalism have frightened too many potential social critics into staying indoors.

endch

11. STEPPING BACK FOR A LOOK

> Mankind thus inevitably sets itself only such tasks as it is able to solve, since closer examination will always show that the problem itself arises only when the material conditions for its solution are already present or at least in the course of formation.
>
> Karl Marx,
> *A contribution to the critique of political economy*
> 1859

Meliorism rules

I know of two novels set in {xe "goals:Australia's future"} distant future, *Tomorrow and tomorrow* by M. Barnard Eldershaw and *The sea and summer* by Robert Turner.[78] Turner's work paints a fairly grim picture of Australia in the middle of the 21st century, grossly overpopulated and poor and beset by the problems of atmospheric warming and land degradation. Eldershaw's, set some 400 years away, is more optimistic. It depicts a civilised Eurasian society which has solved the problems of violence and distributive justice, but suffers a spiritual malaise stemming from some rather heavy social engineering. This book is my contribution to avoiding Turner's scenario and achieving the better aspects of Eldershaw's.

Meliorism is the optimistic doctrine that the world can be made better by human effort; it rests initially on the perception that a great many of the things which are important about the more or less distant future are largely determined by human decisions made in the present. Much of what will happen in the 21st century is already being determined by decisions today, just as much of the functioning of today's society was set by land-use etc. decisions a century ago. To qualify as a {xe "meliorism"}t in the present discussion, you have to believe that if enough people of good will try hard enough they can make Australia a better place in which to live; that they can make good, or at least better, use of the place. Despite the very real limits to the manageability of natural and social systems, I do. (Shout if you believe in fairies.)

Obviously, you also have to believe there will be no blood on the wattle (cherry blossom?), that the system will be continuing to function in some way roughly comparable to the present. That is, unless you think that things are so bad that the only option is to pull everything down and start again. I do not. Our starting point must be to make what we have more effective.

Even more conservatively, I choose to see our resource-management problems as `adjustment'

problems rather than `rebuilding' problems. I have made it clear that I see **economic fundamentalism**{xe "**economic fundamentalism**"} as a real threat to the efficient, equitable and conservative (in the non-political sense) use of the country's natural resources. **However, provided we can** {xe "population:**stabili**ty"}**se population, avoid the excesses of ideologues and intelligently draw on the range of available policy instruments to help (Box 11.1), we should be able to make the adjustments and adaptations which will keep this a good place to live next century.**

Box 11.1 The broad .i.policy **instruments**{tc "**Box 11.1 The broad** .i.policy: **instruments" \f b} of public policy;**

* economic measures

* education

* research

* administrative structures

* equity-oriented social technologies

The spectre lurking behind this relatively cosy view is that most of the rest of the world is faced, not with `fine-tuning', but with the need for massive reconstruction of values, institutions and production-protection systems. **With the best will in the world, we cannot really help and we stand to get hurt in the process.**

{xe "foreign aid"}If Australia gave half its gross domestic product in aid to the people of the low income countries, each would receive $US 38.25 (1986 dollars); of this, 42% would go to China.(Table 11.1)

Table 11.1 Spreading it out thin{tc "**Table 11.1 Spreading it out thin**" **\f t**}

Country type	Population (millions)	GDP/head $USm	Total GDP $USm
Low income (under $425 p.a.)	2493	270	673 110
Middle income	1268	1 270	1 610 868
High income oil	19	6 740	128 734
Industrial market	742	12 960	9 611 136
Other367			
World	4889	2 459	12 023 848

Source: M. Young (pers. comm)

If Australia took in 50 million immigrants, the number we could possibly feed if we gave up exporting food, the rest of the world would have zero population growth for 215 days.

mind to weigh the ever-changing probabilities of the real world and make reasonable policyimportance of judgement{xe "policy:importance of judgement"}s on what to do about significant problems; that it is possible to rise above ad hocery and the tyranny of small myopic decisions. The key word there is *well-informed*. {xe "rational planning"}I am quite happy to see rational thought embedded in a learning and participatory framework, but in the end I believe that it is worthwhile (pays better than evens!) to try and think out and learn the consequences of the available options as you see them and choose the one which appears to have superior consequences. Nonetheless, almost all decisions are finally made through an intuitive leap. We should neither regret nor laud this; it is the way the world is.

Within the above context, the time has come then to face up to whether this book delivers. It has promised to show how to make good use of Australia, to lay out how and what to think about her natural resources in order to make the place more habitable. This is not quite the same as promising cut-and-dried, hard-and-fast plans, firm programs of action. That would be naive indeed. Why?

First, the only planning worth the effort is that which starts from somebody's powers and capabilities and works out how to use those powers to achieve their goals. It has taken me years to learn to remain calm in the face of so-called plans and strategies which are nothing more than statements of goals, of ends without means. I have no national planning powers so I do not draw up national plans. Second, developing serious plans for the use of a wide range of natural resources is a massive task, well beyond the time and skills of an individual. What then? In what direction am I pointing?

I am saying, `Here are some goalsresource-management{xe "goals:resource-management"} goals, here are some policies for creeping up on them and here is a range of instruments for implementing policies'. I am also saying that it is a demanding, ongoing multifaceted task to keep improving on our resource-management achievements, but not an impossible one. This book succeeds if my vision for doing so is convincingly comprehensive and practicable; if the reader believes for a moment or two.

I have no national planning powers so I do not draw up national plans.

Goals beget policies beget ...

Questions about the management of Australia's natural resources quite clearly cover an extended spectrum of bio-physical, environmental, socioeconomic and political issues. The 15 goals identified at the start of this book are an attempt to disaggregate the overall land and resource-management task into something more graspable, an identification of the main areas where plans, programs, social and material technologies etc. are required. They are an assertion of Australian society's expectations for the country's natural resources.
I find the Canadian term goals**scoping**{xe "goals:**scoping**"} a useful description for this sort of operation. Even if the goals are not as well chosen as they might have been, they allow us to see a wood of sorts, one with just 15 trees. Fifteen trees is comprehensible; the mind can cope with that.

The intellectual device which allows one to move from goals towards plans, without losing the broad perspective, the `inclusive frame of reference', which a goal-set represents, is {xe "goals:**policies** and"}.[79] Policies suggest the types of decisions that will need to be made in order to move towards goals. I am trying to implement what Etzioni calls **mixed scanning**{xe "**mixed scanning**"}, i.e. while it is impossible to focus on several levels of detail at once, it should be possible to switch back and forth between two levels (e.g. goals and policies) if these are hierarchically structured.[80]

Policies, values and programs

Policies flow from **values** and are expressed in **programs**.

How are these three concepts related? Recall, {xe "policy:**values** and"} are, in an

choice, the person proposing the value can commonly identify some property of the choice which satisfies one of their values more as it increases and less as it decreases (or vice versa), for example, an alternative generating more profit has higher value (in the profit dimension) than one generating less profit. Alternatives being compared in terms of values for which acceptable measurable indicators cannot be found (e.g. equity) can only be ranked intuitively (nothing wrong with that, just harder to defend). **Goals** are statements of *which* {xe "goals:values and"} are to be pursued. **Policies** are statements of *how* values can be taken into account (satisfied) by the members of a collective when choosing among alternatives, e.g. as far as possible, the goal of conserving genetic diversity is to be approached by conserving rare species. **Ethics** are the personal counterparts of an organisation's policies, i.e. general-purpose codes of conduct for individuals which will lead to their values being satisfied. For example, the core of the increasingly popular idea of a **land ethic**{xe "**land ethic**"} is a conviction of individual responsibility for the `health' of the land, meaning its capacity to recover to its former state after disturbance.[81]

Policies are sometimes `policyhard and soft{xe "policy:hard and soft"} guidelines' and sometimes `hard decisions.' Hard policies state that future actions will (will not) definitely meet certain criteria, e.g. the number of immigrants admitted to Australia over the next decade will not exceed 100 000. Soft policies say that, **as far as possible**, future actions will (will not) meet certain criteria, e.g. immigrant numbers will be kept as low as possible, preferably under 100 000.

The role of hard policies is to cover situations where, irrespective of other contingencies, future actions can be confidently chosen. Soft policies are a sign of willingness to compromise, to `trade off', when there is conflict between the actions suggested by different policies. Soft policies do not `lock the decisionmaker in' to some particular action.

When policies clash

Consider two policies. `As far as possible, preserve prime agricultural land around Sydney' and `As far as possible, make flat, well-drained land around Sydney available for urban expansion'. These two policies cannot both be fully implemented; they clash. The point is that by stating the policies simultaneously and in this way, the requirement to seek a balance or tradeoff between them becomes crystal clear. It is a political decision where that balance point is to be.

Policies are not programs. **Programs** are action specifications. They come *after* policies have been formulated and emerge as the result of balancing all relevant policies to reach a compromise on the extent to which conflicting {xe "programs:policies and"} will be implemented in a program for a particular situation.

P{xe "social technologies:p**olicy instruments** and"} are social technologies for creating programs out of policies. For example, `the last colony of Rock Wallabies will be protected by a fence'. That is a **program** for implementing a **policy** of conserving genetic diversity through reservation. The **value** being satisfied is genetic diversity and the **goal** is to conserve genetic diversity. The **policy instrument** being used is a site-management plan. I find the increasingly common practice of equating policies with particular {xe "policy:**programs of action** and"} to be unhelpful; it elides a useful distinction.

Policy instruments

An enormous range of policy instruments has been introduced in this book, some in greater, some in lesser detail---administrative, managerial, institutional, regulatory, educational, economic, research, political. Just as it is important not to focus on but one or two natural-world management issues, it is important not to `lock onto' a handful of policy instruments as panaceas for most resource-based problems. Both economists and environmentalists are particularly prone to blinkered thinking of both types.

Because we live in a relatively homogeneous {xe "values:culture and"} (set of shared ideas), the set of values and the policies they spawn is likely to be initially somewhat

from situation to situation, from person to person, is how policy policymeasuring achievement{xe "policy:measuring achievement"} is `measured' and the relative extent to which policies are differentially satisfied.

Given some starting goals, what is then practicable is to develop a *range* of policy policy guidelines{xe "policy: guidelines"} for approaching each one. This was attempted earlier in sketching out the bones of a national land-use policy. These guidelines are effectively criteria supplied by different stakeholders for helping make choices between programs or are reference points for beginning to design social technologies. It is important to capture the widest possible range of policies (and goals) at an early stage of decisionmaking. Otherwise, neglected values have a habit of springing out from behind trees and challenging the legitimacy of emerging programs. All very well, but resources for identifying values, goals, policies and programs are always limited and, in the end, planners can only include what seems most important after limited research.

Sland-use planning**stakeholders**{xe "land-use planning:s**takeholders**"}

Individuals or groups who stand to win or lose depending on the way decisions go.

Are all the above terms just so much obfuscating jargon? No, not so. They are the bones of a very simple, powerful resource management**procedural theory**{xe "resource management:**procedural theory**"} for making decisions about resource-management problems. It fits on the back of an envelope.

A powerful procedural theory of resource {xe "resources:**management** theory"}

1. Start with issues; they point to values.

2. Use values to help identify goals.

3. Goals suggest policies (lots preferably).

4. Trade off degrees of achievement of different policies to create a plan.

5. Use available policy instruments to create action programs for implementing the plan.

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*Values do {*xe "values:changes in"*}*
Turning from `theory' to practice, it is coming home to me that a steering correction which I have felt necessary to advocate at a number of points in this book might be rendered unnecessary by community attitudes which are changing as I write. **While arguing that we must avoid being run down by the juggernaut of economic fundamentalism**{xe "**economic fundamentalism**"} **because I see that as the reigning threat to social progress generally and improved resource management in particular, the threat of ecological fundamentalism**{xe "**ecological fundamentalism**"} **has appeared in the rear-view mirror.** Bellamites may yet replace Hughmorgans as the bogeymen.
For example, I recently heard a radio talk advocating strong immediate action to combat the Greenhouse effect{xe "Greenhouse effect"}, even though we cannot yet predict with any confidence how global warming will differentially impact on different parts of Australia. Again, there is nothing wrong with spending billions of dollars on combating soil erosion in the pastoral zone---provided that we first calculate that this is the best way of spending limited funds. Soil conservation is in fact one area where there are signs that the organisations and infrastructure to spend the funds becoming available sensibly are just not there. The decision not to sign the Antarctic minerals treaty{xe "Antarctic minerals treaty"} in 1989 may well have been right in terms of long-term global welfare, but it was taken for the wrong reasons one suspects---that it would win environmental votes without hurting anyone's foreseeable profits. Are politicians going to start feeling a ban rather than a dam coming on in future election campaigns?

The single value which has historically dominated resource management in Australia, it is that `valuesdevelopment{xe "values:development"} is a good thing'. Recently that has been changing to `development is a good thing provided it is environmentally sound'

Things seem to change so slowly, but looking back over the two years it has taken to write this book, the range of resource-management initiatives flowing from changing values is startling ... Salamanca agreement{xe "Salamanca agreement"}, World Heritage listings, mining in Antarctica, driftnetting, the Resource Assessment Commission{xe "Resource Assessment Commission"}, Landcare{xe "Landcare"} ... to name just a few. Perhaps we can control our destiny!

Scenarios

Scenarios, defined earlier as plausible futures, are much loved by futurologists. If you do not feel confident about predicting the future, it can at least be `perception-heightening' to trace out a chain of intuitively possible (up to probable) events which would lead to some interesting state of society, like World War III. The basic question to ask is `What will happen if ...? and then repeat the question a second time on the assumption that the first answer is certain rather than speculative. And so on. An alternative approach to scenario generation which might be useful in deciding how to head off disasters is to keep asking `What may happen unless ...?'
It is not intended to build up resource-use {xe "scenario generation"}s here because that is a very lengthy business. It can however be indicated how this might be done quite simply. The method is to argue backwards from those ever-hovering 15 goalsresource-management{xe "goals:resource-management"} goals assuming, in turn for each goal, that, by 2040, the goal is either badly missed or well achieved. Combinations of high and low achievement on each of 15 goals gives over 32 000 potential scenarios! The sequence of questions now is `How could that have happened?'; `What plausible events could have led to that goal being well (badly) achieved?'.

Scenarios seem to be a very effective device for making people aware of what the future might hold and, more importantly, helping them realise how the long-term future can be strongly determined by social decisions today. The Commission for the Future{xe "Commission for the Future"} could do worse with some of its minuscule resources than engage in some serious scenario generation.

Some inescapable truths

It would be counterproductive to woodenly summarise the premises and conclusions introduced throughout this book; the list would be overwhelmingly long or the implication would be that those left out were somehow less important. I will however enjoy the indulgence of pulling out a handful of these on which I feel particularly strongly and granting them the status of truths. Credo:

1. Every Australian has a {xe "values:personal rights"} to an environment where s/he can live a long healthy life, wherein the daily round is a pleasant and satisfying experience.

2. Our political-economic system just cannot foresee or respond efficiently to problems.

3. We need more people in Australia like we need a hole in the head.

4. The Aborigines{xe "Aborigines"} have a very strong claim on this country.

5. Development is a one-way street; you can't back up.

6. Ssustainable development{xe "sustainable development"} is a myth; nothing is sustainable for ever and all development destroys something. Conservative development is a realistic option.

7. Resource-allocation questions have no right answers; all assertions of values and goals are valuesas acts of faith{xe "values:as acts of faith"}, pointing the way, one hopes, to a better world. Avoiding the `bad' is more likely to be successful than pursuing the `good'.

8. It is social investment{xe "social investment"} which makes private profit possible.

9. When spending public money, it can be difficult to detect the line between private subsidy and social investment.

18. Loss of vegetation is the main cause of {xe "vegetation:land degradation and"}.

19. Habitat retention and pest control are the main keys to species survival.

20. The only non-fragile environment is a buggered one (now there is an indulgence).

21. It is quite wrong to regard soil as a renewable resource.

22. Technological determinism is a red herring; technology assessment{xe "technology assessment"} is not.

23. People do not want to accept that there are no simple answers to resource-use questions.

24. The Australian public is not interested in distributive justice.

25. The Australian public is not averse to polluting, wasting, irreversibly degrading and needlessly destroying natural resources. Responsibility to future generations is as important as efficiency and equity today.

26. The essence of many environmental decisions is choosing between short-term benefits and long-term benefits as solutions to problems. We are comfortable enough to be able to favour decisions which protect the future over decisions which improve the present.

27. Sure, it's a great country.

Importance of the social infrastructure

We must not be overwhelmed by the task of developing and implementing a phalanx of goals and policies. After all, there are 16 million of us. **One fundamental prerequisite for being able to make progress flexibly and quickly on so many matters is to get the social infrastructure right. To a very large extent, this amounts to having knowledgeable and experienced people working in a well-focused range of organisations.** Thus, as ideas in good currency change, there will normally be a relevant and competent organisation poised to slightly refocus and address the challenge. The pillars of the social infrastructure selected for comment here are education, research, public administration and `key' organisations, i.e. those it is particularly important to nurture.

Beyond myopia---environmental education

Three somewhat different tasks are subsumed under the banner of environmental education{xe "environmental education"}. One is the training of resource and environmental scientists and managers (including foreigners). The second is improving the information getting to resource users about the physical and economic effects of different management practices. The third is the educating of children to have a balanced appreciation of the conservation--utilisation tradeoff.
As regards the last, I can see a need for first teaching children what used to be called **clear thinking**{xe "**clear thinking**"}. We all benefit from being formally alerted to the tricks of persuasion and the nature of bias, fallacy, tautology etc. The other background skill to be mastered is formal **decisionmaking** in which the student is shown how to identify and compare options for action. Tentatively, the substantive part of children's environmental education should focus on analysis of and participation in case studies, e.g. local land-use conflicts.

At tertiary level, one sensible option is to start with two years rigorous training in the biological sciences, the earth sciences and the physical-mathematical-computing sciences. Thereafter, the student could specialise in forestry{xe "forestry"}, marine science{xe "marine science"}, agriculture{xe "agriculture"}, park management{xe "park management"}, conservation biology{xe "conservation biology"}, ecology{xe "ecology"}, resource economics{xe "resource economics"}, natural resource management etc.

Informing, no, teaching resource users about the economic and bio-physical consequences of their actions is a public responsibility justified, one hopes, by consequent reductions in external costs imposed on the community. Perhaps the Australian Broadcasting Corporation needs an environment unit to complement its

nutshell, this is because Australian resources and environments are unique and no one else is going to develop the deep and specific understanding needed to manage these conservatively yet productively. As to the size, focus and organisation of that effort, I am not sure. Neither is government, the scientific community nor the broader community.

The Federal Government recommitted itself in 1989 to enhancing science and technology capacity. Whether the bits and pieces presented in the document can, unblushingly, be called a *science* science *policy{*xe "science: *policy"}* is an open question.[83] A new **Prime Minister's Science Council**{xe "**Prime Minister's Science Council**"} is intended to provide authoritative briefings to senior ministers. A **Co-ordination Committee on Science and Technology**{xe "**Co-ordination Committee on Science and Technology**"} will bring together senior officers from departments with science and technology interests.

A range of research corporations{xe "research corporations"} designed to focus, fund and co-ordinate Federal research in selected fields has been established. Notably, these include a National Environmental Research Corporation{xe "National Environmental Research Corporation"} and a Land and Water Resources Research and Development Corporation{xe "Land and Water Resources Research and Development Corporation"}. Plans for establishing up to 50 co-operative research centres{xe "co-operative research centres"}, bringing together university, CSIRO and agency talent have been announced subsequently.

Research priorities

The above procedural experiments in developing new social technologies for managing scientific research are laudable; whether they will lead to more, better and more useful substantive research is problematic. To help out here, there is, seemingly, always an inquiry or review going on somewhere to establish science**research priorities**{xe "science:**research priorities**"} in some field or other. The Australian Science and Technology Council{xe "Australian Science and Technology Council"} is at present reviewing research priorities in environmental science{xe "environmental science"} for instance. Reviews of marine science{xe "marine science"} and research within the Department of Primary Industries and Energy{xe "Department of Primary Industries and Energy"} have been recently completed. Such reviews tend to collect the disjointed and partial views of establishment scientists and others and collate them into a distillation of conventional wisdom. This does not mean they are without value, especially if supported by commissioned specialist studies. Working scientists read such studies mainly to see how they can re-express their research interests to conform to the `new' funding priorities.

The first trap to be avoided in discussing research priorities is sterile debate on the relative importance of **basic science**{xe "**basic science**"}, **applied science**{xe "**applied science**"} and **engineering/**{xe "science:**technology** and"} **development** in tackling these tasks. As noted earlier, basic research is what you do when you have few promising ideas on how to achieve some sought-after result. In a recent submission on priority funding areas to the Australian Research Council{xe "Australian Research Council"}, the Institution of Engineers{xe "Institution of Engineers"} argued that Australia should do little basic research and devote much more attention to applied research and engineering research.[84] If that argument is accepted, we need, at very least, a well-funded unit to systematically filch new ideas coming from overseas research in resource management. The Institution was assuming the underlying question to be `What sort of research should we be doing in order to make a quick buck?' I think they are probably right---given that assumption. To make money from research you try and meet existing needs more efficiently through product innovation; so-called market-pull research. But what if the question is `What do we do to achieve such-and-such a state of the system? To make Australia a better place in which to live?'

Also, science starts letting you down if you spend all your research efforts on marginally improving existing technology. Diminishing returns set in; intellectual capital{xe "intellectual capital"} starts running down. Once quick results start being demanded, too much effort goes into trying hunches, few of which work. Too often research is planned to seek a solution to a problem when a better approach would be to seek initially to define the *cause* of the problem.

The way to organise scientific scienceorganising **research**{xe "science:organising **research**"} **is to work in a balanced way on broad socially relevant problems at a number of levels simultaneously, including**

Box 11.3 F.i.science**five challenges**{tc "

Box 11.3 F.i.science:f**ive challenges" \f b} for Australian resource scientists;**

* understanding and modelling key {xe "landscape processes"} and ecosystems processes{xe "ecosystems: processes"} (fire, water movement, vegetation change, soil movement etc.)

* improving resourcesinventory and monitoring methods{xe "resources:inventory and monitoring methods"} (locating and counting plant and animal species, measuring and remeasuring forests, climate change, minerals, agricultural soils etc.)

* improving decision-support systems{xe "decision-support systems"} for managers (to help them with choosing and timing operations, allocating resources, etc.)

* learning to design social technologies (achieving conservative exploitation, social technologiesfor resolving conflicts{xe "social technologies:for resolving conflicts"} between resource users, distributing the rewards from resource exploitation fairly etc.)

* developing technologiesbenign and profitable{xe "technologies:benign and profitable"} material technologies (low pollution per unit of output, low degradation per unit of output etc.)

When all the inquiries are done and finished, we will have to be prepared to support work on a handful of research foci (not necessarily these five), and methodically move to concentrate resources around them. I am concerned that the planned co-operative research centres are simply going to be selected from proposals put up rather than also proactively seeking proposals in key areas. Such is the real stuff of science policy.

Public administration

An effective social learning system was characterised earlier as one with several well-developed subsystems, viz. an **appreciation system** for identifying priority threats and opportunities, an **options system** for identifying candidate social technologies, an **implementation system** for applying policy instruments and a **monitoring and evaluation system** for checking progress. These procedures can be applied equally to small and large problems; **the challenge facing public administrators is to see if they can minimise the tyranny of small decisions by applying the social learning**{xe "**social learning**"} **paradigm to increasingly larger problems**.
Applying economic thinking to issues and developing and applying {xe "public administration:economic policy and"} is and will remain a very large part of public administration of natural resources and the environment. A closing word on the subject is in order.

Eeconomic instruments{xe "economic instruments"*}*
I have hereto treated economic analysis with caution and suspicion, partly to counter the reverence with which it is regarded by so many, not least practising economists. In perspective, economics is just another imperfect tool, older and more sophisticated, but neither better nor worse, than environmental impact assessment, land-use planning etc., etc. It is only more important than these to the extent that it focuses on dimensions of choice (e.g. short-run efficiency) presently valued highly. **The** {xe "economics:**environmental movement** and"} **has no choice, but to accept that economics is not going to go away. It must be studied, understood and used intelligently.**
From an economic perspective, there are three broad ways in which governments can influence natural resource use:

* change property rights{xe "property rights"} in natural resources, basically ownership of bundles and parts of bundles of rights to use particular resources;

* influence the prices and costs faced by producers and consumers, basically through

that regulations can be very blunt instruments, but they are effective, legitimate and easily understood.

Key organisations

State and Federal departments and agencies are the workhorses for environmental and natural resource management in Australia. However there are other organisations, both old and new, which support or complement mainstream departmental activities. Some of the most useful of these, to be protected and supported, are now briefly discussed.

The research bureaux

Four established bureaux play an important role in gathering basic information about resource use and developing policy advice for the Federal departments they are associated with. All have reputations for being very professional. They are Australian Bureau of Agricultural and Resource Economics{xe "Australian Bureau of Agricultural and Resource Economics"}, Bureau of Mineral Resources, Geology and Geophysics{xe "Bureau of Mineral Resources, Geology and Geophysics"}, Bureau of Rural Resources{xe "Bureau of Rural Resources"} and Bureau of Flora and Fauna{xe "Bureau of Flora and Fauna"}.[85]

The Bureau of Transport and Communication Economics{xe "Bureau of Transport and Communication Economics"} and the Bureau of Immigration Research{xe "Bureau of Immigration Research"} are new and very new respectively, but are potentially important sources of more or less independent policy advice. The Bureau of Tourism Research{xe "Bureau of Tourism Research"} seems too interested in marketing and tourist numbers to be of much relevance to resource management at this stage.

The commissions

Commission for the Future{xe "**Commission for the Future**"}**.** This Commission has set itself the task of educating people about what the future might or can be like and how they can adapt to it and shape it. Their mission is `a sustainable economy, in a sustainable healthy environment, within a generation'.[86] That is not enough. I would like to see the Commission taking on several high-profile controversial tasks.

One, already mentioned, is that of developing a discussion set of goalsnational priorities{xe "goals:national priorities"} and a set of `anti-priorities' or things we should be moving away from. The other is to speak for future generations; this could be a valuable new countervailing social technology. In our present enthusiasm for devising social technologies for improving equity, our great grandchildren are not represented directly in debates on deficit financing, infrastructure replacement, rate of loss of environmental values etc.. **What I am suggesting is that the Government specifically charge the Commission for the Future with the responsibility of becoming a `pressure group'** social technologies**for** representing **future generations**{xe "social technologies:**for** representing **future generations**"}**.**

Resource Assessment Commission. The Resource Assessment Commission{xe "Resource Assessment Commission"} was created in 1989 to help governments make decisions that are in the public interest about major resource-use issues, but issues at a grander scale (sectoral, regional) than that of the individual project. It is given references by the Federal Government, the first inquiries being into forests, coastal development and mining in Kakadu national park{xe "Kakadu national park"}.

> The Commission's job will be to assemble all reasonably available information, acknowledge those areas where uncertainties remain, take relevant viewpoints into account and advise the Government on the options it can adopt---within a reasonable time frame.[87]

How this is to be done is left to the Commission, although the Act requires the Commission to identify alternative uses for the resource, the consequences of those uses in terms of `environmental, cultural, social, industry, economic and other' values

energy be fairly self-interested only if strategic energy is directed to the public interest. The Resource Assessment Commission is tactical. We have no bodies comprehensively interested in resource-management strategy. The Commission for the Future is too weak and does not yet have a coherent philosophy. This problem must be addressed.

Murray-Darling Basin Commission. The Murray-Darling Basin Commission{xe "Murray-Darling Basin Commission"} operates in a constitutional and social minefield. It is slowly building up its expertise in more than regulating river flow and slowly gaining the confidence of the States and the communities of the Basin. It may yet turn out to be a blessing that the Basin straddles four States, forcing recognition of the need for a professional management body in a way that is not possible for Cape York, central Australia etc.

Federal Pollution Commission{xe "**Federal Pollution Commission**"}**.** There is no such body as the Federal Pollution Commission, but there may be a place for one to set national pollutant emission and ambient pollution standards. Such a body would be a necessity if the Federal Government were successfully to seek environmental protection powers through a referendum. In fact, the need is to go further. It was suggested earlier that pollution management could be one of several responsibilities of a National Risk-management Authority.

Ministerial councils

The development of relevant ministerial councils{xe "ministerial councils"} (e.g. Australian Water Resources Council{xe "Australian Water Resources Council"}, Australian Fisheries Council{xe "Australian Fisheries Council"}, Australian Minerals and Energy Council{xe "Australian Minerals and Energy Council"}) and their associated systems of standing committees and working parties with representatives from all States has undoubtedly improved the social learning rate in natural resource-management.

However, it is important that further efforts be made to devise new social technologies which will move the contributions of these councils nearer their potential to make a very major contribution to national resources management. One simple improvement would be to integrate the Council of Nature Conservation Ministers{xe "Council of Nature Conservation Ministers"} and the Australian Environment Council{xe "Australian Environment Council"} because they have related responsibilities and membership. Similarly, it would be worth investigating whether soil, water and agriculture councils could be better integrated.

CSIRO and the universities

The future for those parts of the Commonwealth Scientific and Industrial Research Organisation (CSIRO){xe "Commonwealth Scientific and Industrial Research Organisation (CSIRO)"} concerned with the understanding and management of land-based natural resources (wildlife, soils, forests, rivers etc.) is not bright. First, the States are increasingly doing the sorts of applied research that CSIRO once did. Natural-resource mapping, agronomic research and wildlife research are three within my own experience.

Second, even when CSIRO{xe "Commonwealth Scientific and Industrial Research Organisation (CSIRO):future of"} researchers want to work in a State on something which is not directly competitive with State efforts, the States are keen to guide and control that work, especially if it might generate results useful to critics of State resource-management policies, e.g. measuring erosion, identifying fauna-rich areas in State forests. There are numerous ways in which research can be made difficult for the non-conforming scientist, e.g. procedures for granting collecting licences, getting access to State-held data.

These problems are less marked with {xe "marine science"} research, because the Commonwealth probably has ultimate control over the resource of interest. Similarly, the problem is limited with atmospheric/climatological research{xe "climatological research"}, because research there is more about understanding than management. Also climatic understanding is fairly obviously a continental-scale rather than a regional-scale task.

The present situation is that CSIRO researchers are spending more and more time attempting to get research money out of industry research funds (e.g. the Australian Meat and Livestock Research and Development Corporation), many of which demand extremely quick results and many of which are unsympathetic to research which is not oriented towards short-term profits. The other alternative is commercial consulting, and more and more time is being spent in CSIRO on background studies for environmental impact assessments and policy studies of all sorts. Socially useful work no doubt, but the result is that we are running down our intellectual capital in terms of generating bright new ideas to try on difficult resource-management problems. One intangible cost of commercialising CSIRO is that it is proving difficult for its former ethos of values**public service**{xe "values:**public service"**} to coexist with the new commercialism.

The CSIRO reward system no longer looks kindly on people who just want to sit and think and experiment on fairly narrow topics for long periods. This is understandable since in the past there were as many just sitting as sitting and thinking. Unfortunately, it can take quite a long time to tell the difference.

One fallout from this economically sensitised environment is that government scientists are much more reluctant to give casual advice and they seek payment for anything more. More disturbing, data collected at public expense is sold at monopoly prices to other government agencies and to the private sector. As already noted, given the negligible cost of distributing data already on hand, this is inefficient in the extreme. Public data gets seriously under-used under the cost-recovery policies{xe "cost-recovery policies"} which have been thrust on a number of agencies.

Best Bet Scenario

Unless there is a change in the community's perception of the value of fundamental research into the nature and functioning of natural resource systems, CSIRO's natural-resource divisions will become high-class commercial consultants and contractors for short-term projects for resource-based industries and State agencies. Then they will be privatised.

University departments interested in natural resource management are in a position similar to that of CSIRO. Their untied funding is drying up and they are having to pay more of their own way. There is nothing wrong with that in principle; it is a matter of degree. A certain amount of pressure to deliver commercial and practicable results is stimulating. When that pressure becomes overwhelming it is more efficient to convert to a wholly commercial enterprise like Bond University{xe "Bond University"}. The point is that the community almost certainly is under-investing in long-term resource and environmental research, but there are no social technologies for either identifying that balance or moving towards it.

In a radio talk in mid-1989, *Facing Environmental Problems*, Mr Justice Tom Waddell made the point that the things needing to be done (stabilise population, reduce CO_2 emissions, stop deforestation etc.) are fairly clear, but are not seriously acknowledged, analysed or incorporated onto the political agenda in most countries.[88]

His recommendation is for Australia to establish `The Australian Universities Working Party on Environmental Problems{xe "Working Party on Environmental Problems"}'. It would co-operate with CSIRO, Australian Academy of Science, Commission for the Future etc. and include experts in many branches of science, in government, economics, international relations, education, social science and law. He suggests that the recommendations of such a body, representing all Australian universities, would carry enormous weight. Donald Horne of `lucky country' fame has expressed similar ideas. This could be the body to supply the strategic thinking{xe "strategic thinking"} identified above as missing from the Australian institutional scene.

*Ggreen groups{*xe "green groups"*}*
The rise of active urban-based community interest in environmental matters has had many triggers including

* increased real incomes and leisure;

* increased personal mobility;

international group, {xe "Greenpeace organisation"} (40 000 members).[89]

Just how important a political role the social changerole of green groups{xe "social change:role of green groups"} are going to play in coming decades is not yet obvious. Their present status has been likened by Bob Brown to the early stages of the labour movement last century---not yet organised, but strongly based on a widespread fear of the consequences of industrialisation.[90]

While valuesenvironmentalism{xe "values:environmentalism"} is largely, but not exclusively, a middle-class phenomenon, its intrinsic values are neither of the left or the right. Both pollutionsocialism and{xe "pollution:socialism and"} {xe "pollution:capitalism and"} have shown themselves to be `pollution-insensitive' and indifferent to resource degradation and depletion.[91] Locally, the Australian Democrats{xe "Australian Democrats"} have not been able to capture the support of environmentalists despite being more obviously committed to green values than either the Labor Party{xe "Labor Party"} or the Liberal Party{xe "Liberal Party"}.

As an indication of the pressures that will be applied to the political system over the next decade, the Australian Conservation Foundation{xe "Australian Conservation Foundation"}'s plans for this period cover four core issues: climate change{xe "climate change"} (including the Greenhouse effect, ozone depletion and energy conservation), species conservation, natural resources management and environmentally sound technology.

The major issue confronting the environmental movement is one of long-term {xe "social change:strategy of green groups"}. The larger organisations have expanded from fighting environmental `brushfires' to undertaking at least some major serious proactive studies of broader issues, such as John Cameron's recent study of national forestry options, the Mosley-Figgis study of potential World Heritage areas and several studies of the pastoral industry.[92] The larger organisations are also attempting to sit at the same tables as big business, big unions and big government. Consolidating these new directions may be enough for the moment.

Industry groups

In natural resource-management matters, the farmers (National Farmers Federation{xe "National Farmers Federation"}), the miners (Australian Mining Industry Council{xe "Australian Mining Industry Council"}) and the Forestry and Forest Products Industry Council{xe "Forestry and Forest Products Industry Council"}/National Association of Forest Industries{xe "National Association of Forest Industries"} are the most relevant and most powerful industry associations. The tourism and recreation industries are more fragmented and not quite so central to the conservation--development debate. Industry groups have had and are continuing to have great trouble in coming to grips with the environmental movement and changing community values. For a long time they successfully relied on the `jobs and exports' argument to protect development proposals. Their `second front' has been to try and get the environmental impact assessment process set in stone, i.e. environmental requirements for development proposals to be predefined quite explicitly and no `rule changes' for at least some time after a project gets under way.

Council for Conservative Development. The only long-term strategy I can see for social changestrategy for **industry groups**{xe "social change:strategy for **industry groups**"} **is to sit down with green groups in a Council for Conservative Development**{xe "**Council for Conservative Development**"} **and work out joint policies for achieving conservative development, and criteria for identifying which parts of Australia are of high, medium and low priority for each party. If this is not done, there can be no end to the present guerilla war between conservation and development forces.**

This is beginning to be recognised. A recent report from the Basic Metals and Minerals Processing Industry Council{xe "Basic Metals and Minerals Processing Industry Council"} recommends the establishment of a `round table' to facilitate communication and understanding between parties in relation to the environmental approval process.[93] This would be an independent body with representatives fron State and Federal economic and environmental departments, industry, unions, and environmental groups.

natural resource management in Australia is to develop a co-ordinated set of programs around a range of key policy instruments, key land-use sectors and key regions, to actively experiment with these and to monitor the results against explicit, comprehensive goals{xe "**goals**"} **and** {xe "**polic**y"}**ies.**

Think twice; keep thinking

Can the summary be summarised? Probably not, but a rallying cry for what I am advocating might be `Think twice; keep thinking'. That is, think hard and long about where we are going and think hard and long about how to best get there. Then keep thinking.

{xe "social change"}In responding to the challenge of keeping Australia a good place in which to live, we have no alternative, but to try to advance incrementally and adaptively and persistently on many fronts simultaneously. The problems we face are not yet sufficiently threatening to demand desperation measures. It is no good succumbing to fads or to the illusion that after solving one or two pivotal problems with a magic spell it will be cakes and ale all the way to the land of milk and honey. Nor must we restrict the range of instruments we use for solving problems. Finally, we must believe that not only can the job be done, but that it is going to be rewarding and fulfilling to try; that it will be inspiring to both travel and arrive.

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