Chapter 6

Land Resources

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Introduction

The word 'land' has different meanings for different people. For many Australians — including indigenous communities, farming families, conservation workers and others who work daily with the land — 'our land is our life'. For Aboriginal people the landscape not only provides a source of sustenance, but also expresses spiritual beliefs and power relationships. The community takes responsibility to actively care for the land and to fulfil ritual obligations. Many non-Aboriginal people also have a strong personal attachment to the care of particular landscapes. For others, especially the 88 per cent of Australians who live in coastal cities, the land is a more distant entity. Nevertheless, acceptance of the land ethic — that is, our individual and collective responsibility for the stewardship of our land — is widespread in the Australian community.

We make many different uses of our land resource and often the same patch of land can serve multiple uses. We are a small population in a large island country with old and relatively infertile soils and low rainfall. The prevailing vegetation is woodland and shrubland. The land is mainly used for extensive grazing by introduced stock, but we also have significant areas of intensively managed land.

This chapter deals with the environmental impacts of the way we use our land resources, the pressures leading to those impacts and the responses taken to the changing state of the land resources. It incorporates the economic forces that encourage or constrain particular actions and also deals with the impacts on agricultural productivity, because losses in productivity are often associated with off-site impacts and pressures to use more land resources. The approach taken is to describe the condition and, where possible, the trends of each of the major land resources (such as agricultural land, which is dealt with mainly in the section on soils, rangelands and forests). The chapter also deals with the sustainability of recent and current usage.

Pressure

General pressures

Australia's land resources are influenced by a number of factors that the OECD describes as 'general pressures'. These are indirect pressures that affect all aspects of our land use and thus the state of our land resource.

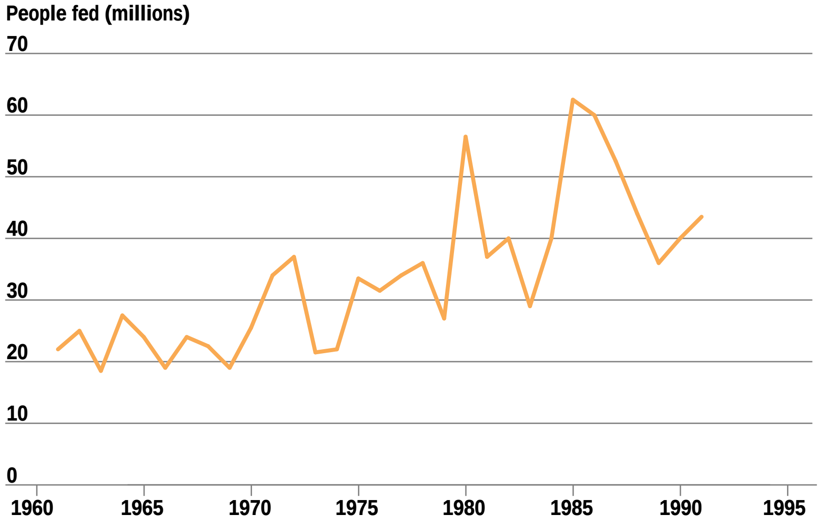
Australia has a much lower population density than most other countries: about two people per sq km compared with a world average of 42. By themselves, these figures suggest that Australians need exert little pressure on their land resource. But this simple estimate hides the true situation. The population is not evenly distributed but is concentrated along the eastern, southern and south-western coasts. More than 80 per cent of us live on only three per cent of the land. Australians enjoy a high standard of living and the country supports more than its own population. For example, we feed the equivalent of about an extra 50 million people with cereals (see Fig. 6.1). We also produce one-third of all the world's wool and more than twice our own meat requirements.

Our arable land totals 467 000 sq km or six per cent of our land surface. By comparison, the United States has 20 per cent arable land, the United Kingdom 26 per cent and Spain 30 per cent. And, despite the low fertility of our soils, we also use less fertiliser than comparable countries — only 0.03 tonne of fertiliser per hectare of arable land, or one-quarter of the rate used in the United States and Spain and one-twelfth of that in the United Kingdom. Thus, the effective population pressure on our land resources is far higher than the simple population density would imply.

Australia is a dry continent with infertile soils and high climatic variability (see Chapter 2). These features themselves do not put pressure on our land resource, but human activities that fail to take them into account do. For example, although we should take account of the cycle of droughts caused by the El Niño–Southern Oscillation in our biological and financial planning of land use, individuals and governments often overlook these in strategic planning, leading to responses in the form of crisis management. Whatever its precise nature, climate change will most likely occur as an increase in apparent climatic variability (see Chapter 5). Australia may be in a better position than most countries to deal with this since we are used to coping with variability and have not only an effective research and development infrastructure but the educational and financial resources needed to change agricultural practices.

A sustainable ecosystem must have a set of species to carry out the essential cycle of production (plants), consumption (animals) and decomposition (mostly micro-organisms). Many species perform specialist roles in these cycles — for example, as decomposers of certain substances, as plants adapted to particular habitats and so on. When an ecosystem loses or gains species, the cycles may be disrupted and pressure exerted on the land resource (see Chapter 4).

Figure 6.1 People fed by Australian cereal exports



Source: World Resources Institute, 1994

The demand for food and fibre imposes general pressures on land resources, which vary depending on production levels and commodity prices. Government actions may exacerbate or relieve the pressures depending on the social and political climate at the time.

Indirect and proximate pressures

Different forms of land-use have a number of indirect and direct (proximate) pressures associated with them.

Agriculture

Most agricultural practices lead to natural vegetation being replaced by plants more suited to the agricultural systems. This occurs either through direct clearing and replacement of native vegetation with crops or pasture species, or through the gradual destruction of native vegetation by overgrazing, by changes in water availability and salinisation, or simply by the failure of the native species to recruit new individuals to replace those that die. Although land clearing was essential if we wished to grow food and fibre, it has opened our land resource to damage by erosion, destroyed soil structure, changed soil chemistry and caused losses of biodiversity and other problems.

Australian soils have very low nutrient contents and much of our agriculture is dependent on inputs of nitrogen, phosphorus and other elements applied as chemical fertilisers or achieved by planting legumes to improve soil nitrogen levels (see page 6-30). For Australia as a whole, the nutrient balance is positive for all the major elements. That is, the natural release of the major elements by weathering, fixation of nitrogen by native and introduced species such as clovers, plus net imports and production of artificial fertilisers amount to a total that exceeds the estimated losses (see Table 6.7). However, on a local level, some areas have a net loss and others a net accumulation. Total fertiliser use per hectare of crops has changed little over the past 15 years. But, the amount of

Intensive agriculture places pressure on the land.

phosphate has decreased while that of nitrogen has increased, reflecting changes in cropping practices and the price relativities (see Fig. 6.2).

Cultivation practices often result in land degradation. For example, mechanical fallowing can lead to wind and water erosion, and repeated cultivation for weed control can cause soil compaction, organic matter oxidation and soil structural decline. Realising this, many farmers have changed land management practices — to include rotations with pasture phases, conservation tillage and stubble retention — and reduced stocking density to maintain ground cover.

Most land-use practices modify the hydrology of the surrounding area either directly or indirectly. A common example is heavy grazing, which can lead to vegetation loss and expose the soil to increased water and wind erosion. Another is land clearing, leading to raised water tables and salinisation. Transport corridors often cause inadvertent but severe changes to water flow. Another pressure arising indirectly from agriculture is the construction of water-storages for stock use and irrigation, ranging in size from small farm dams to major reservoirs. They divert stream flow with subsequent effects on downstream environments and redistribute water for irrigation, which can lead to salinity problems (see Chapter 7).

Pollutants, whatever their source, may kill organisms directly or indirectly by changing the environment. Some pollutants — such as pesticides associated with sites of former sheep and cattle dips — have a point source. Others, such as pesticides or herbicides applied over wide areas of land, or gases such as sulfur dioxide released from industrial areas, are described as having a diffuse source (see page 5-33). On a world scale, Australia releases only a small proportion of pollutants and potential pollutants such as pesticides and herbicides. On a national level, a lack of information on the nature and amounts of the materials being released is a matter of concern. Pollutants can gradually become a problem when very persistent chemicals accumulate, or become concentrated in some biological cycles. Organisms can evolve resistance to previously effective chemicals, so higher dosages or new chemicals need to be applied. Chemical usage on farms is increasing rapidly. For example, in Victoria the area treated with insecticides rose from 80 000 ha in 1983 to 226 000 ha in 1989. Many conservation tillage practices require an increased use of farm chemicals for weed and pest control.

Pastoralism

Pastoralism exerts an indirect pressure on the land resource. Its biggest impact is due to increases in the number of large herbivores — domestic, native and feral. These animals can destroy the vegetative cover and break up the soil surface, exposing it to water and wind erosion (see page 6-26). Pastoralists have greatly increased the number of watering points and in sheep grazing areas reduced the population of dingoes, leading to an increase in the density of kangaroos and the maintenance of high densities of herbivores over more of the landscape than before European settlement. They have also modified fire frequencies (usually decreasing them compared with Aboriginal practices), often leading to changes in the vegetation (see pages 6-8 and 6-9).

Forestry

The Resource Assessment Commission Forest and Timber Inquiry of 1992 assessed the pressures of human activities on forest resources. Pressures arise from our use of forests as sources of wood products and for grazing, recreation, conservation and water-catchments. The Inquiry identified areas of concern including: impacts of logging operations on populations of forest flora and fauna, soil compaction and erosion, stream siltation and reduced water quality, and the effects of changed fire regimes in all forests. Its report concluded that human use of forests, including some wood-production activities, affects the habitats and population sizes of some forest-dependent species and increases the risk of invasion by exotic species. However, there was no evidence that these risks posed an immediate threat to the ecological processes on which forest systems depend.

The report highlighted the availability of only a very small amount of scientific information about forest impacts, reflecting the lack of basic research and effective monitoring of many of our land resources.

Mining

Numerous mining sites and petroleum fields occur across Australia (see Fig. 6.3) but the land area they actually occupy is very small (less than 0.01 per cent). Some sites are affected by land clearance and pollution or waste disposal, but the most widespread effects are associated with roads and infrastructure that provide access to remote areas surrounding prospecting leases and mining towns. The major controversies over land use for mining occur where mining priorities coincide with sites of high biodiversity or cultural significance.

Human habitation

Although Australian cities and towns occupy only 0.01 per cent of the continent, this area is concentrated in our most important catchments and often on high-value agricultural land. Urban fringe development and coastal development often compete with agricultural and conservation land uses. The impact of human habitations extends far beyond the area cleared for buildings and infrastructure (see Chapter 3).

The tendency for city-dwellers to acquire land for rural retreats or hobby farms has brought about major changes in land use around many cities. These changes can have both positive and negative effects on land and related resources. Hobby farmers often have off-farm incomes that can support improvements such as fencing, weed control, tree-planting, erosion-control measures and improved pastures. Negative effects may include pollution of surface and groundwater by septic effluent, soil erosion through overstocking and destruction of habitats by clearing. Hobby farms in the Adelaide Hills and around Canberra present contrasting examples. While the former have reputedly increased turbidity of urban water supplies through erosion caused by overstocking with horses, the latter have reduced land degradation through increased tree-planting.

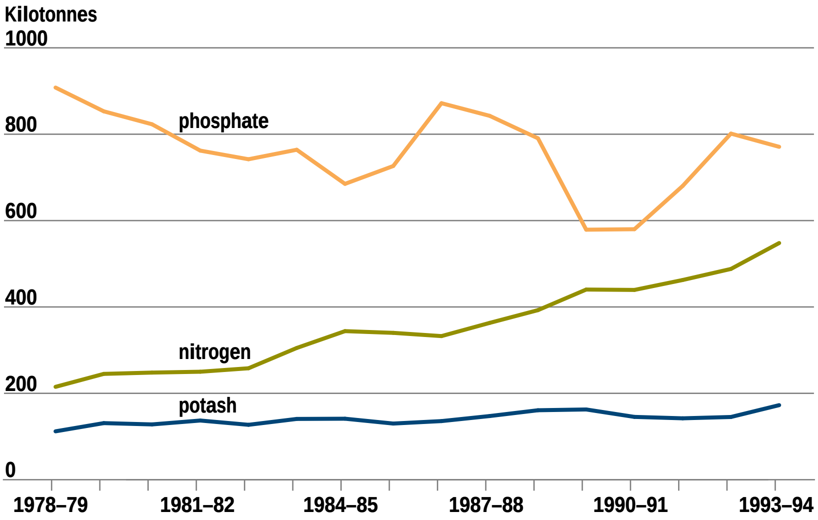
Tourists may exert pressure on our land resources (see Chapters 4 and 9). In some places (for example, alpine areas in Kosciusko National Park), concern about camping wastes and trampling pressure of numerous tourists has led to steps to control access by camping restrictions and the use of raised footpaths. In Tasmania there is evidence that fires are more frequent along popular tourist routes and concern that tourists may significantly increase the spread of weeds and diseases.

Corridors for roads, railways, pipelines and powerlines open up access and bring tourists, development, grazing animals, weeds and pests. They can also modify water flows and act as barriers to the movement of native organisms (see Chapter 4). In some areas, corridors are less than a kilometre apart and on a State by State basis separation varies from an average of 1.5 km in Victoria to 71 km in the Northern Territory.

The loss of traditional Aboriginal land-management practices, particularly burning, has led to changes in vegetation. Fire management can be traced through several phases:

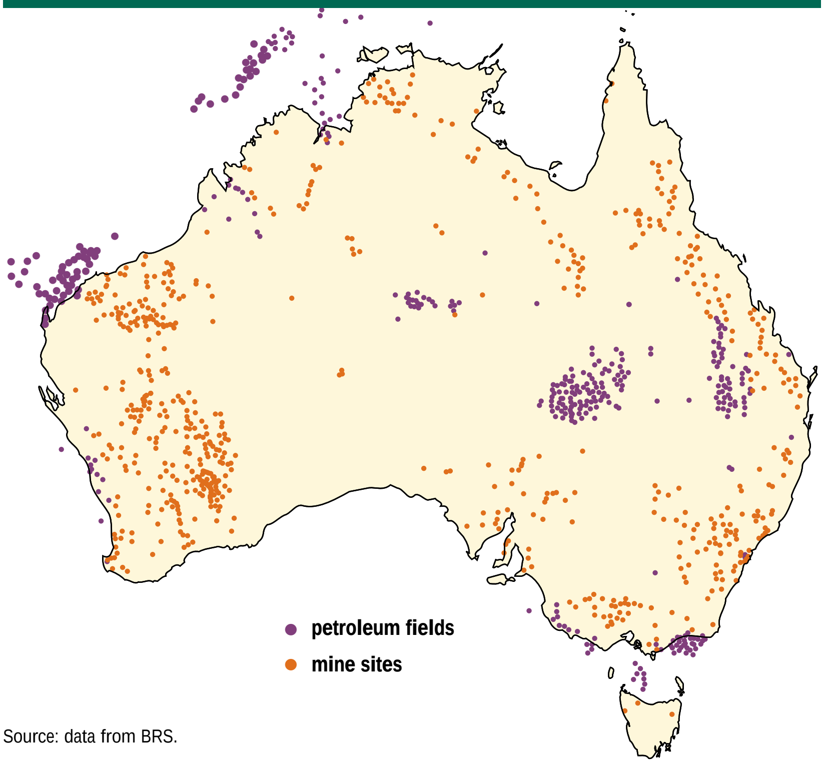
- Long-established patterns of burning under Aboriginal management modified the vegetation, but over tens of thousands of years it reached a new equilibrium.
- After European occupation, periods of reduced burning often occurred as Aboriginal practices were lost. These were usually followed by a period of frequent and intense burning during a clearing and settlement phase.
- The new occupants attempted to protect their investment in fencing, buildings, pastures and forests by suppressing fires, but fuel loads built up, leading to years of major bushfires.

Figure 6.2 Australian fertiliser consumption



Source: data provided by ABARE, 1995.

Figure 6.3 Distribution of major mine sites and petroleum fields (past, present or potential)

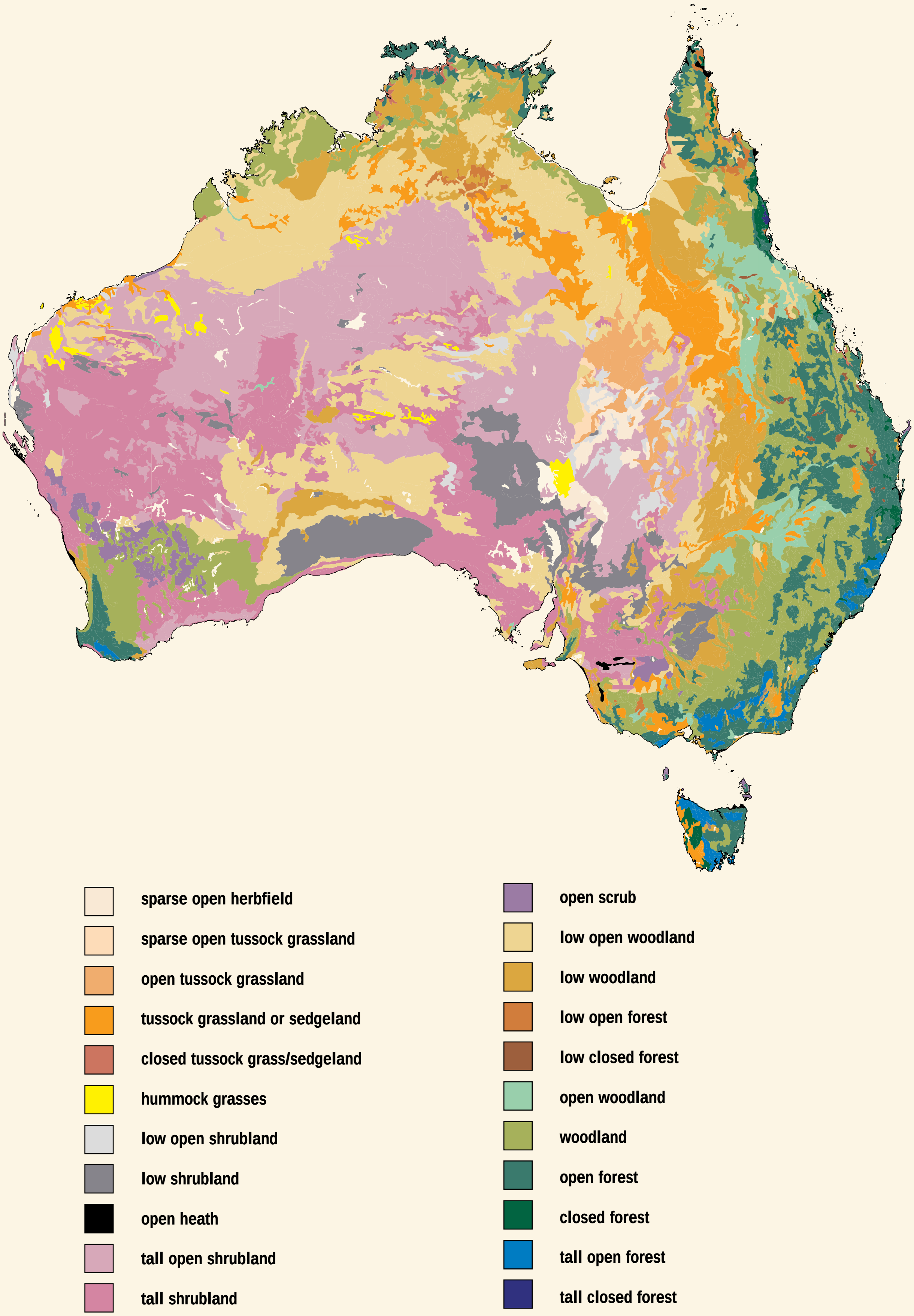


Source: data from BRS.

- In many areas prescribed burning regimes have been introduced — in some places these are designed to reflect Aboriginal practice (although they may no longer necessarily be appropriate in the modified vegetation).

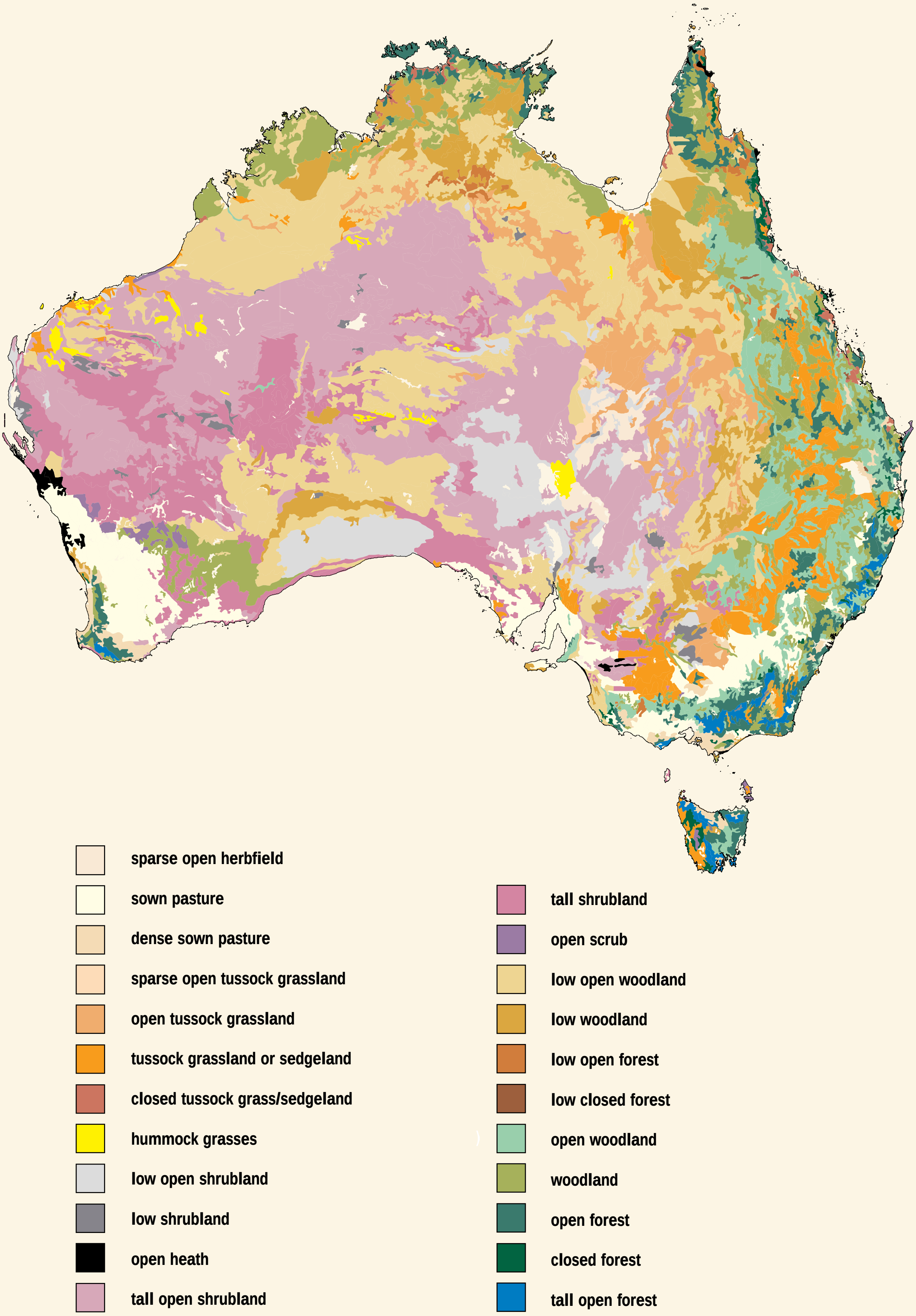
Each of these fire regimes changed the vegetation, animals and even soils. Although the amount and nature of change varies from place to place, it is clear that changes in fire management have imposed significant pressures on the biota and soils.

Natural vegetation (1788)



Source: AUSLIG, 1991.

Present vegetation (1988)



Source: AUSLIG, 1991.

State

This section emphasises some of the more important aspects of the state of our land resources. Land cover, for example, is important for describing the condition of the land resource, since it both moderates the effects of weather on the land surface and reflects the impact of disturbances. Major variations in land cover warn of some potentially significant changes in the state of the land itself. Other changes may be reflected not by variations in the amount of cover but in more subtle shifts in the balance of certain plant types. These and related changes are discussed under the heading of changes in land condition. The condition of the soil, which underlies the ecological integrity and productivity of land resources, is described in some detail. Many of our responses to the state of land resources are reflected in changes in land use. Thus, this section finishes with a brief summary of current land uses and land tenure, and trends over the past decades.

Changes in land cover

The term 'land cover' refers to the physical state of the land surface and includes vegetation, soil, rock, water and man-made structures. Land cover is the interface between the earth's crust and the atmosphere, influencing the exchanges of energy and matter in the climatic system and the biogeochemical cycles. Land cover changes can affect a wide range of processes — such as the movement of nutrients through plants, soil, water and the atmosphere, emission of greenhouse gases and the movement of soil and water within catchments (see Chapter 7). They can also have major consequences for living organisms; for example, clearing of vegetation can result in an organism with a very limited distribution becoming extinct (see Chapter 4).

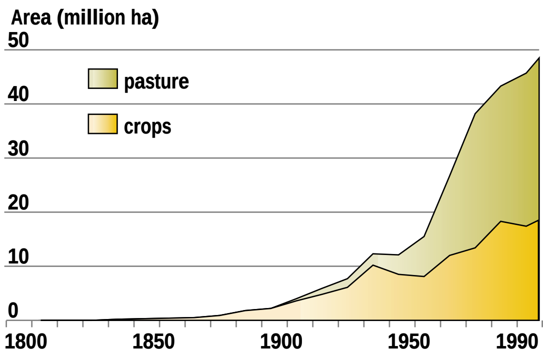
Vegetation covers most of Australia. There is little bare soil apart from the three per cent of the continent that is fallow prior to cropping. In the arid zone, vegetation cover may be sparse in some seasons. Surface waters, including salt lakes, occupy some three per cent of the continent (Cocks, 1992). Australia's vegetation cover when Europeans arrived and that prevailing 200 years later are shown on pages 6-8 and 6-9.

Management practices affecting land cover

Some of the management practices affecting land cover include expansion and intensification of cropping, grazing practices, commercial forestry, mining and urbanisation.

In the 1950s and 1960s, long periods of high prices for many rural commodities and general national growth led to an expansion and intensification of farming (see Fig. 6.4). Intensification resulted in substantial clearing of remnant stands of trees on grazing properties to develop sown pastures. In some wheat-growing regions — such as south-west Western Australia, the mallee wheat lands of South Australia and the wheat belt of central New South Wales —

Figure 6.4 Area of crops and sown pastures 1800–1995



Source: ABS Yearbooks.

expansion and intensification of cropping activities have resulted in major changes to land cover (see Fig. 6.5). Less than 20 per cent of the native vegetation remains in these regions.

Lands used for grazing comprise predominantly woodlands, open woodlands and shrublands. Only a small proportion of grazed land is true grassland, although tussock and hummock grasses form an understorey over very extensive areas. As well as clearing, landholders have thinned trees to promote grass growth, by ringbarking and more recently by using chemicals, over large tracts in the high-rainfall and semi-arid zones. Little thinning has occurred in the arid zone although pastoralists lop scrub, particularly mulga, in the arid and semi-arid zones of eastern Australia to provide drought feed for livestock. Overgrazing of chenopod shrublands by livestock and rabbits has prevented seedling regeneration, which, in conjunction with periodic wildfire, has resulted in the conversion of extensive areas to grasslands and herbfields. In the semi-arid and arid woodlands and shrublands, thinning of perennial grasses due to overgrazing by livestock, and to some extent rabbits, kangaroos and feral goats, together with a reduction in fire frequency, has resulted in an increase in native and exotic woody species or 'woody weeds'.

Overgrazing of grasslands in the semi-arid zone has resulted in some thinning of Mitchell grass communities, and in some instances conversion of grassland to herbfields, although most of these grasslands remain relatively intact. The expansion of exotic and native woody species poses a serious problem. In the tropical woodlands, native grasses are generally of low quality from a pastoral perspective. In the past, this, together with the use of British breeds of cattle (*Bos taurus*), which need relatively high-quality diets, limited the grazing pressure on these communities. The introduction of hardier *Bos indicus* cattle and the use of urea and molasses supplements around watering points have allowed much higher grazing pressures, and consequent degradation of sensitive areas. In southern Australia the temperate native grasslands have largely disappeared, replaced by cereal crops and introduced pasture species.

Commercial forestry involves harvesting and removal of some or all of the land cover in a given area. Each year about 200 000 ha or one per cent of the native forest available for logging is harvested and undergoes various regeneration practices. Additionally, about 30 000 ha of new softwood and over 10 000 ha of new hardwood plantations are established annually — mostly on land previously cleared for agriculture. Historically, harvest operations have ranged from clearfelling, which removes all the timber in a coupe or patch ranging in size from 10 to 300 ha, to various forms of selective logging, which removes part of the existing growing stock at each harvest to create a stand of trees with a range of ages and sizes (see Fig. 4.3). Clearfelling is the most common method of harvesting in the wet sclerophyll forests of Tasmania, Victoria and Western Australia, the drier forests of south-eastern New South Wales and lower-elevation mixed forests in Victoria (RAC, 1992). No estimates are available of the areas of forest clearfelled in the past or the current annual rates of clearfelling. This practice, which is usually followed by burning of the wood debris to provide an ash bed for seedlings, results in a temporary loss of land cover until natural regeneration occurs or the coupe is replanted or direct-seeded. Clearfelling is often modified by leaving a number of trees for environmental protection or conservation. The site is seldom reharvested until the trees have reached a commercially valuable size — usually after 60 to 120 years.

Selective logging operations harvest part of the growing stock, repeating the harvest at relatively short intervals (decades), resulting in regular regeneration of seedlings. Practices range from single-tree selection to 'heavier' selective logging, where groups of trees are removed. Variants of the systems are used in the forests of Queensland and northern New South Wales, the jarrah forests of Western Australia and some mixed forests of Tasmania and Victoria.

Mining was responsible for destroying local land cover, as smelting was often done on the spot to reduce the bulk of the material to be transported. For example, miners stripped the timber around the Kapunda, Burra and Wallaroo/Kadina copper mines in the 1840s–'60s, around Broken Hill in the 1880s–'90s and around Zeehan, Mt Lyell and Mt Bischoff in western Tasmania in the early 1890s. The activities of gold-miners also laid waste to large areas of woodland — around Kalgoorlie and Coolgardie among others (Williams, 1988).

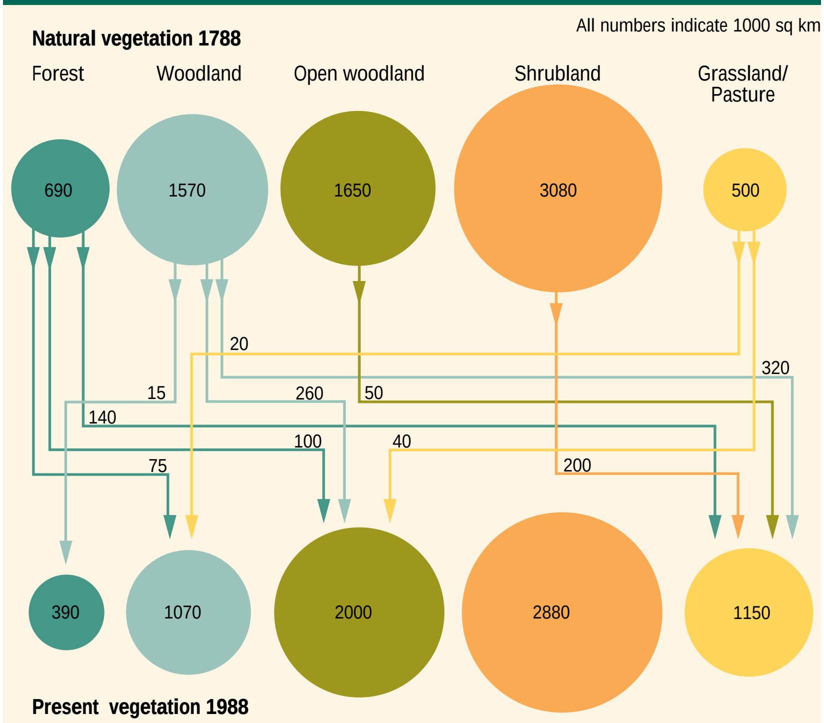
Although the growth of cities has only affected land cover over a small area, most of the urbanisation has occurred around the coast, sometimes in regions of high biological diversity. Patterns of clearance are usually influenced by slope and elevation, resulting in disproportionately high impacts on the vegetation of gentler slopes and coastal plains. For instance, in coastal south-east Queensland between 1974 and 1989, 33 per cent of the remaining bushland was cleared, predominantly for residential development but also for some plantation forestry and sugarcane production (Catterall and Kingston, 1993).

Land cover change 1788–1993

In 1788 forests covered almost nine per cent of Australia (see Fig. 6.5). Woodlands and open woodlands each covered about 21 per cent, while shrublands — including acacia and mallee eucalypts, heaths and saltbushes — occurred across 40 per cent of the continent. About seven per cent of the continent's surface was grassland (that is, grasses without an overstorey of woody vegetation) and less than one per cent was unvegetated. By the 1980s, about 175 000 sq km of forest had been thinned to woodland or open woodland, and a further 140 000 sq km cleared mainly for grazing, leaving about five per cent of the continent forested. Some 260 000 sq km of woodland were thinned to open woodlands and a further 320 000 sq km cleared for pasture and cropping as well as 50 000 sq km of open woodland. Altogether, clearing led to a decrease in the area of woodland, from 21 to 14 per cent, and a four per cent increase in that of open woodland. While the proportion of shrublands cleared (mostly mallee) has been relatively small (three per cent), about 20 per cent has been thinned. Grasslands now cover almost 16 per cent of the continent, the major changes being an increase of three per cent in the tussock grasslands and a six per cent cover of sown pasture grasses. Eight per cent of the native grassland present in 1788 has become open woodland.

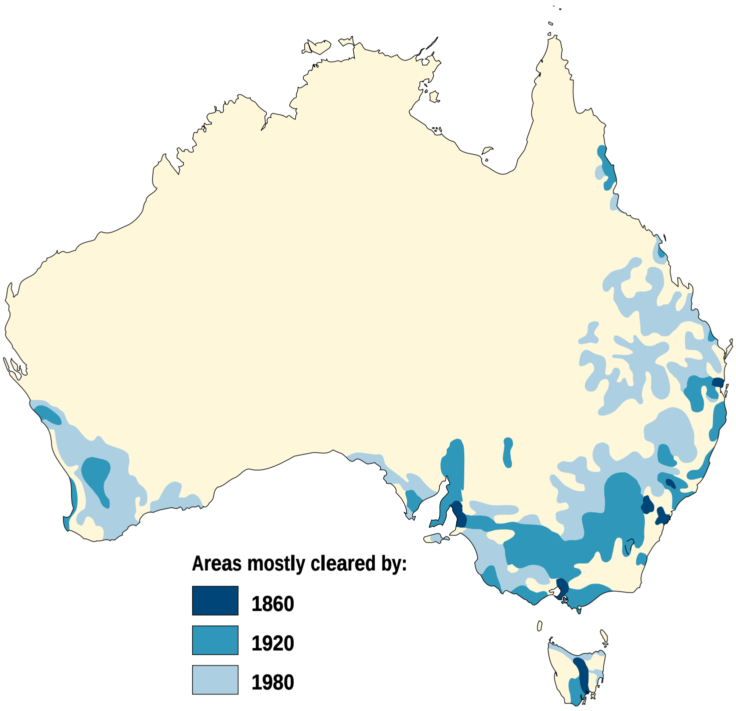
Some people believe that the reduction in burning, which occurred as European settlers displaced Aboriginal people, resulted in extensive eucalypt regrowth and a subsequent expansion of the area of forest and an increase in its density. Anecdotal reports suggest that these changes took place in the

Figure 6.5 Land cover change by major vegetation type 1788–1988



Source: AUSLIG, 1990.

Figure 6.6 Timing of vegetation clearance since 1788



Source: derived from AUSLIG, 1990.

Table 6.1 Estimated rates of clearing on agricultural land 1983–1993

Sources of data used to estimate clearing 1983–93	*Estimated area cleared* Average 1983–93 (sq km)	1990 (sq km)
ACT		
1983–93[1]	0	0
New South Wales		
1983–93[1]	1500	1500
Northern Territory		
1983–91[2] 1992–93[3]	163	163
Queensland		
1983–93[4]	3000	4500
Victoria		
1983–88[5#]1989–93[3]	78	62
South Australia		
1983–93[3]	116	45
Tasmania		
1983–88[6#]	60	60
Western Australia		
1986–89[7] 1990–93[3]	260	311
Total		**6640**

Notes: Estimates based on:
1. Professional opinion
2. Department of Lands, Housing and Local Goverment records
3. Clearing permit data (Estimates of clearing based on the area for which permits have been granted are uncertain as the clearing may not have been done and illegal clearing may have occurred)
4. Survey of clearing contractors
5. Woodgate and Black, 1988
6. Kirkpatrick, 1991
7. Kestel Research and Victorian DCE, 1990

#. Figures based on remote sensing of land cover change

Source: adapted from DEST, 1994.

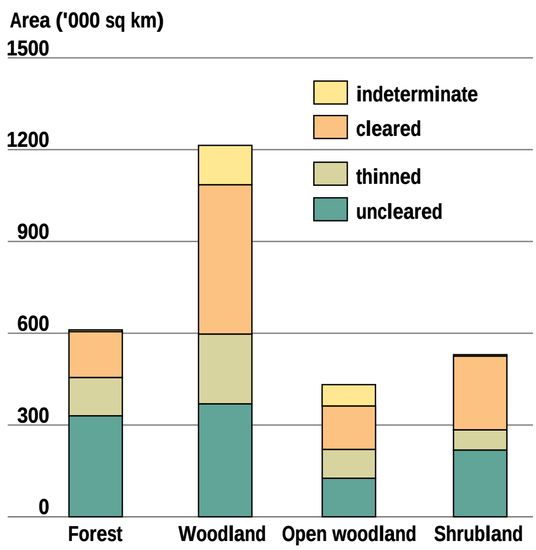
Victorian Wimmera and right across Gippsland, particularly after heavy rains in the early 1860s and 1880s and in northern New South Wales (the Pilliga forest). The extent of this regrowth is not known. More recently, increases in the density of woodlands in central and south-west Queensland managed for pastoralism have been attributed to increased grazing pressure and reduced burning.

Until recently, many people believed that the last major clearing for agriculture occurred in the 1970s and that relatively little had taken place since (see Fig. 6.6). However, a recent review undertaken for the National Greenhouse Gas Inventory (DEST, 1994) suggests that annual rates of clearing over the last 10 years could be greater than 5000 sq km (see Table 6.1).

ABARE's 1994 survey of broadacre and dairy farms asked farmers how much forest and woodlands they intended to clear in the next five years. At the national level, the response was about 3.28 million ha between 1994–95 and 1998–99 — equivalent to about 6500 sq km a year, and close to the estimated national rate of clearing for 1990 (see Table 6.1). Most of this intended clearing was expected to occur in Queensland (ABARE, 1995). Recent changes in that State (see Table 6.8) will influence the extent of any future clearing.

Researchers (Graetz *et al.*, 1995) have assessed the extent of clearing or thinning of major vegetation types in eastern Australia, south-west Western Australia and the Top End using low-resolution satellite data (see Fig. 6.7). By 1991, about 35 per cent of Australia's vegetation within this region had been cleared and 17 per cent thinned. About 36 per cent is largely unaffected, while the remaining 12 per cent could not be assigned to either category. It is unlikely that these estimates include the smaller-scale clearing of remnant vegetation.

Figure 6.7 Status of vegetation in the regions used for agricultural production in 1991



Source: Graetz, pers. comm.

Changes in land condition

Land condition may be likened to the 'health' of the land, but how it is assessed depends on what the land is being used for. The condition of agricultural land, for example, is judged by its potential for production, which in turn depends largely on the state of the soil. The state of Australian soils is discussed in detail in a later section. The condition of remnant native vegetation within agricultural areas is usually assessed with reference to its 'pristine' state or, in other words, to its conservation status. People often equate it with the degree of change in structure or species composition. The presence of remnant vegetation may contribute in some degree to the productive potential of the surrounding agricultural land, by providing shelter for stock or by harbouring useful insects or predators of pests, but this contribution is largely unknown for Australian agricultural systems. Rangelands can be evaluated in many ways since they support a diversity of uses. The most common commercial use is pastoralism and so current assessments focus on productive potential. Range condition in this sense depends on the status of both vegetation and soils, and is discussed in greater detail below (see page 6-14).

Agricultural lands

About six per cent of the continent is now used for broadacre cropping (predominantly cereals), intensive grazing of sown pastures, intensive horticulture and field crops such as sugarcane and cotton. Development of the wheat–sheep zone (see Fig. 6.8) resulted in large-scale conversion of native land cover to agricultural land cover. In the high-rainfall region, forests and woodlands have been replaced by pastures sown for dairying, sheep and beef production as well as for cropping. However, substantial areas remain uncleared, particularly on more rugged terrain.

Clearing for agricultural development has been very selective, with the vegetation types occupying the better soils and gentler slopes being used first. As a result, many land cover types are now severely under-represented in remaining vegetation. For example, 85 per cent of Victoria's box–ironbark forests and woodlands have been cleared. Those remaining are located mainly on rocky areas, upper slopes, poorer soils or periodically inundated floodplains (Bennett, 1993).

Today, in the more intensively used grazing and cropping lands, remnants of the native land cover occur as isolated, uncleared patches or narrow strips along roadsides. The condition of the remainder is of considerable concern. Some remnant vegetation is now dying through old age, and is not being replaced because of poor seedling regeneration due to grazing by livestock or rabbits or competition from introduced pasture grasses. Invasion of weeds and fertiliser drift from adjacent agricultural lands will also affect the condition of patches of remnant vegetation.

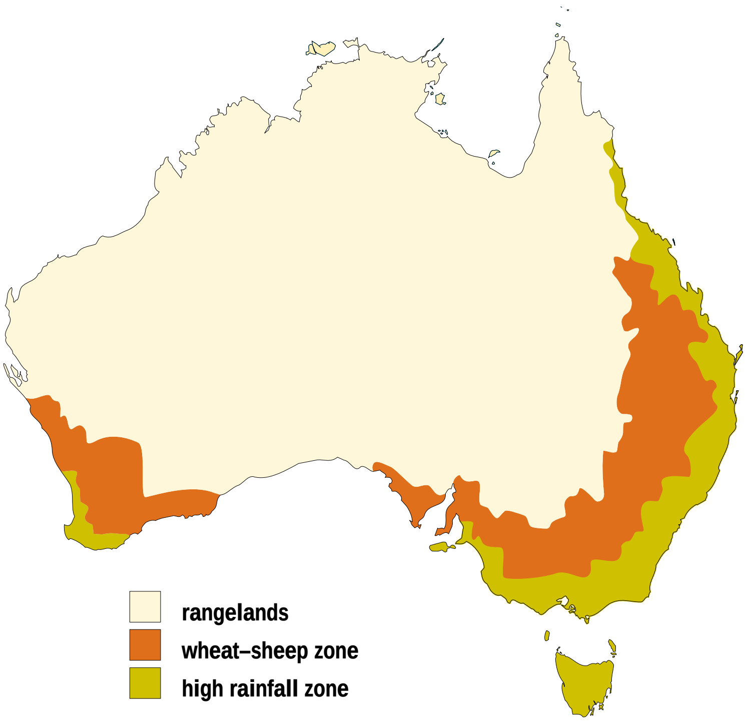
Implications of clearing for greenhouse gas emissions

Australia, as a party to the United Nations Framework Convention on Climate Change, is required to prepare an inventory of greenhouse gas emissions. The inventory is prepared using an internationally agreed method developed by the Intergovernmental Panel on Climate Change. Using this method, several land use changes that can modify carbon dioxide fluxes between the terrestrial biosphere and the atmosphere were identified — including clearing for agriculture. These fluxes were calculated from estimates of the areas of vegetation cleared over the last 10 years (see Table 6.1) and the likely carbon content of this vegetation (about half the dry weight of this vegetation is carbon) and the soils below. The results suggested that land clearing may be contributing up to 27 per cent of total greenhouse gas emissions. However, the limited amount of information available on rates of clearing, the type of vegetation cleared and the effect of regrowth on carbon fluxes means that such contributions could be anywhere between seven per cent and 45 per cent of total emissions.

Since the mid '60s reports of premature tree decline or 'rural dieback' have been frequent. This affects many species and all ages of trees, and has been reported in most States. The condition is particularly severe in areas used for intensive livestock production and has a long list of possible causes. They include not only direct effects of pastoral management — such as fertiliser application, the introduction of exotic pasture species and damage from livestock and machinery — but more indirect changes in the quality of soil and water resources, as well as increases in the populations of tree-defoliating insects. In most regions it is likely that dieback has multiple causes.

Large-scale clearing for agricultural purposes has occurred mostly on the better soils and gentler slopes.

Figure 6.8 Location of the major agricultural zones



Source: ABARE.

Rangelands

Rangelands occupy about 75 per cent of the Australian continent, or approximately 6 million sq km (see Fig. 6.8). About 46 per cent is shrubland and 42 per cent woodland or open woodland. Tussock and hummock grasslands cover only about nine per cent of the rangelands, although grasses occur as an understorey over a further 68 per cent.

Most of the rangelands are leasehold and administered by State agencies, with only small areas privately owned (freehold). Extensive areas remain vacant Crown land. No nationally coordinated data-collection and reporting procedure exists for monitoring the vegetation and soil resources of these lands, although one is being developed. Consequently, their condition, and changes in condition, cannot be reported from a single set of national figures.

Nevertheless, it is widely accepted that rangelands have been degraded by the grazing pressure of domestic livestock, feral animals (such as goats and rabbits), and the increase in population of some native herbivores, particularly the larger kangaroo species, which in some areas has accompanied pastoral development.

Evidence for such degradation may be found in the historical pattern of livestock numbers typical of many semi-arid and arid areas. Livestock numbers commonly rise to a peak some years after settlement, crash during a period of severe drought and fail to recover to pre-drought levels (see Fig. 6.9). Stocking rates during the early years of pastoral development were generally unsustainable and the interaction of unfavourable seasonal conditions with grazing pressure undoubtedly caused much change. Rangelands in many areas still reflect these impacts. However, overall Australian rangelands are not extensively 'desertified', despite the changes.

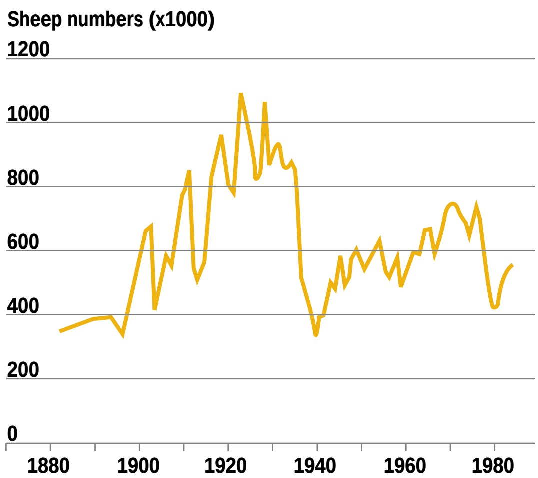
The term range condition is used to describe the state of their vegetation and soil. The meaning of this term has been the subject of considerable controversy. Historically, attempts to assess range condition as a basis for management of grazing land have been either ecologically or productivity based. The ecological approach measures condition by the change in species composition from the original vegetation (Dyksterhuis, 1949). An assessment based on productivity defines the productivity of the landscape for its current use (Humphrey, 1949). Both concepts require that assessments are made relative to some ideal state that is specific to each type of land, and are not influenced by short-term seasonal conditions.

Australian usage has generally favoured the productivity approach, either implicitly or explicitly. However, the uncertainty in the relationship between assessed range condition and animal production requires a degree of caution in interpreting survey results. The emphasis on pastoral productivity means that the available data are of limited value in defining other aspects of land condition, such as conservation status.

Recently, a radically different approach to rangeland assessment has been proposed, based on the capacity of the landscape to produce cover in response to rainfall (Pickup, 1989). This method has so far been used successfully only in central Australia. Virtually all other published data are based on assessment of the landscape as a pastoral resource, except where particular forms of land degradation (for example, rilling, sheet or gully erosion) are described.

To date surveys have been conducted over about 51% of the rangelands which includes most of the pastoral lands. In all survey regions most of the land is assessed to be in fair to good condition, with only a relatively small proportion considered

Figure 6.9 Sheep numbers in the rangelands of the West Gascoyne region of WA



Source: Payne *et al.*, 1987.

to be in poor condition or unrecoverable by normal property management. Where assessed, areas of severe degradation and erosion, which are probably unrecoverable, amount to no more than 2.3 per cent of the land surface. However, Wilcox and McKinnon (1972) believed that a considerably larger proportion (about 15 per cent) of their survey area required removal of grazing to prevent irreversible degradation. Throughout the Australian arid zone as a whole, about 4.4 per cent of the land used for pastoralism was estimated to exhibit vegetation degradation and severe erosion in l975, with an additional 8.5 per cent showing vegetation degradation and substantial erosion (DEHCD, l978).

Regional differences occur in range condition (see Table 6.2). The arid zone of Western Australia, the

Table 6.2 Results of regional rangeland condition surveys

Survey region	Reference	Survey area (sq km)	% severely degraded & eroded	% of survey area Good* or A**	Fair* or B**	Poor* or C**
Western Australia						
Gascoyne*/***	Wilcox and McKinnon, 1972	68 700	1.9#	6	65	29
Carnarvon Basin*	Payne *et al.*, 1987	74 489	0.9	45	32	23
Murchison*/***	Curry *et al.*, 1994	85 890	1.8	21	37	42
NE Goldfields*/***	Pringle *et al.*, 1994	110 570	0.4	39	33	28
Nullarbor*/***	Mitchell *et a*l, 1988	47 400	0	50	10	40
West Kimberley*/***	Payne *et al.*,1979	89 600	2.3#	19	51	30
West Kimberley**	Tothill and Gillies, 1992	127 270	N/A	73	19	7
Ashburton* (Alienated land)	Payne *et al.*,1988	61 128	0.9	64	27	9
Roebourne Plains*	Payne and Tille, 1992	10 200	2.3	51	27	22
Pilbara	Tothill and Gillies, 1992	264 740	N/A	79	19	2
North Kimberley	Tothill and Gillies, 1992	88 950	N/A	84	15	<1
East Kimberley	Tothill and Gillies, 1992	73 370	N/A	55	35	10
Northern Territory						
Darwin	Tothill and Gillies, 1992	18 550	N/A	91	6	3
Gulf	Tothill and Gillies, 1992	101 960	N/A	96	4	0
Barkly Tableland	Tothill and Gillies, 1992	150 520	N/A	79	15	6
Victoria River District	Tothill and Gillies, 1992	130 450	N/A	94	6	<1
Central Australia	Condon *et al.*,1969***	140 595	N/A	48	44	9
	Condon *et al.*,1969*** excluding spinifex dunes and plains	86 179	N/A	27	59	13
				##%PL<5	%PL 6–15	%PL >15
	Bastin *et al.*, 1993	34 263	N/A	75	21	4
	Bastin *et al.*, 1993 excluding spinifex dunes and plains	19 506	N/A	57	36	7
Queensland (compiled from data of Tothill and Gillies provided by the Meat Research Corporation)						
Burdekin (AER 23; 75%)		65 060	N/A	47	34	18
Nth Qld Tableland (AER 25; 100%)		8 060	N/A	67	27	6
Central West & Gulf (AER 26;100%)		353 559	N/A	56	34	10
Cape York (AER 27; 100%)		209 896	N/A	44	41	14
Marraki-Arnhem Land (AER 29; 30%)		41 230	N/A	74	21	5
Maranoa/Warrego (AER 40; 36%)		91 070	N/A	23	52	25
Channel country (AER 43; 60%)		296 042	N/A	36	44	20
South Australia						
Kingoonya Soil Con.Board.*/***	Anon., 1991	65 815	N/A	43	27	30
New South Wales						
Western Division	Soil Con. Service of NSW, 1988	325 000		Nil–Minor	Moderate	Severe
Woody Shrub Infestation				62.4	27.3	10.3
Sheet and Rill Erosion***			N/A	99.9	0.1	0
Gully Erosion***			N/A	91.1	7.4	1.5
Scalding			N/A	81.4	17.4	1.2

Notes:
* Range condition classes from surveys marked*
** Degradation classes from Tothill and Gillies, 1992; A — sustainable, B — deteriorating; C — degraded
*** Amalgamation of classes, or change of class names, from original survey; data for Condon *et al.* refer to watered area only
\# Estimate only, not mapped
\## % Productivity Loss Index for Bastin *et al*, 1993
AER Agro-ecological region after Australian Agricultural Council, 1991. Percentages indicate the proportion within the Queensland rangelands
N/A Not available

Table 6.3 Condition of major vegetation types in the rangelands

Vegetation type	Survey area	Derived from	Survey area (sq km)	% of survey area Good/A	Fair/B	Poor/C[1]
Chenopod shrublands[2]	Nullarbor	Mitchell *et al.*,1988	46 856	50	10	40
	Murchison	Curry *et al.*, 1994	15 313	26	30	44
	Gascoyne	Wilcox and McKinnon, 1972	16 123	5	63	32
	NE Goldfields	Pringle *et al.*, 1994	16 881	50	28	22
	Ashburton	Payne *et al.*,1988	8 231	26	42	32
	Carnarvon Basin	Payne *et al.*,1987	12 750	35	30	35
	Kingoonya Soil Con. Board, SA	Anon., 1991	38 870	55	25	20
Mitchell grasslands	West Kimberley	Tothill and Gillies, 1992	12 190	60	30	10
	Barkly	Tothill and Gillies, 1992	68 190	78	16	6
	Victoria River District	Tothill and Gillies, 1992	12 680	71	29	<1
	Qld - Rolling downs (north)	Tothill and Gillies, 1992	208 830	70	25	5
	Qld - Stony downs	Tothill and Gillies, 1992	26 320	30	50	20
	Qld - Ashy downs	Tothill and Gillies, 1992	24 110	30	50	20
Acacia woodlands/shrublands	Gascoyne	Wilcox and McKinnon, 1972	34 630	9	68	23
	Ashburton	Payne *et al.*,1988	28 120	63	31	6
	NE Goldfields	Pringle *et al.*, 1994	39 596	33	37	30
	Murchison	Curry *et al.*, 1994	64 827	22	39	39
	Carnarvon Basin	Payne *et al.*, 1987	41 954	40	39	20
	SW Qld - mulga[3]	Tothill and Gillies, 1992	183 580	20	50	30
	W Qld - gidgee	Tothill and Gillies, 1992	8 040	70	20	10
	SW Qld - gidgee	Tothill and Gillies, 1992	9 400	20	35	45
	W Qld - Georgina gidgee	Tothill and Gillies, 1992	15 980	70	20	10
	Kingoonya Soil Con. Board, SA	Anon., 1991	15 180	20	30	50
Perennial tallgrass pastures	Darwin, NT	Tothill and Gillies, 1992	1 450	40	40	20
	North Kimberley	Tothill and Gillies, 1992	10 700	78	21	1
	East Kimberley	Tothill and Gillies, 1992	2 130	29	44	27
	West Kimberley	Tothill and Gillies, 1992	3 600	85	10	5
	Cape York	Tothill and Gillies, 1992	9 280	90	5	5

Notes:
1. Amalgamation or renaming of condition classes as for Table 6.2 A (sustainable), B (deteriorating) and C (degraded) refer to classifications of Tothill and Gillies, 1992
2. Includes communities in which chenopod shrubs form a mid storey
3. Includes hard and soft mulga, mulga on residuals and mulga-whitewood

The vegetation types listed are derived from the survey reports and do not correspond to Carnahan's 1990 classification.

Cape York and Burdekin regions of north Queensland, and the Maranoa/Warrego and channel country regions of south-west Queensland are more severely affected than elsewhere. The degradation in south-west Queensland extends into New South Wales and north-east South Australia (Woods, 1983), but a lack of comparable data makes comparison difficult.

Regional assessments generally disguise considerable local variability in land condition. A common finding in rangeland surveys is that those land types or vegetation communities with the highest potential for pastoral production (for example, creek and river frontages) are the most severely degraded. These are frequently the most accessible for livestock and are generally well supplied with watering points. They are also generally limited in area, and surrounded by much larger tracts of less-productive country, so they receive preferential use. Thus, the implications of rangeland degradation for total pastoral productivity may be greater than the regional assessment figures indicate.

Examination of the condition of major vegetation types (see Table 6.3) shows that: extensive areas of Mitchell grassland remain in good condition; perennial tallgrass pastures in the higher-rainfall areas of the west Kimberley, north Kimberley and Cape York are also generally in good condition; and the chenopod and acacia communities in the arid zone with winter or non-seasonal rainfall show the most severe degradation. However, all vegetation types display wide variation in condition between survey areas and few generalisations are possible.

Trends in rangeland condition

Although it is not possible to present a comprehensive account of the trends in rangeland condition on a national basis, some regional trends can be shown. Comparison of data from surveys of the west Kimberley region (Payne *et al.*, 1979;

Tothill and Gillies, I992) and evidence from long-term photographic monitoring sites (WA Dept of Agriculture, unpublished data) strongly suggest that rangelands in this region have improved over the period 1972–91. The improvement can be attributed to the reduction in stock numbers and improved stock control associated with both the Brucellosis and Tuberculosis Eradication Campaign and changing markets for cattle, together with control of feral donkeys by aerial shooting.

A similar comparison in Queensland (Weston *et al*., 1981; Tothill and Gillies, 1992) suggests that both positive and negative trends have occurred over the period 1978–80 to 1991. Of 21 rangeland pasture communities, six appear to have remained relatively stable (albeit in some cases in poor condition), eight have apparently improved in condition and eight have deteriorated. Generally the improvements have been relatively minor while the downward trends are often marked. Part of this deterioration may be attributed to the encroachment of exotic weeds, such as *Parkinsonia*, prickly acacia (*Acacia nilotica*) and mesquite (*Prosopis* spp.) in the Mitchell grasslands, and rubber vine (*Cryptostegia grandiflora*) and chinee apple (*Zyziphus mauritiana*) in the Gulf and Cape York Peninsula areas. Increased grazing pressure resulting from low beef prices in the mid 1970s (and consequent retention of stock), widespread adoption of tropically adapted *Bos indicus* cattle and increased provision of feed supplements, combined with poor seasonal conditions during the 1980s, have also contributed to the decline.

Site data collected by the Western Australian Rangeland Monitoring System (WARMS) in the southern rangelands of the State also indicate mixed positive and negative trends. Comparison of data collected over (usually) a five-year interval showed that density of palatable perennial shrubs had increased on 39 per cent and decreased on 50 per cent of 539 sites analysed in 1991–92; the remainder were unchanged (WA Dept of Agriculture, unpublished data). Pastoralists in this region generally agree that range condition is better now than 20 years ago (Wilcox and Cunningham, 1994), but over the shorter period covered by the monitoring data it is evident that changes have not been uniform.

Recent trends in woody vegetation cover in western New South Wales have also been variable. Increases in cover, due mainly to encroachment of 'woody weeds', occurred over substantial areas in the Cobar and Bourke districts in the 1980s. Over some smaller areas cover decreased (Weir *et al*., 1992). Extensive regeneration of degraded chenopod shrublands and sandhill–claypan complexes in various parts of the New South Wales rangelands has occurred since the 1950s, due to favourable seasons, reduced rabbit numbers and a range of socio-economic factors leading to more conservative management (Condon, 1983).

In South Australia, a similar example of rangeland regeneration has occurred (Nicholson, 1983). However, in another case in that State, substantial declines in chenopod shrub density on three out of four large arid-zone properties were reported over a 22-year period to 1972. No decline was recorded on the fourth property, which was conservatively stocked between surveys (Lay, 1979).

Comparison of central Australian surveys (Condon *et al*., 1969, Bastin *et al*., 1993) is difficult owing to differences in methods and the size of the survey areas (see Table 6.2). Also, the earlier survey was conducted under severe drought conditions and, thus, some recovery, as suggested by the data, is to be expected.

It is clear that the present condition of our rangelands and the trends over time are highly variable. Thus it is difficult to make broad generalisations about either.

Heavy grazing can lead to vegetation loss and expose the soil to increased water and wind erosion.

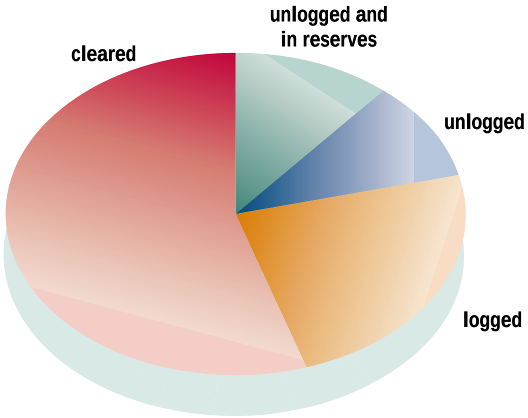
Forests

When European settlers arrived in Australia, the land carried 69 million ha of forests. Since then, about 40 per cent of the forests have been cleared and about the same area has been affected by logging at some stage (see Fig. 6.5). Only about 25 per cent of the original forest estate remains relatively unaffected by clearing or harvesting (see Fig. 6.10). A separate State of the Forests Report is being prepared by the National Forest Inventory for JANIS, a joint committee of Commonwealth, State and Territory governments established to oversee the implementation of the National Forest Policy Statement. This report is expected to be released in 1996.

Relatively little is known about the condition of larger areas of privately owned forests in the high-rainfall zone (see Fig. 6.8). Undoubtedly, some thinning has taken place on less rugged terrain and grazing has affected forest regeneration (see page 6-11).

Forests in conservation areas are usually selected because they provide good representations of pre-European conditions. However, in some areas there is concern about declining condition. In small reserves invading species from neighbouring pasture, crop or urban areas threaten the forest. In all reserves, changes to the fire regime can alter forest condition. Conservation agencies are faced with problems of identifying pre-European fire regimes, deciding whether they should be maintained and establishing how to do that without threatening other values and property.

Figure 6.10 Forest areas affected by clearing or harvesting since 1788



Source: RAC, 1992.

Sustainability of our forests

Forests are renewable resources that can be used to provide timber products, water, recreation opportunities and conservation values. Forest management is a long-term issue. Decisions made at the turn of this century still affect the forest resource available today, and planning for the forests of 2050 and beyond is happening now. Forests are dynamic — the resources and values that they provide change with the age of the forest and with the occurrence of bushfires or cyclones. Human values also change; those we hold now are not the same as those held 50 years ago. Nor are they likely to be the same as those held 50 years hence.

The question: 'Is our use of forests sustainable?' will always have an ambivalent answer. About 75 per cent of the 1788 forests have been cut and the timber and other products used; about half of this land has been converted to other uses such as agriculture. While this has resulted in the irretrievable loss of certain values, such as biodiversity, and some Aboriginal cultural heritage, others have been maintained. Much modern forestry practice is designed to allow near-to-natural forest to regenerate after harvesting. The goal is to retain as many of the multiple values of the forest as possible. In practice, ecosystems tend to be modified so that forests can be harvested on a 50–80 year rotation.

People commonly confuse the concepts of sustainable use and sustainable yield from our forests. Sustainable yield means the output of a specified level of a certain mix of products, under a particular management scenario and with particular assumptions about future climatic conditions and demands for forest products. In its simplest form, sustainable yield can be achieved as an even flow by ensuring that each year's harvest is limited to the net growth during that year. This can be achieved in a fixed forest estate by cutting and regenerating each portion of the estate in a rotation that will allow the return of logging to the same site just at the time it has regrown to its optimum yield (the rotation time). In Australia, forestry is not practised on the basis of even-flow sustainable yield. The existing stock of old-growth forests, competing uses and changing value systems led the Resource Assessment Commission Forest and Timber Inquiry (RAC, 1992) to conclude that sustainable yield was too simplistic a concept to be useful in assessing whether our use of the forests is sustainable.

The following are some important criteria that can be used to assess whether forest use is sustainable:

- no decrease in area
- maintenance of ecological processes
- mechanisms to retain the range of biological diversity

The forest estate includes forests of all types — natural, modified and plantations, publicly and privately owned. To satisfy the first criterion, the total forest estate should not permanently decrease in area. Since the arrival of Europeans 40 per cent of forests have been cleared and only 25 per cent remain relatively unaffected by logging or other significant human activity. Governments throughout Australia have agreed that the permanent forest estate should not decline further.

Second, our forest estate must be sufficient to maintain the ecological processes on which the forests, and many catchments and waterways, depend. Third, it should also be sufficient to protect the full range of biodiversity. In numerous cases, clearing of forests has led to breakdowns in biological processes, erosion, siltation and loss of species and biodiversity. A more contentious issue is whether our use of the remaining forest estate for timber production endangers any of the above values. The RAC concluded that, although inappropriate practices had occurred in the past, there was not enough evidence to conclude that current forest management practices threatened these values. However, it remains possible that some of our patterns of use — and in particular unforeseen problems arising from them or their cumulative effects — are threatening these values. So, any forest use should proceed cautiously, using the best current practices (including conservation practices) and continuous monitoring of the forest to detect emerging problems.

A further issue is maintaining the industries and communities that directly depend on forests. About 10 000 people are employed in log extraction and sawmilling. The number has been declining by more than 500 per year over the past 40 years, mostly due to technological changes. About 30 000 people are employed in the wood products industry, using raw material from native forests, plantation forests and imported timber. It is difficult to attribute the proportion of employment in the recreation and tourism industry that depends directly or indirectly on forests. However, this source of employment is growing.

The RAC considered a number of scenarios of timber production over the next century, including ‘current trends’ and specific scenarios proposed by industry and conservation groups. These projections dealt mostly with hardwood (usually wood from native eucalypt species) and with sawlogs (logs suitable for processing for sawn timber). The RAC found that, if current trends continued, the availability of hardwood sawlogs would decline slightly, as suitable native forests become scarce, until about 2030 or 2040. Following this, the availability of logs from eucalypt plantations and intensively managed regrowth stands would begin to increase and future timber production would become increasingly reliant on this resource. This scenario depends greatly on how industry investment plans for plantations and intensively managed regrowth develop.

Forests: a renewable resource providing timber, water, recreation, conservation and cultural values.

Other ways of relieving pressures on native forests and maintaining industry activity include the substitution of softwoods (mostly from *Pinus radiata* plantations) for hardwoods. For many uses (such as housing construction) this could occur, but in other cases it would be difficult to substitute the values of hardwoods. Removal of obstacles to plantation forestry; development of fast-growing hardwoods; and removal of subsidies for the harvesting of native forests are other ways of relieving the pressure on native forests.

Activity at the international level seeks to define indicators for ecologically sustainable forestry (the Helsinki and Montreal processes). Australia is active in these processes, but it will be several years before effective indicators are available.

There is no clear answer to whether our current use of the forests is sustainable. Past practices have not been. All forest management agencies have implemented policies designed to meet sustainability criteria. However, there is no simple path to the destination of sustainable use. Rather it is a compass bearing in a never-ending journey. Staying on that bearing will require a continuing debate by many elements of society with different goals and different value systems for the forests.

Old-growth forests

Old-growth forests have been at the centre of much of the debate about the use of our native forests. The National Forest Policy Statement (1992) defined old-growth forest as forest that is ecologically mature and has been subjected to negligible unnatural disturbance such as logging, road building and clearing (Commonwealth of Australia, 1992). The definition focuses on forest in which the upper stratum or overstorey is in the late mature to overmature growth phases. The Statement acknowledged the significance of these areas to the Australian community because of their very high aesthetic, cultural and nature conservation values and their freedom from disturbance. Their rich understoreys, numerous epiphytes, hollow limbs and fallen logs harbour high biological diversity. They are also a significant timber resource. Old-growth forests are distinguished from regrowth forests that re-establish themselves after logging. They are often rare and scattered throughout the forest estate. They are vulnerable to fire and human disturbance.

The Resource Assessment Commission (RAC) Forest and Timber Inquiry found that across all forest types about 172 000 sq km (40 per cent) remained unlogged but only 24 000 sq km (14 per cent) stood in conservation reserves. The areas protected in conservation reserves range from 64 per cent for mangrove and swamp forest, to five per cent for south-eastern dry forest and woodland.

The RAC concluded that clearing of old-growth forests was potentially a violation of the 'precautionary principle' in that an irreplaceable resource would be destroyed. The National Biodiversity Council and other bodies can see no justification for any further clearing of such forest remnants.

Proper management of old-growth forests is difficult to achieve. It takes many decades or centuries to recreate an old-growth stand. A policy of total preservation is not sufficient to maintain old-growth forests into the future. They are but one part of a cycle of renewal and ageing in native forests. Old-growth stands will inevitably be lost through wildfires and, therefore, we need to ensure that there is a pool of maturing forests ready to replace them.

The Regional Forest Agreement process initiated by the Commonwealth Government will assess the extent of old-growth forests and seek to place at least 60 per cent of existing old-growth forests and 100 per cent wherever practicable (but at least 90 per cent) of rare old-growth forest in a national forest reserve system. The reserve system is also intended to contain 15 per cent of each forest type existing prior to European settlement and 90 per cent or more, wherever practicable, of high quality 'wilderness'.

Impact of pest animals and plants

Pest animals

European settlers brought many animals with them from 'home' — some were brought intentionally, others not. Many animals were domesticated and were intended to provide food, fibre, transport and labour or simply companionship. Some were brought for sport or pleasure, while others arrived as stowaways. Over time, animals escaped or were deliberately released and a number of species became so well established that they now have a significant impact on both agricultural production and conservation values. Some native vertebrates have become pests too. In sheep country, where dingoes are controlled, kangaroos have increased as a result of the greater availability and permanence of watering points and a reduction of natural predators (see Fig. 6.11). Elsewhere, dingoes have flourished because of the availability of food in the form of rabbits and young livestock.

The most significant environmental impact of pest animals and plants is on our biodiversity and this is dealt with in Chapter 4. Nevertheless, pest animals and plants significantly affect our environment by the additional pressures they place on the land resource. Many of these effects occur through losses and control costs to agricultural and pastoral production. Few reliable and comprehensive figures exist to measure the environmental or economic impact of any pest at a national level. Such figures as are available will be affected by year-to-year variation in seasonal conditions. Financial losses in some regions may be counterbalanced by gains in others: for example, a reduction in grain yields in one region may lead to higher prices nationally. Off-site environmental damage is difficult to assess.

Many vertebrate pests are familiar to us, but a number of invertebrates, particularly insects, cause major damage to agricultural production and yet are not known to the general community. The heliothis caterpillar (*Helicoverpa armigera* and *H. punctigera*) attacks cotton and other broadacre crops. Infestations of Queensland fruit fly (*Bactrocera tryoni*) can have a severe impact not just in the short term on local crops but on overseas trade prospects. A variety of insects cause post-harvest damage to stored grain. Australia faces a greater threat from insect pests than countries in higher latitudes, where the cold winters kill pests. Not all insect pests are introduced; indeed, *H. punctigera* and the fruit fly are native to Australia.

Losses due to animal pests

It is difficult to estimate the economic costs of pest species as the result depends so much on what impacts are taken into account and the assumptions that are made about their flow-on effects.

Losses of crop production in one area may be creating opportunities for production in a less affected area. For example, estimates of the costs of rabbits in the agricultural and pastoral industries vary from $90 million to $600 million. A mouse plague in South Australia and Victoria during 1993 cost the affected grain-growers an estimated $54.8 million in reduced yields alone. When on- and off-farm costs were added, the total reached $64.5 million (Caughley *et al*., 1994).

Kangaroos resulted in estimated losses of $113 million in agricultural production in the commercial shooting areas of Australia in the 1984–85 financial year (1.4 per cent of the gross value of all agricultural production).

No one has quantified the economic damage to the pastoral industry, as a whole, inflicted by large herbivores. It is incurred through competition with livestock for food and water as well as through land degradation, damage to infrastructure, disturbance to mustering and, in some cases, indiscriminate mating among domestic and feral members of the same species, such as cattle.

For invertebrates, costs are also high. The total annual loss due to insects in primary production is about $3.1 billion. The red-legged earth mite (*Halotydeus destructor*), one of Australia's worst pasture pests, causes annual damage of $200 million. The two species of *Helicoverpa* moth mentioned earlier cost the cotton industry over $50 million each year, and failure to control them would lead to the collapse of the industry, worth $800 million per year.

Costs of control

Any control costs will vary widely depending on the enterprise, the pest and its density and the land type. During the 1993 mouse plague in South Australia and Victoria, baits alone amounted to $1.7 million. On a single property in central Australia, ecologists estimated the cost of controlling 2000 feral horses to be about $25 000 and, while the subsequent income from sales was likely to return a profit of about $130 000, follow-up control would have eaten into this return. The reduced carrying capacity resulting from land degradation, and the repair of damage were not costed. In semi-arid South Australia, the cost of controlling rabbits was estimated to be $150 000 for a single property over seven years.

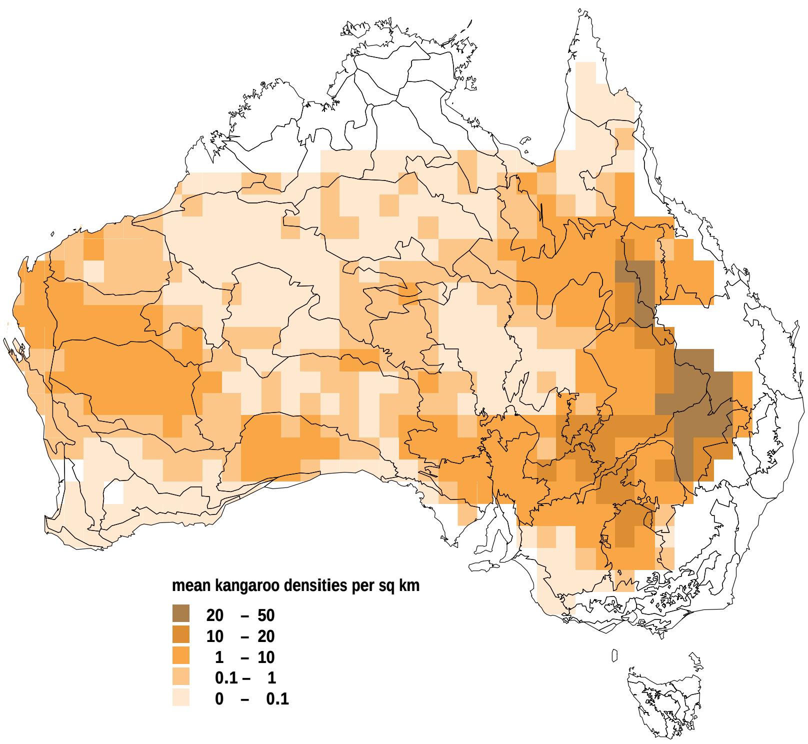
Nationally, sheep blowfly, buffalo fly and cattle tick — all major pests of livestock — are estimated to cost more than $600 million annually to control. The cost of controlling all insect pests in Australia exceeds $1 billion annually, mostly due to expenditure on chemical pesticides. Integrated pest management may reduce dependence on pesticides. No annual estimates of national expenditure on vertebrate pest control are available.

Costs of control per individual pest animal increase as their density decreases, making eradication an unrealistic aim for many species (see Fig. 6.12). As well, any eradication campaign must use techniques that are socially acceptable, do not adversely affect non-target species and are effective against all individuals in the population. It must be possible to detect very low densities of the species and immigration must be zero. In general, practical

Rabbits are a major contributor to environmental damage.

Mice sometimes reach plague proportions.

Figure 6.11 Kangaroo densities



Source: ANCA.

The cost of controlling all insect pests in Australia exceeds $1 billion annually.

and economic limitations rule out the option of vertebrate pest eradication (Braysher, 1993).

Another economic impact of animal pests involves potential disease outbreak. A 1991 study, for example, estimated that an outbreak of foot-and-mouth could cost $9 billion in lost exports, and losses in the first year alone could be $2 billion. Mammal pests would play a major role in such an event.

The economic benefits of pest animals are modest relative to costs, and are likely to remain so. The estimated annual wholesale value of trade in wild animals and their products is $132–156 million. Commercial harvesting can improve the cost effectiveness of pest management, but can also lead to pests being maintained at commercially rather than environmentally desirable levels. It also has value in improving conservation status and agricultural productivity, but the benefits have not been quantified. The commercial harvesting of native species, whether or not in the context of ‘pest control’, is a controversial conservation issue and is opposed by many in the community.

Control measures appear to be reducing pest numbers in some regions from earlier peaks. In the Northern Territory, for example, buffalo numbers reportedly fell from more than 340 000 in 1985 to 140 000 in 1989. Now, numbers are limited to 10–15 thousand domestic animals and 20–40 thousand in Arnhem Land. Similarly, over the last decade or so, donkeys in the Kimberley have been reduced from about one per sq km to about one per 10 sq km — that is, to 10 per cent of former levels. In contrast, the number of camels in and around the Northern Territory appears to be increasing. Estimates of 3000 to 6000 in 1969 rose to more than 31 000 by 1984. In the 10 years to 1993, the numbers increased further to around 47 000, due to the animals expanding their range rather than increasing their density in core areas.

Accurate trends for pest numbers are not available and, in any case, such figures would probably be seasonally variable. Trends in damage caused by pest species are likely to be a more valuable indicator, but we lack quantitative information.

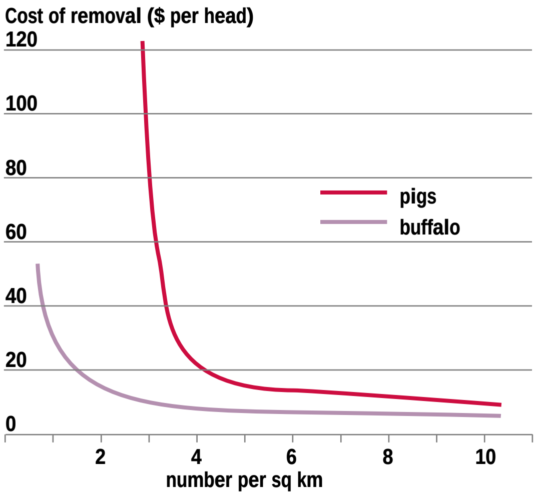
Pest plants

Plants are deliberately introduced for their agricultural, forestry or ornamental value and a number of them are of great worth to Australia, providing almost all of our crops and many of our important pastures.

Introductions continue on a significant scale for all our major crop and pasture plants. Since European settlement, more than 1900 new vascular plant species have been added to Australia's complement of 15 000 indigenous species by either intentional introduction or accidental release. About half of these are now regarded as weeds, with more than 220 of them declared as noxious weeds. At least 46 per cent of the noxious species were deliberately introduced.

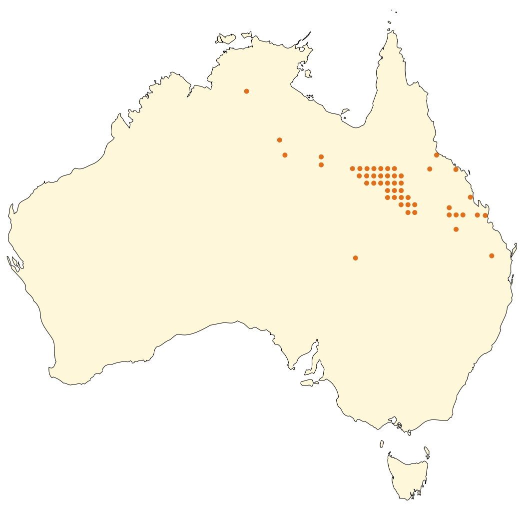
What is a weed? Common parlance defines it as a plant in the wrong place at the wrong time. The National Weeds Strategy, under development in 1995, defined it as ‘a plant which has, or has potential to have, a detrimental effect on financial, social or conservation values’. Nevertheless, many

Figure 6.12 Cost of pest control in relation to population density



Source: Choquenot, 1994.

Figure 6.13 Distribution of prickly acacia



Source: Parsons and Cuthbertson, 1992.

so-called weeds may have some desirable characteristics for particular applications. A definition in financial terms is appropriate for weeds of agriculture but not for those of conservation ('environmental weeds'), which are best defined with regard to their disruption of ecological processes. Weeds in forests (see page 4-18) appear to be of minor economic importance and are not considered further here, where only agricultural weeds are considered.

Weeds can vary from short-lived and herbaceous plants to long-lived trees (for comprehensive descriptions of Australia's noxious weeds, see Parsons and Cuthbertson, 1992). Common short-lived species include wild oats (*Avena fatua*) and skeleton weed (*Chondrilla juncea*) in cereal crops, Bathurst burr (*Xanthium spinosum*) and Noogoora burr (*X. occidentale*) in summer crops and grazing lands, Paterson's curse (*Echium plantagineum*) and blackberry (*Rubus fruticosus*) in temperate pastures and parthenium weed (*Parthenium hysterophorus*) in tropical pastures and crops. Long-lived species such as prickly acacia and various mesquites infest northern grazing lands.

Native species can also become agricultural weeds. For instance, brown beetle grass (*Diplachne fusca*) is a major weed of drill-seeded rice in New South Wales, and a number of native shrubs in the arid and semi-arid grazing lands have reached densities that suppress native pasture production.

A number of pest species remain benign for many years until an environmental trigger like high rainfall, disturbance or a new dispersal agent stimulates a dramatic expansion. Prickly acacia was introduced to grazing lands of western Queensland for shade and fodder in the 1890s, but was only regarded as a weed after its expansion during a series of wet years in the 1950s (see Fig. 6.13). In some cases, expanding populations could simply have been overlooked until the species was entrenched.

Potential weeds are still being introduced. Between 1947 and 1985, 463 exotic pasture grasses and legumes were intentionally introduced into northern Australia (Lonsdale, 1994). Only 21 (five per cent) were subsequently regarded as useful and, of these, 17 were also weeds. Thus, only four species (less than one per cent) were useful without causing weed problems while of the non-useful introductions, 43 became listed weeds, giving a total of 60 (13 per cent) new weeds of either cropping or conservation areas or both.

National quarantine procedures focus on the introduction of potential pests and diseases of agricultural crops and pastures, and do not restrict the importation of plant species that are not on the prohibited list. Thus plants that are not classified as weeds overseas can be introduced here, even though overseas conditions may be a poor guide to potential weediness of a species in Australian environments. Formal procedures exist at State level for screening introductions, but they are more stringent for pasture plants than for horticultural or other crops.

Impacts of weeds

Weeds cost Australia about $3.3 billion annually, excluding the cost of associated health issues and environmental weeds (Combellack, 1989). Annual losses due to crop weeds are usually estimated at 10–15 per cent of crop value (see Table 6.4).

Such estimates must be treated with caution. For pastures, different authorities assess pest impact in different ways and there is little standardisation of methods of data collection or of units of measurement. Rating infestations from heavy to light — a common procedure — does not provide data that can be readily related to pasture or livestock productivity. In the estimates for agricultural crops, costs of cultivation are incurred not just for weed control but to improve soil structure as well. Some 'double counting' of costs probably occurs.

Nevertheless, the cost of weeds to agriculture — in terms of reduced post-production quality, such as vegetable fault in wool, and of herbicide application — is relatively well documented compared with the costs of land degradation and loss of biodiversity.

Primary producers incur costs due to loss of production through reduced crop or pasture yields, poisoning of stock, vegetable fault in fibres, tainted products, carcass damage and animal stress due to physical discomfort. Weeds can also act as hosts for crop diseases, especially if they are closely related. Pathogens cause annual losses estimated at $187 million in agricultural production.

The costs of controlling weeds are not simply those listed in Table 6.4. For example, farmers spend more than $700 million annually in cultivating crops, to control weeds as well as to modify and loosen the soil surface. But added to this is the cost of soil degradation — primarily caused by cultivation. Herbicide use and direct-drilling techniques offer alternatives to cultivation, but these strategies may adversely affect yields in some soils or contaminate soils. The issue of weed control is complex and requires an approach that

Table 6.4 Annual financial losses due to weeds

	Financial loss in $ million			
	Agricultural crops	Horticultural crops	Pastures	Non-crop areas
Direct losses				
Cultivation	710			
Herbicides	263			
Herbicide application	40			
All direct losses	1013	63	71	177
Indirect losses				
Yield losses	713			
Product contamination	143			
All indirect losses	856	240	900	unknown
Total	**1869**	**303**	**971**	**>177**

Source: Combellack, 1989, based on 1986 data.

integrates agronomy and ecology with soil and weed science and engineering design.

Few weeds of crops and pastures have been studied systematically with a view to understanding yield loss, seed production or the decline of seed banks (Cousens and Medd, 1994). As a consequence, weed control using ecologically based management practices has not been widely adopted. Similarly, much of the research on exotic woody weeds has focused on chemical, mechanical and biological control, and there is little information regarding the ecosystem effects of invasions, mechanisms of spread or the effects of grazing and fire on spread. It is conceivable that, once one woody weed species is controlled, another will invade the gap unless follow-up management is ecologically sound.

The benefits, if any, of successful pasture introduction in the northern Australian tropics accrue to the pastoral industry, while the costs of the introduction becoming a pest are largely borne by others (Lonsdale, 1994). Species introductions in arid native pastures are rarely of economic benefit.

Pests and the future

Significant problems to arise in future could include introduction of new animal and plant pests, introduction of diseases, parasites or vectors that interact with pest species, variations in market value of products and complex impacts of climate change. Species already present in Australia — in zoos, plant nurseries and private collections, even some family pets — also have the potential to become pests. The five-lined palm squirrel (*Funambulus pennanti*), an escapee from Australian zoos, and the red-billed quelea (*Quelea quelea*) in private aviaries are pests elsewhere in the world and could become so here.

Changes in the way land is used could alter distributions and densities of pest species. A switch from sheep to cattle, or from grazing to cropping, the introduction of a new crop or a tourism enterprise are a few examples of new sources of disturbance and dispersal.

Pest control is a complex issue requiring the integration of agronomy and ecology with soil science and engineering.

In anticipation of future invasions, researchers are relating the genetic diversity of pest organisms outside Australia to that in the country and determining suitable management strategies.

The future offers the potential for new technologies, such as genetically engineered infertility, to control pest animals. However, control of one pest, such as the rabbit, could lead to increased predation on native fauna if feral cats and foxes were not controlled at the same time. There is also a risk that existing forms of control will not be maintained, in the expectation of a single 'magic' solution to a pest problem. Any new techniques will have to be integrated with existing methods, and with underlying ecological processes, for the optimal management of pests.

Soils

Australian soils, compared with those of the Northern Hemisphere, commonly have lower organic matter and poorer surface structure. Their clay content often increases abruptly just below the surface (for example, kurosols, chromosols and sodosols) (see Fig. 6.14). Such layers restrict drainage and impede root growth. In these soils, bleached layers with very low nutrient levels are also common. Soils affected by salt, either now or in earlier geological times, cover large parts of the continent (sodosols in Fig. 6.14) and they have various nutrient and physical limitations.

Australia has an unusually large proportion of cracking clay soils (vertosols). Their shrinking and swelling cause problems for engineering structures and farming. Extensive areas in the arid zone are covered by soils formed on aeolian sands (rudosols and tenosols). Finally, the remaining ancient land surfaces have very deep and strongly weathered soils (kandosols), which have very low levels of nutrients.

Soil structure

Structure is a complex soil property that influences physical, chemical and biological processes. It has the following three components (see Fig. 6.15):

- form — the arrangement and packing density of soil particles
- stability — the ability to resist stresses such as cultivation, trampling and rainfall
- resilience — the ability to recover from stress-induced changes

The natural structure in Australian soils is often poorly developed and the impact of European land-use is often not easy to characterise. While changes in soil structure due to land use may be one of Australia's most serious forms of land degradation, the extent, severity and cost have not been well documented.

In many soils, a fall in organic matter after clearing and cultivation has changed their structure. During the first few years of regular tillage, between one-third and half the organic matter may be lost due to increased oxidation. After several decades, organic matter reaches an equilibrium under a given management system. Pastures usually increase organic matter, but the rate of increase is slow. Substantial increases may take at least a decade and a minimum level of two per cent may be needed to maintain soil structure. The effects of management practices on organic matter levels in wheat soils in southern New South Wales and Victoria are shown in Table 6.5.

Significant changes in soil structure can occur in seconds when wet soil is exposed to stresses caused by machinery (for example, tractors, logging vehicles etc.) or stock. One such event can undo years of careful soil management and reduce crop or tree growth. Similarly, exposing bare soil to intensive rainfall can cause slumping and crusting of the soil surface: this is usually a precursor to run-off and erosion.

The degree to which structural decline can be reversed depends on the resilience of the soil and the resources available for land management. For example, on cracking clay soils (vertosols in Fig. 6.14) used for cotton, heavy machines working on wet soil caused soil compaction that reduced yield. This has been remedied by carefully timing operations with respect to soil moisture. Cracking soils are resilient and regenerate structure by shrinking and swelling. In contrast, structural decline in red soils (for example, ferrosols in Fig. 6.14) of eastern Australia is difficult to repair because these soils have no inherent regenerating capability (Bridge and Bell, 1994). Many forest soils commonly have low resilience.

There are few reliable surveys of the extent and magnitude of soil structural changes. One survey of farms on eight major soils in Queensland found adverse changes in soil structure on all farms, with the proportion of individual farms affected ranging from 20 per cent to 80 per cent (McGarry, 1992). Results from other Australian cropping areas could be expected to be similar. The decreases in soil organic matter associated with agriculture shown in Table 6.5 are from southern New South Wales and Victoria and are representative of farming areas elsewhere in Australia.

Soil structure decline can have the following effects:

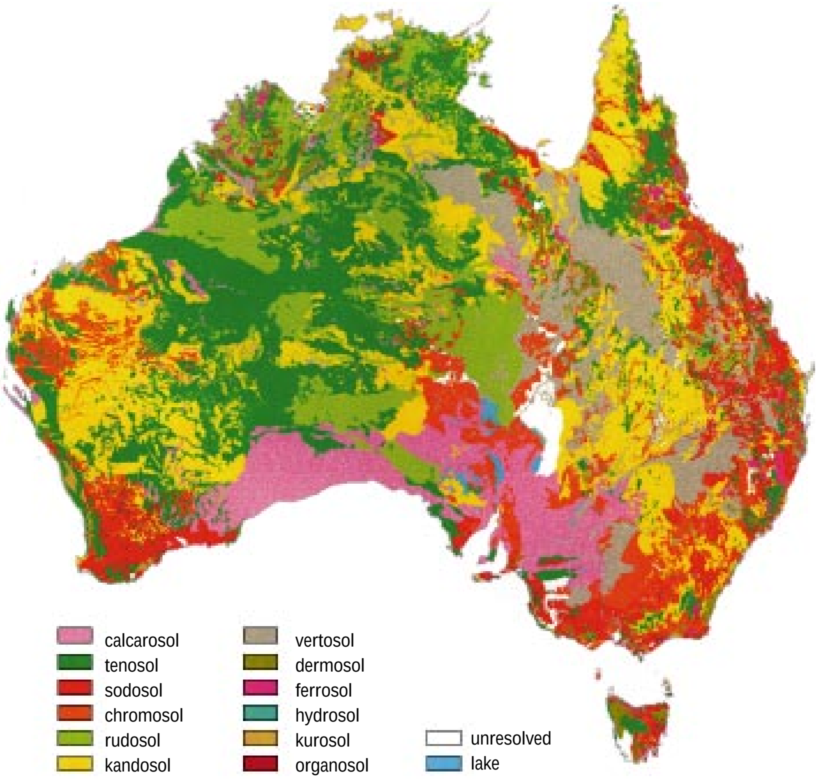
- reduced porosity and permeability leading to waterlogging, excessive run-off and soil erosion

Table 6.5 Effect of management practices on soil organic matter

Management system	Soil organic carbon level (%)
Undisturbed woodland	8.2
Grazed pasture	4.8
Direct drilled cropping	2.0
Overgrazed pasture	1.6
Tillage-based cropping	1.3

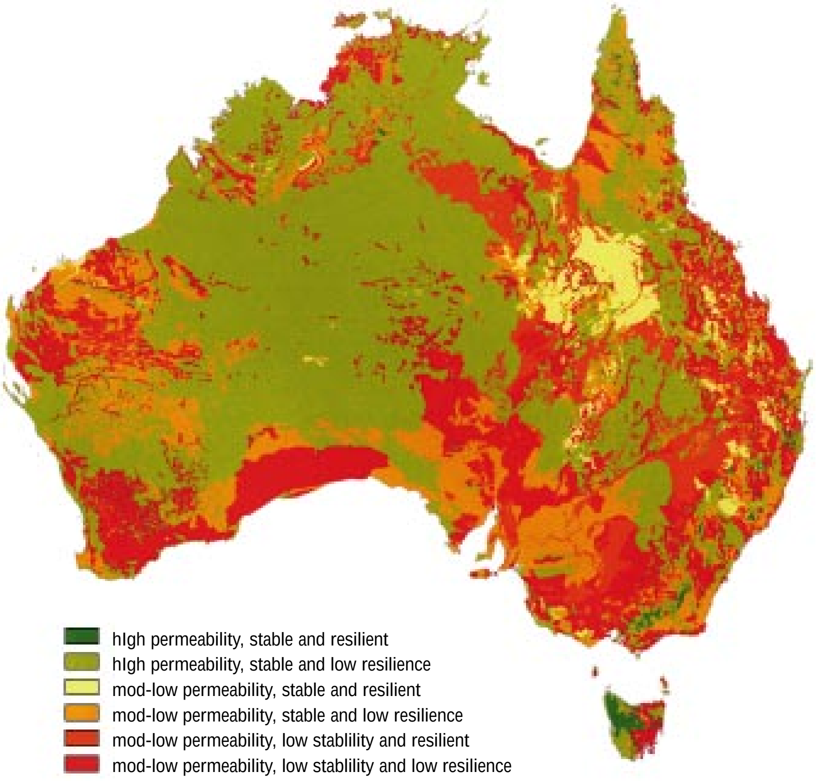
Source: Geeves *et al.*, 1995.

Figure 6.14 Distribution of Australian soils



Source: CSIRO Division of Soils.

Figure 6.15 Structure characteristics of the upper 0.5 m of soil



Source: CSIRO Division of Soils.

- reduced root vigour leading to plant nutrient deficiencies and restricted water extraction
- reduced yield if management inputs are not increased
- increased management costs (fuel, labour, machinery, irrigation and fertiliser needs)
- fewer management options, and restrictions on the timing of farming operations

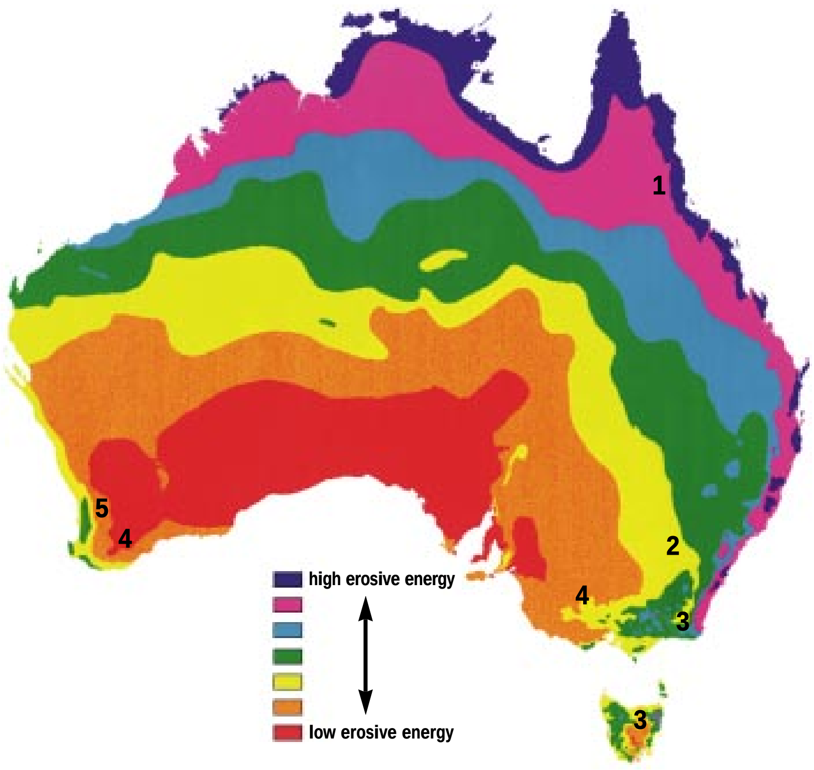
The problems of soil structure decline, nutrient decline and erosion are closely related. In general terms, successful management practices maintain a protective cover on the soil surface, increase organic matter levels and minimise damage to soil structure caused by machinery and stock. Various strategies are required for different land uses, and significant improvements have been achieved in some areas.

Table 6.6 Summary of soil loss on sloping lands

	Land management system	Region	Soil loss on sloping land (t/ha/yr)*
1.	Tropical cropping (eg. sugar, pineapple)	Queensland, NT	100–500
2.	Cereal cropping	South Queensland, NSW, Victoria, South Australia	1–50 (higher in northern areas)
3.	Forested catchments	South-eastern Australia	0–1 (but 10–50 after bushfires)
4.	Pastures (well managed)	Southern Australia	1
5.	Bare fallow	Southern Australia	50–100

*Note: Average rates of soil formation are much less than 1 t/ha/yr.

Figure 6.16 Average erosive energy of rainfall events



Note: Numbers indicate land management systems in the table above.
Source: Edwards, 1991 and CSIRO Division of Water Resources

For example, farming systems that use minimum tillage or permanent beds have demonstrated advantages for improving soil structure. Likewise, the impact of forest operations can be minimised by more careful harvesting layouts, the use of improved machinery and harvesting when soils are relatively dry. Also, adjusting stock rates to avoid overgrazing susceptible soils during wet weather reduces trampling compaction. In addition, soil degradation during engineering constructions can be reduced by controlling traffic and maintaining soil cover.

The degree to which structure limits agricultural production and affects environmental quality is not well documented. Some land management systems are clearly degrading soil structure at present and in other areas structure must be improved to avoid excessive soil loss and improve production.

Waterlogging and salinity

Where changes in land use have replaced deep-rooted vegetation with shallow-rooted species, more water drains past the root system, particularly in southern Australia where winters are wet and cool. Consequently, groundwater levels have risen and waterlogging of the root zone may cause serious yield decline as well as damage to roads and buildings and septic tank absorption systems.
In some cases, changed hydrology redistributes salt within the landscape leading to dryland salinity (see page 7-20). Reclamation of saline lands is expensive and not feasible in many areas. Direct costs to landholders result from reduced productivity and erosion. Off-site costs arise with diminished water quality and environmental effects.

Water erosion

The limited data available indicate that rates of soil formation in Australia are very low by world standards. The great age of many Australian landforms and the generally low relief and rainfall differentiate this continent from the very young glaciated landscapes of Europe and North America. For alluvial landscapes, scientists have estimated rates of 0.4 tonne per ha per year (30 mm per 1000 years), but rates for soils forming on bedrock (that is, on hillslopes) would be considerably lower, particularly in the drier parts of the country.

Therefore, given human life spans, soil has to be considered as a finite and non-renewable resource. The few exceptions are in areas where regular deposition occurs (for example, alluvial plains) and where high inputs of organic and mineral materials become affordable (for example, urban areas and some forms of intensive horticulture).

Infrequent but destructive storms are responsible for much of the soil loss even in the gentle-rainfall zones of southern Australia (see Fig. 6.16). The rates of soil loss on sloping lands under different land management systems are summarised in Table 6.6.

Accelerated soil erosion results from clearing, grazing and cultivation. In some regions the rates of soil erosion by water have been much higher

than at present; for example, in southern regions, gully erosion developed soon after clearing.
The impacts of erosion can be masked for many years, as they are quickly obscured by cultivation or plant growth. The most immediate impact is a loss of nutrients carried away in the soil. This reduces productivity, although it can be offset by applying more fertilisers. A medium- to long-term impact is the reduced water-storage capacity of the soil, which is critical where soil depth, and thus available storage capacity, is already marginal such as on upper slopes in the Central Highlands of Queensland. The reduced water storage causes a loss of productivity and eventually increased run-off.

Most off-site impacts of accelerated erosion are associated with the deposition of sediment (for example, damage to roads, filling of dams etc.) or reduction in water quality (see page 6-28).

The most critical factor in protecting soils from accelerated erosion by water is the maintenance of cover — plant residues, pasture, forest litter etc.— in close contact with the soil surface. Other techniques for erosion control, such as contour banks, reduced tillage and strip cropping, provide supplementary measures. For example, a storm at Cowra in southern New South Wales during 1992 caused soil losses of 342 tonnes per ha for areas under traditional tillage, 362 tonnes per ha under reduced tillage and 65 tonnes per ha under direct drilling (Hairsine *et al.*, 1993).

Despite its demonstrated value, not enough cover is maintained over large areas of the sloping lands of Australia used for cropping and grazing. The reasons include the following:

- Difficulties in destocking and subsequent overgrazing can remove the cover completely, leaving soil unprotected and extremely vulnerable both during drought and when rains (often heavy) eventually fall.
- Systems of minimum tillage that maintain cover can be more difficult to manage. Problems with crop establishment, diseases, pests and machinery may occur and yield may not increase in the short term.
- Landholders often do not recognise that erosion is occurring at rates that are faster than soil formation.
- Many farmers can afford to substitute the costs of other inputs or are able to defer the costs of degradation so they are borne by future generations.

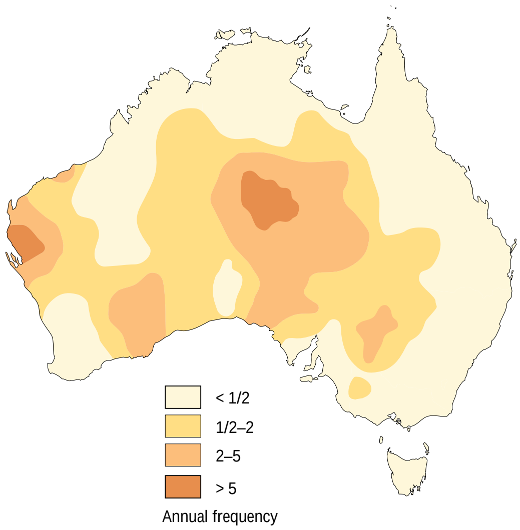
Even in the best-managed systems, the rates of soil loss still exceed rates of formation by an order of magnitude or more across many parts of Australia. It is clear that current farming practices on sloping lands are unsustainable, and the productive lifespans of soils in these areas vary between decades and centuries.

Wind erosion

Natural and human-induced wind erosion

Soil erosion and deposition by wind has had a major role in creating landforms and soils across large parts of Australia. The continent experienced a severe arid period between 15 000 and 20 000 years ago, during which dunefields were active and large quantities of dust were deposited around their fringes and in the surrounding oceans. As climates became less arid, vegetation stabilised large dunefields, for example, in the Murray–Mallee, Eyre Peninsula and parts of south-west Western Australia. When these were cleared, the soils became very susceptible to wind erosion. Dust storms provide striking evidence. Most of them occur in the semi-arid and arid lands where annual rainfall is less than 400 mm (see Fig. 6.17). In these areas, large sand drifts can have substantial impacts on agricultural production and local infrastructure.

Figure 6.17 Annual frequency of dust storms across Australia



Source: McTainsh and Leys, 1993.

In many instances, the only evidence that wind erosion is occurring may be atmospheric haze, where the dust consists of fine mineral and organic particles of soil. These particles have nutrient concentrations many times greater than the soil from which they came. Significant quantities of dust are deposited offshore and Australian dust is reported to have been transported to New Zealand on at least seven occasions this century.

The mass of the 1983 Melbourne dust storm was calculated to be about two million tonnes and the cost of replacing nutrients at around $4 million (Raupach *et al.*, 1994). However, the fine haze in previous days, which went largely unnoticed, carried more soil into the Southern Ocean than did the dramatic dust storm.

Landholders can minimise wind erosion by retaining vegetative cover and using windbreaks to reduce wind speeds at the land surface. It is critical to maintain soil structure, particularly in light-textured soils, and this is best achieved by minimal tillage and a low frequency of cropping.

Water erosion and sedimentation

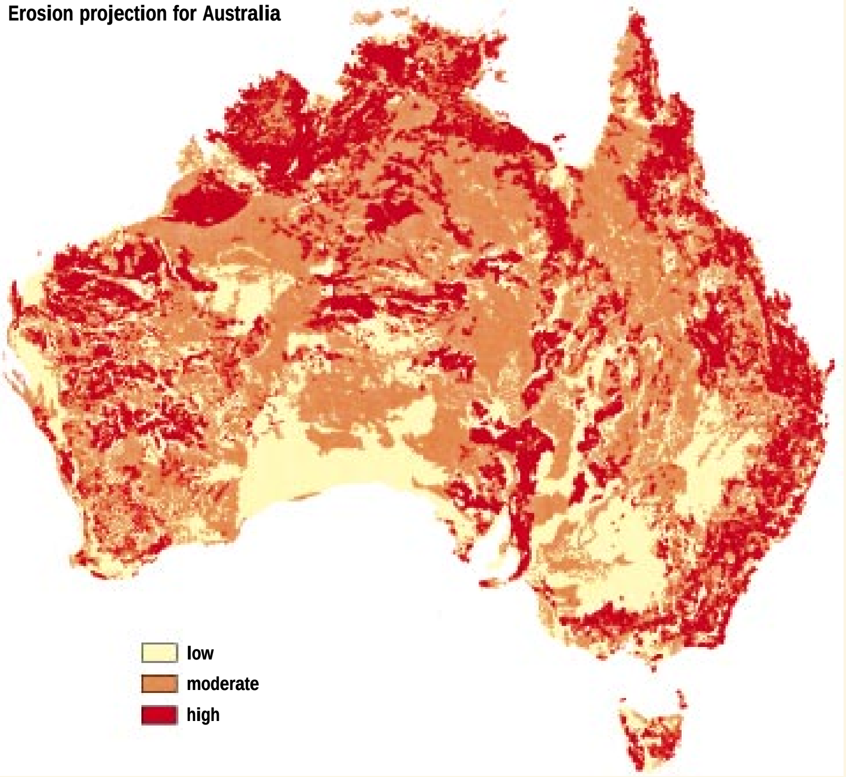
Erosion affects both the soil resource and also the quality of inland waters and aquatic habitats. Erosion occurs as sheets and small channels called rills on bare or poorly vegetated soils, as gullies, and along stream banks and in stream beds. In an average year in Australia, about 14 billion tonnes of soil is moved by sheet and rill erosion (Wasson *et al*., 1996). This is about 19 per cent of the total soil moved each year globally, even though Australia is only five per cent of the world's land area. Australia, therefore, has a higher than average erosion rate, in places up to 1000 times the rate on undisturbed sites (Edwards, 1991). Sheet and rill erosion is occurring up to about 100 times the soil formation rate on sloping land — a clearly unsustainable situation (Edwards, 1991).

Gully formation, resulting from increased run-off and subsurface flow after clearing, also erodes catchments. Gullies remove soil, reduce access on farms and carry a lot of sediment into water bodies downstream.

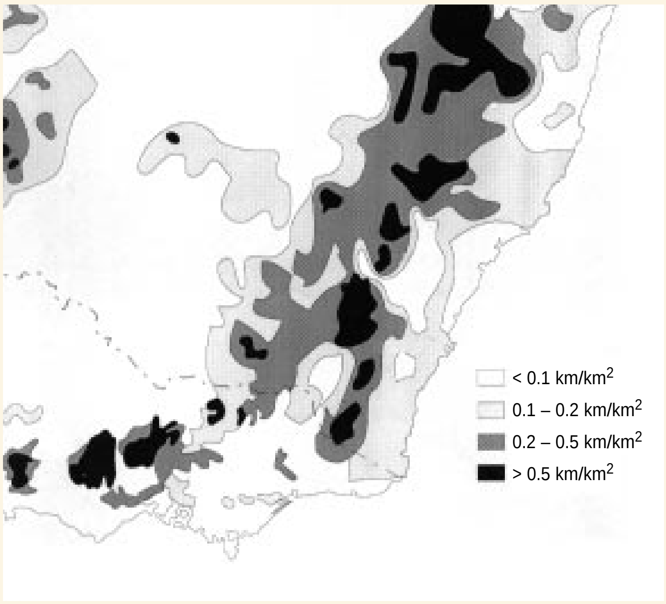
The density of gullies over most of the area in the figures below is not changing, because gully networks reach their maximum extent within 50 years of clearing (Stewart, 1968). In areas of recent clearing, such as Queensland, gully formation can be expected. Gully density in areas of stable networks provides a useful indicator of sediment yield from gullied catchments. On the Southern Tablelands of New South Wales and the Australian Capital Territory, annual sediment yield rises on average by 41 tonnes/sq km/year for each increase of 1 km/sq km density of gullies.

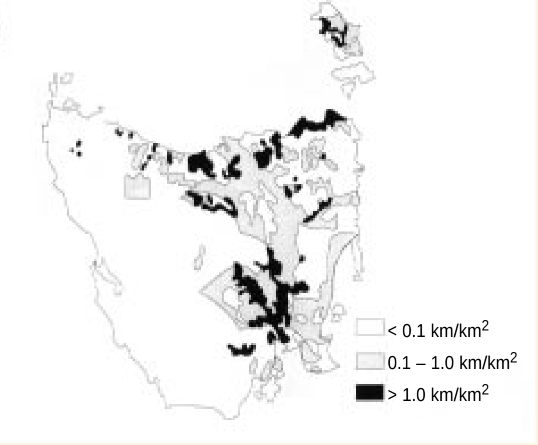
The other major type of erosion in catchments occurs along stream banks, but few data exist in Australia to estimate the rate.

Erosion projection for Australia



An estimate of the spatial pattern of sheet and rill erosion based on a soil erosion equation (Rosewell, in press). It shows high rates (>1000 t/sq km) in areas such as the steep lands of the eastern seaboard, the north, centre and west. This map probably overestimates erosion in the seasonally wet tropics, and in areas of rock outcrop.

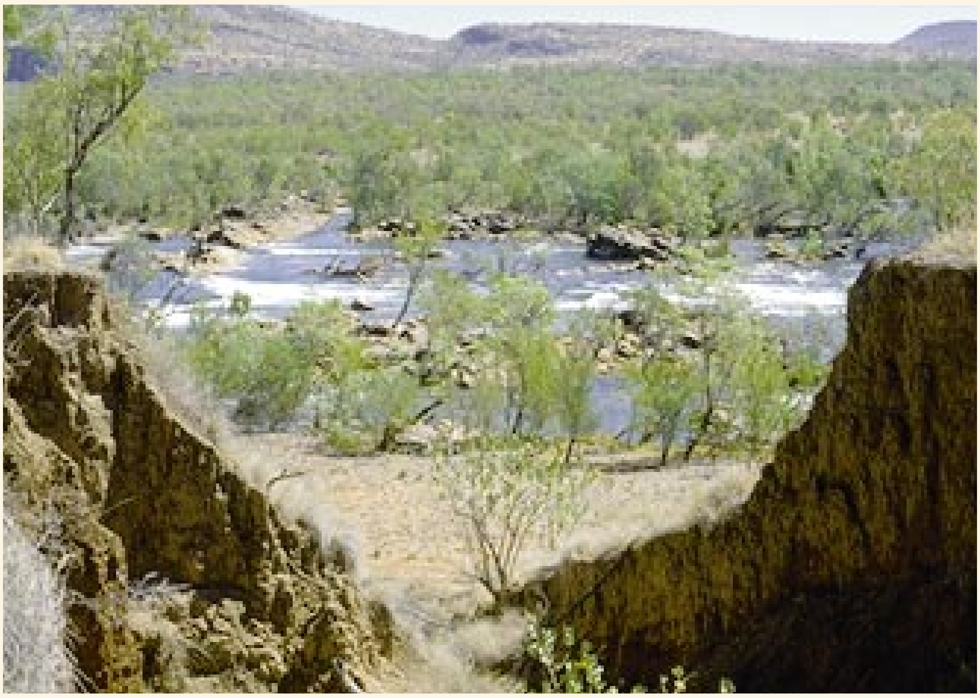




Gully density in south-eastern Australia — that is, the total length of gullies per sq km of catchment. The highest density occurs in areas of soils that have high concentrations of sodium salts — a characteristic that promotes collapse of soil structure.

Source: Ford *et al.*, 1993.

Sheet and rill, gully and stream erosion combine to contribute to both turbidity and sedimentation in streams, reservoirs, lakes and estuaries. Sediments have changed the nature of streams and wetland habitats by, for example, filling waterholes that used to be drought refuges for plants and animals, and interfering with the foraging habits of fish. Sediment also carries nitrogen, phosphorus, soil organic matter and possibly pesticides and bacteria. It reduces the storage capacity of reservoirs, and adds substantially to the cost of water treatment.



Channel bank slump in the Ord River, WA.

An indicator of the amount of sediment moving in streams is the sediment yield, which is the quantity lost from a catchment each year. The highest known rate is for mine waste from the King River in southern Tasmania. Estimates for rural catchments show very low rates in southern temperate areas and much higher rates in northern and arid Australia. In general, these yield estimates match those reported from other continents for similar landscapes which are under similar climatic conditions and disturbed by human activities (Wasson, 1994).

Sediment transport rates in rivers change with time, a long-term measure of which is the rate of accumulation in reservoirs. The rate has been declining this century in eight reservoirs in the uplands of southern and south-eastern Australia. This change reflects improved stock and land management, the use of soil conservation practices, rabbit control and the stabilisation of gullies. Reduced sedimentation in the Laanecoorie Reservoir in Victoria reflects the end of sluice mining for gold in the catchment.

The relative significance of the three types of catchment erosion (sheet and rill, gully, and channel erosion) as contributors to stream sediments is poorly known. In the uplands of south-eastern Australia, Neil and Galloway (1989) showed that gullied catchments yield about eight times more sediment than ungullied catchments — whatever the land use. Radio-cesium, a product of nuclear weapons testing, has been used to show that much less than 30 per cent of the sediment in the Darling River, Murrumbidgee River, upper Condamine, Burdekin and Ord rivers is derived from sheet and rill erosion (Wallbrink and Murray, 1993; Wallbrink *et al*., 1996). In Victoria, 56 per cent of the sediment in streams has been estimated to be the result of gullying and the rest contributed by the erosion of large channels (Rutherfurd *et al*., in press). While these results indicate that sheet and rill erosion are not important contributors of sediment to Australian rivers, there may be places where this is not true.

Responses

A lot of effort has been devoted to soil conservation using contour banks, minimum tillage and grazing control. A particularly difficult problem for land managers is that most sheet and rill erosion result from infrequent but destructive storms. Even the best conservation measures can be inadequate in these circumstances, although good ground cover is beneficial.

Gully control — by means of damming, infilling, revegetating and constructing weirs in gully beds — is widespread but limited to small areas due to cost. However, the mounting evidence that gullies are a major source of sediment in Australian streams means that cost-effective control measures are badly needed.

Soil conservation in Australia has mostly been designed to protect the soil resource, and so is primarily targeted at slowing sheet and rill erosion with some attention to gully erosion. While appropriate for its purpose, this form of soil conservation, which emphasises vegetation cover and engineered works to slow water flow, may not be the most appropriate form for water quality protection. As landcare and catchment management become more integrated, truly multipurpose management techniques will be necessary.

Prepared by the Inland Waters Reference Group.

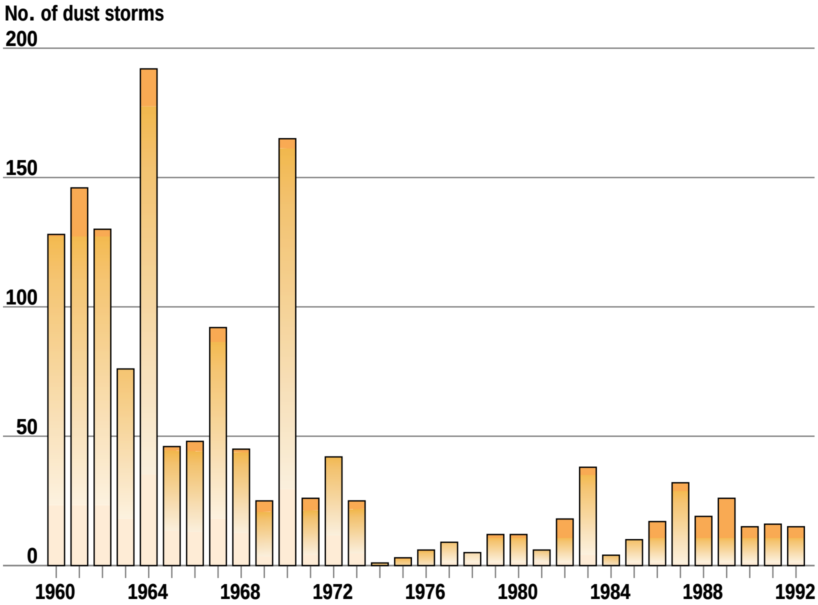
The large dust storm that swept across Melbourne in February 1983 made many urban dwellers aware of wind erosion. However, the fine haze in previous days, which went largely unnoticed, carried more soil into the Southern Ocean than did the dramatic dust storm.

An indication of the severity of wind erosion during recent years in eastern Australia. Note that the data for the 1994–95 drought are not yet available although it is known that the graph will show a sharp increase.

Notable periods of wind erosion included the 1895–1903 drought and the extended drought of the 1930s and early ’40s. During these periods, severe wind erosion occurred in the Mallee areas of New South Wales and Victoria and across many of the agricultural lands of South Australia.

Long term, the number of dust storms appears to be falling (see Fig. 6.18), which suggests that control measures have been successful to some extent. For example, rabbits are not in the plague proportions experienced during the 1930s and ’40s, and methods of minimum tillage have been adopted in some areas. In other places, invasion of woody weeds has increased cover and surface roughness.

Figure 6.18 Total number of dust storm days from 41 eastern Australian weather stations



Source: McTainsh, G.H. and Reddan, S.P. 1995 (unpublished data).

The highly episodic nature of wind erosion caused by climatic variation indicates that major phases will occur again. For example, in 1994 the number of dust storms increased.

While images of drifting sands and direct damage to properties and infrastructure have dominated media coverage, in recent times it has become apparent that a less visible but serious problem is the loss of nutrients in dust. However, apart from localised case studies, the magnitude, extent and cost of nutrient depletion caused by wind erosion remain largely unknown.

Soil nutrients

Many Australian landscapes are ancient and heavily weathered or have impoverished parent materials. Thus large areas have naturally low nutrient status and only small areas have highly fertile soils (see Fig. 6.19). Acute deficiencies of nitrogen and phosphorus are common and deficiencies of sulfur and potassium and the trace elements molybdenum, copper, zinc, boron and manganese are also not uncommon (Williams and Raupach, 1983). The few toxicity problems that occur are usually related to aluminium or manganese in soils of low pH. Boron toxicity occurs in some of the cropping lands of Western Australia, South Australia and Victoria.

Over the last 200 years, the export of phosphorus, sulfur and nitrogen via food and fibre products has increased. For phosphorus and sulfur, this has at least been matched by inputs. The input/output budget for nitrogen is more difficult to determine because of fluxes associated with erosion, leaching, gaseous losses and fire. Estimated budgets suggest that, at the continental scale, inputs are exceeding outputs (see Table 6.7).

Regional patterns of nutrient increase and decline occur across Australia but reliable evidence is only available from isolated surveys, experiments and monitoring studies with the exception of Western Australia where the main fertiliser company monitors regional trends.

In many permanent pastures or long-rotation pasture systems, soils have accumulated nutrients through biological fixation of nitrogen and fertilisation — most commonly with phosphorus, sulfur, calcium, potassium, molybdenum and zinc. In some areas these gains have to be balanced by costs associated with soil acidification. Nutrient accumulation is probably occurring in areas used for intensive agriculture with high fertiliser use (for example, horticulture and sugarcane production). In some instances, risks of groundwater pollution are associated with excessive fertilisation.

Evidence suggests that nutrient losses are occurring in the nation’s most productive soils (Dalal and Mayer, 1986). They have been documented for the cropping lands of south-east Queensland and northern New South Wales, and in the deep red soils formed on basalt (ferrosols in Fig. 6.14) that are used for intensive cropping in eastern Australia. These declines are caused by inadequate fertilisation, excessive cultivation (resulting in the mining of nutrients in organic matter) and losses associated with soil erosion.

The nutrient status of soils has declined across extensive areas used for wheat production (Hamblin and Kyneur, 1993). Between 1950 and 1990, Australia had one of the lowest average rates of wheat-yield increase in the world (8 kg per ha per year). Although climatic constraints limit the potential gain in grain yield and the likely response from fertiliser and other inputs, this is a disappointing result when the improvements in plant varieties, weed control, tillage methods and fertiliser technologies are considered. However, in one-quarter of the wheat belt, farmers have achieved yield increases of more than 20 kg per ha per year and many have enhanced soil fertility by the use of legume pastures in the rotation.

Without an organised and comprehensive system for surveying, monitoring and predicting the sustainability of nutrient supplies for different systems of land use, it is hard to make conclusions on nutrient status across large parts of Australia. It seems that nutrient levels of soils used for forestry are being maintained except where erosion rates are high or where intensive fires have become more frequent. Some areas used for plantation forestry have experienced nutrient declines and decreases in yield (for example, pine plantations in the south-east of South Australia), but the problem has been rectified by improved land management.

While nutrient losses are probably occurring in those parts of the arid zone prone to wind erosion, their magnitude and significance are unknown. Water erosion causes local redistribution of nutrients in many arid zone ecosystems and substantial degradation can be associated with it.

The off-site effects of nutrient management in agriculture are discussed more fully in Chapters 7 and 8.

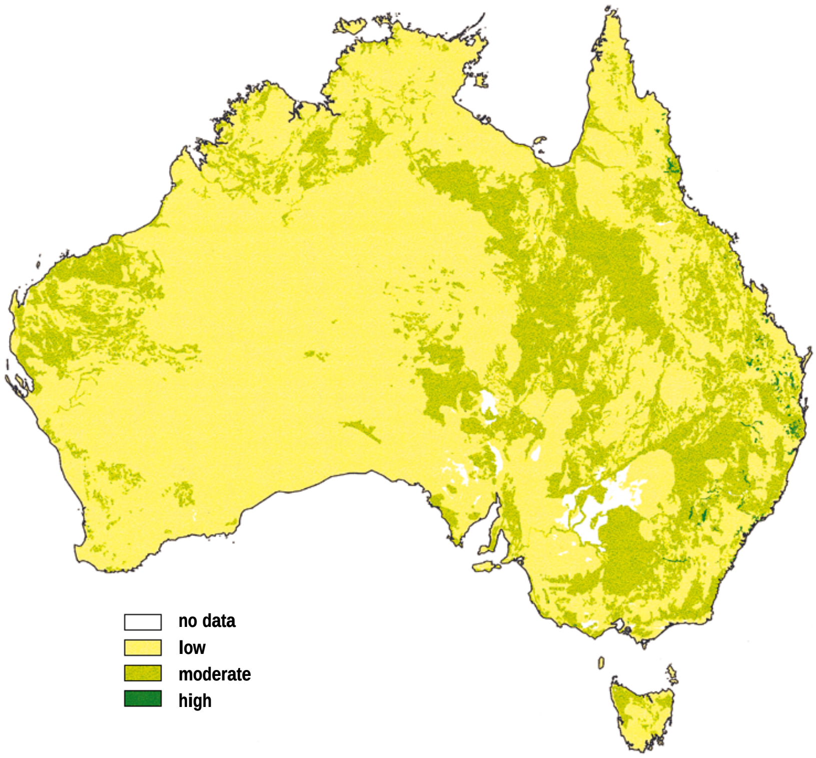
Soil acidification

A decrease in soil pH over a period of time — usually decades, but in some cases years — is the most obvious signal of soil acidification. The effect may take place at or near the soil surface, or in the subsoil. As their pH falls below about five, some soils release aluminium and manganese, which are toxic to some plants. Retarded root growth leads to poor water and nutrient use and impaired nodulation of legumes, resulting in poorer yields. By contrast, many calcareous and alkaline sodic soils of southern Australia are likely to benefit from acidification because more nutrients become available to plants and it creates an opportunity for leaching of sodium. Oxidation of acid sulfate soils, predominantly in coastal areas, can have a major local impact, including fish kills in nearby waterways and loss of vegetation.

A number of factors cause soil acidification:

- oxidation of sulfides (acid sulfate soils), usually in tidal areas or in mine tailings

Figure 6.19 The nutrient status of soils



Source: CSIRO Division of Soils.

Table 6.7 A summary of the continental nutrient budgets

	Flux in kilotonnes per year		
	Phosphorus	**Sulfur**	**Nitrogen**
Inputs			
Atmospheric deposition	77	769	1150
Food, fish and timber imports	<1	<1	<2
Fertiliser	54	325	380
Phosphate rock	326		
Fixation by sown pastures			1500
Fixation by crops			200
Fixation by forests			200
Total inputs	**458**	**1095**	**3432**
Outputs			
Food and fibre exports	56	52	415
Urban discharges	11	77	32
Soil erosion	6–32	3–17	18–98
Leaching	<3	87	243
Ammonia volatilisation			334
Denitrification			41
Fire	4	120	1200
Biogenic gaseous emissions	-	8–154	-
Total outputs	**80–106**	**347–507**	**2283–2363**

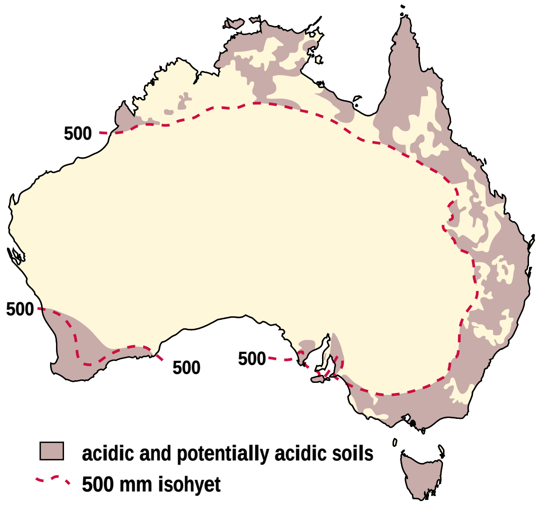
Source: derived from McLaughlin *et al.*, 1992.

- acidifying fertilisers, usually nitrogen fertilisers applied in intensive agriculture, or elemental sulfur
- nitrogen and carbon cycle effects such as nitrogen fixation by legumes and subsequent nitrification and nitrate leaching or increased soil organic acids
- removal of plant products that have more basic cations than inorganic anions and redistribution of nutrients through grazing animals
- acid deposition from the release of oxides of sulfur and nitrogen as gases from industrial sources, sulfide-ore processing or coal-fired power generation
- natural weathering processes driven by rainfall leaching and the action of soil organic acids and carbonic acid; these processes are usually very slow, but many Australian soils on stable landscapes have reached a significant stage of acidification due to extensive leaching and weathering over long periods of time

Soil types vulnerable to acidification are well known (see Fig. 6.20) but the exact distribution of affected soils is not. An estimated 29 million ha of mainly agricultural land are regarded as significantly acidified, at least in the surface layers. Significant areas affected by acidification extending into subsoil layers pose more serious problems for root development and greatly increase remediation costs. Trends in soil acidification are causing concern on some sugar plantations, in intensive horticultural industries and in the northern Australian grazing lands where tropical legumes have been introduced. The extent of acid sulfate soils in Australia is now being assessed.

Soil acidification can be prevented or remedied by applying lime or dolomite as sources of alkaline material. Land managers in areas of acidifying soils have not universally adopted liming practices, despite demonstrated benefits and knowledge of how critical the problem is. Recent estimates in South Australia suggest that only about 10 per cent of the area thought to require liming received applications over the last 10 years. If deep subsoils are acidified the damage will be expensive to repair (Helyar *et al*., 1988). Other approaches to the problem include the manipulation of management systems (for example, limiting the removal of nutrient-rich products such as hay), and the use of tolerant plant varieties.

Figure 6.20 Acidic and potentially acidic soils in the agricultural regions



Source: CSIRO Division of Soils.

Soil contamination

Scientists do not have a good understanding of how contaminants are distributed and move in Australian landscapes. Most of the available information relates to contaminants associated with food (see the box on page 6-49) and water quality (see page 7-34). Researchers have paid minimal attention to the impacts on natural ecosystems.

Impurities in fertilisers and in soil amendments such as lime and gypsum include arsenic, cadmium, fluorine, lead and mercury. Cadmium is the element of most concern because significantly more of it is transferred from soils to the edible portions of agricultural food crops. Some agricultural produce currently exceeds maximum permitted concentrations. However, levels are in a similar range to, or lower than, those found internationally.

Cadmium concentrations in Australian phosphatic fertilisers have been high by comparison to fertilisers used in other countries. However, lower inputs of fertiliser per unit area than in Europe and less contamination of soils from industrial sources have resulted in similar or lower cadmium loadings to agricultural land. In recent years, people have addressed the problem by lowering cadmium levels in phosphatic fertilisers and developing plant cultivars that restrict its uptake. Acidification and salinisation of soils pose threats because they increase the uptake of cadmium by crops.

In the past, pesticides with harmful residues have been used to control pests and diseases in orchards and on a range of crops, particularly potatoes, tomatoes, cotton, bananas and sugarcane. They have also been used to control external parasites on livestock. Although harmful pesticides (such as organochlorines) are now banned in agriculture, they are persistent and their residues will continue to have an adverse impact on environmental quality.

The available information on the extent of contamination by pesticides and herbicides is patchy. The discovery of residues of organochlorines in beef exports in 1987 led to sampling of farms considered to be at risk because of their agricultural history. In Western Australia, surveys detected the pesticides chlordane, DDT, dieldrin and heptachlor in 18.4 per cent, 39.6 per cent, 39.0 per cent and 18.8 per cent respectively of 11 248 samples analysed (EPA WA, 1989). These samples did not include known hot spots such as soils near wooden power poles with a history of pesticide treatment.

Soils at cattle- and sheep-dip sites are contaminated with organochlorines like DDT and with other pesticides, such as arsenic. Thousands of such sites have been documented in northern New South Wales, where the consequences are particularly serious because of urbanisation and construction of dwellings on or near dip sites.

The extent of soil contamination associated with agrochemical usage in cotton, banana and other intensive agricultural enterprises is under investigation. In northern New South Wales and Queensland, past usage in banana and sugarcane production has resulted in contamination with organochlorines, while copper, arsenic and lead have been problems in orchards and market gardens.

Concentrations of endosulfan and other insecticides or of herbicides like atrazine have exceeded guidelines for the protection of drinking water and aquatic environments in the rivers of central and north-western New South Wales (Preece and Whalley, 1993).

The substantial benefits associated with the use of most pesticides in agriculture outweigh their risks especially since their safety and sophistication have increased during recent decades (Ferris and Haigh, 1993). The irony is that new farming systems such as minimum tillage or conservation farming, which conserve soils by minimising erosion and improving soil structure, rely on agricultural chemicals much more heavily than traditional systems. While the impact of this increased use of chemicals is not fully known, it is clear that land-managers require a substantial level of technical sophistication to use them safely.

Although rural lands surrounding industrial areas and cities are contaminated, serious impacts are usually localised — except where contamination of streams or groundwater is involved. As an indication, dispersed heavy metals from lead smelters at Port Pirie can be detected over thousands of square kilometres, although seriously contaminated areas are restricted to tens of square kilometres (Cartwright *et al*., 1977). Other urban-generated pollutants such as lead can also be widely dispersed (Tiller, 1992).

Soil biology

Australian soils host a wide range of soil organisms, varying in size from micrometres (for example, bacteria, protozoa and fungi) to several centimetres (insects and earthworms). One square metre of soil may support populations of about 200 000 arthropods and enchytraeids and billions of microbes. One hectare of good-quality soil could contain 1000 kg of earthworms, 1000 kg of arthropods, 150 kg of protozoa, 150 kg of algae, 1700 kg of bacteria and 2700 kg of fungi. Although we know soil organisms break down organic materials in soils, their role in agricultural productivity and the way different management systems affect them remain poorly understood. Thus it is not easy to assess the biological health (increasingly recognised as a key index of sustainability) of Australian soils or predict the effects of particular practices. People are starting to recognise the importance of soil organisms and placing more emphasis on balanced ecosystem management within agricultural systems.

Aspects of soil biology are sometimes manipulated to improve production. For example, inoculating legume seeds with *Rhizobium* spp. makes atmospheric nitrogen available through a symbiotic relationship between the bacteria and the legume. Highly productive pasture systems in Australia's temperate regions are based on nitrogen fixation by medics and clovers. While these systems provide the benefit of increased soil organic matter, in the long term they can also increase soil acidity to harmful levels. Some land management practices may introduce or favour pests and diseases. For example, crop sequences and management practices can affect the spread of fungal pathogens (like *Phytophthora* or *Fusarium* spp.) and nematodes, or the population densities of organisms such as wireworms or earthworms. Soil surface conditions, particularly the amount of surface litter and the type of tillage practised, influence the suitability of the soil habitat. Surface litter provides food and shelter for macrofauna whose burrows increase aeration and infiltration, while tillage discourages earthworms.

Land resource surveys for good land management

Land managers across large parts of Australia operate with only a rudimentary and sometimes erroneous understanding of the condition, productive capacity and potential hazards associated with the use of land.

Maps of soil and land resources are essential for the development of sustainable systems of land use. Unlike other comparable countries, many parts of Australia have no detailed maps of soil and land resources. Consequently, land use proceeds by trial and error with unnecessary economic and environmental costs, many of which have been documented in this report. The lack of comprehensive survey coverage also severely limits the conclusions that can be drawn about the state of the Australian environment.

The effort directed towards land resource survey by State and Territory agencies has increased during the last decade with funding from the National Landcare Program. However, with the existing level of staff and resources, it would take more than a century to map the arable and forested lands of Australia, which cover only 16 per cent of the continent, at a scale suitable for guiding decisions on practical land management. (For example, 1:25 000-scale mapping or larger is required for farm plans, urban development or forest operations.) Despite this daunting task, land resource agencies have done much to improve the coordination and quality of their mapping programs during the last five years (McKenzie, 1991). This has been achieved through the establishment of the Australian Collaborative Land Evaluation Program and better cooperation between State, Territory and Commonwealth agencies.

A survey scale of 1:100 000 is an absolute minimum for land management except for rangelands, where 1:250 000 is often adequate. These scales provide only a general framework for decisions on land management. It is clear that acquiring the basic information necessary to address contemporary problems of land planning and management will require a long-term commitment by the public and private sector to well focused and strategic land resource surveys.

Land use and land tenure

Land use

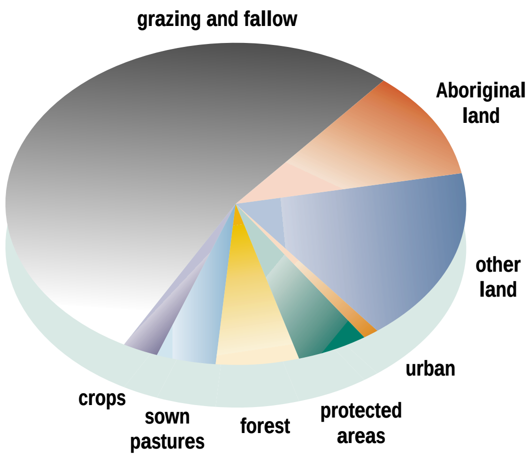
Agriculture is the largest land use in Australia (see Fig. 6.21) with the greatest area supporting grazing of cattle and sheep. Most of this grazing occurs in the rangelands in central and northern Australia (see Fig. 6.22), while cropping is concentrated on the coastal fringe. The area of land used for agriculture reached a peak of 500 million ha in 1975 and has since been declining slowly. Most of the change comes from the transfer of grazing lands to other uses including conservation, urban areas, Aboriginal title and unused land such as vacant Crown land. Agricultural establishments comprise about 460 million ha (or 60 per cent of Australia). Of this, crops or sown pastures grow on 47 million ha. Both these uses have increased steadily over the past 40 years from two per cent to six per cent of the land area.

The number of farming enterprises has fallen dramatically over the last 40 years (see Fig. 6.23). Much of this decline is due to smaller enterprises (defined as having an estimated value of agricultural operations of less than $20 000) being excluded from data collection from 1987 onwards. Nevertheless, the number of farming enterprises has fallen by about 1200 per year since 1950. The reduction of numbers has brought a corresponding increase in the average size of individual farms, from 2200 ha in 1951–52 to 3800 ha in 1992–93. The average area worked by each farm worker — including employers, self-employed people and unpaid family help — has increased from 930 ha in 1951–52 to 1270 ha in 1992–93.

Land tenure

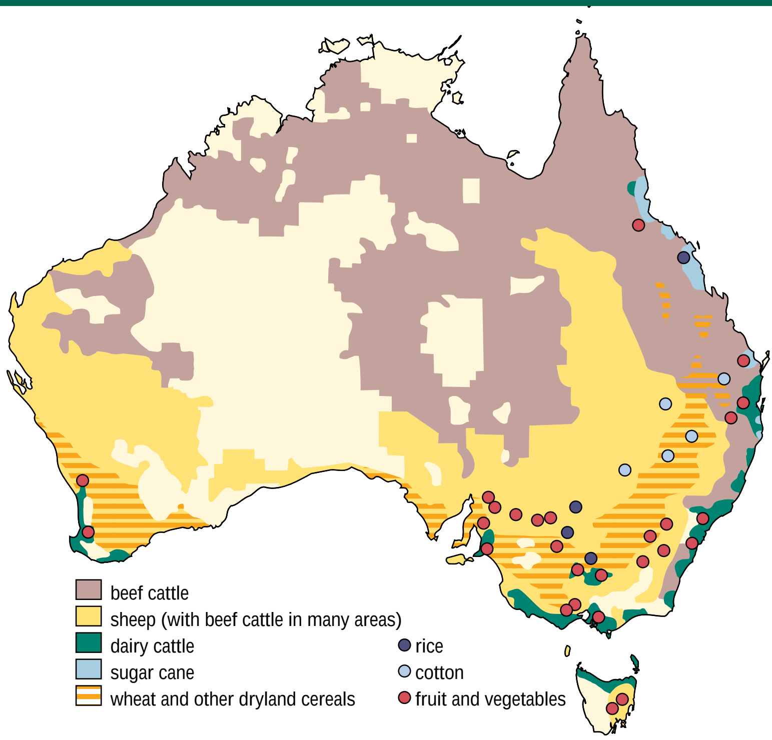
Australia is probably unique among Western countries in that a high proportion of our land is still publicly owned (Campbell and Dumsday, 1990). Most agricultural land is operated under long-term Crown leases. Only 13 per cent of the total area of the country has been converted to freehold title (BAE, 1983), and Queensland is the only State where this is still occurring for a significant proportion of land. However, the more

Figure 6.21 Land use in Australia 1990



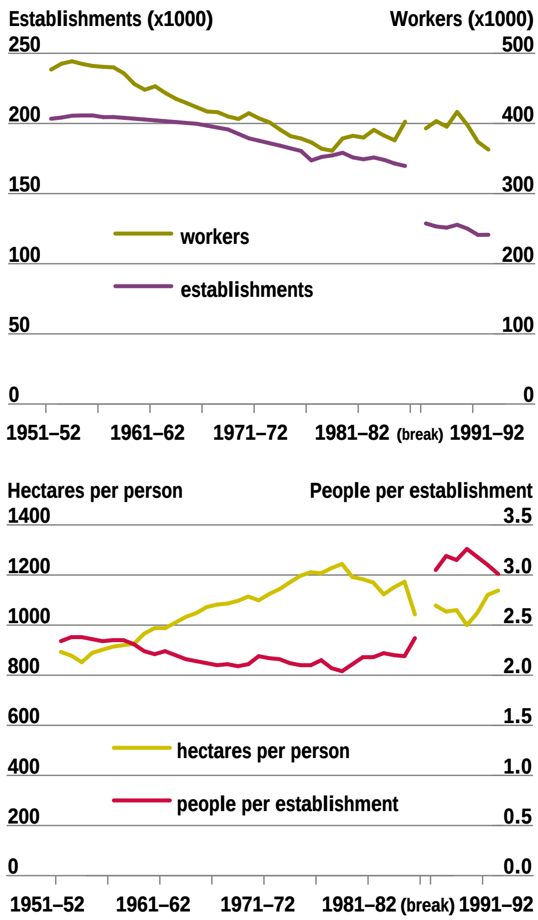
Source: data supplied by ABARE and ABS.

Figure 6.22 Agricultural land use



Source: ABS Yearbooks.

Figure 6.23 Number of agricultural establishments and area per worker



Source: data supplied by ABARE.

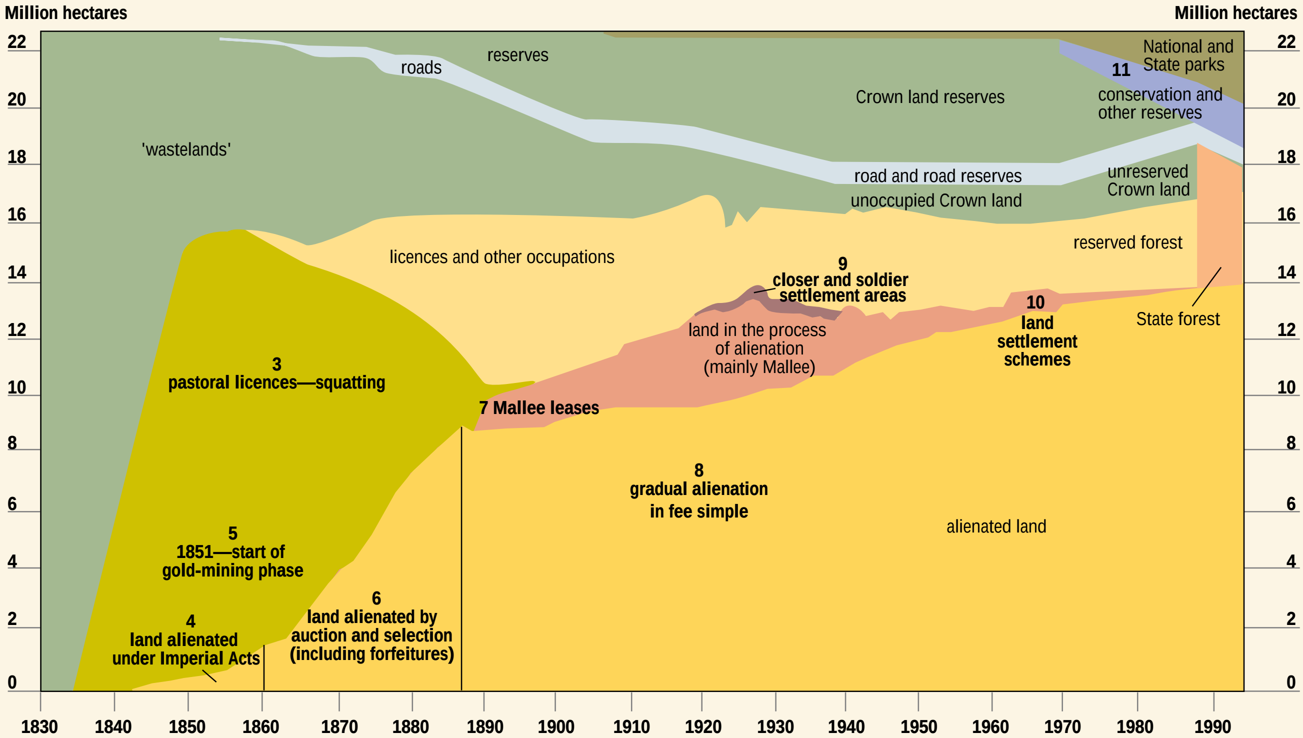
The evolution of land tenure in Victoria

The historical evolution of land tenure in Australia can be illustrated by the case of Victoria.

"'*Terra nullius*' was the term used to describe land tenure in Australia when James Cook's expedition landed at Botany Bay in 1770. It means land of nothing and, by implication, unoccupied or possessed by nobody, and was used as justification for the British Government taking possession of eastern Australia. By the same stroke that effectively dispossessed the Aboriginal people, Cook established the public land estate of Australia, in its best condition and greatest extent. Over the next 160 years, that estate diminished in extent and much of it deteriorated in condition." (Land Conservation Council, 1988).

Of course, much of the damage to the public land estate was neither deliberate nor recognised at the time. However, even if it had been recognised, some of the damage would have been seen as a cost that could not be avoided in furthering the development of Victoria through industries such as agriculture and gold-mining.

In recent years there has been a steady increase in the area of 'protected' land in Victoria, largely at the expense of commercial agricultural leases on public land. The increase is in line with that for Australia as a whole.



Date		Phase	Pressures on public land estate
1770		Cook's landing at Possession Island	Establishment of the public land estate of New South Wales, including the area later to become Victoria.
1788	1.	First Fleet	First European settlement — clearing of vegetation; hunting of fauna with firearms
Early 1800s	2.	Sealers and whalers	Harvesting of native fauna
1820s to 1890	3.	Pastoral settlement — squatting	Damage to ground flora; competition with grazing fauna; spread of weeds; erosion
1837 to 1860	4.	Alienation under Imperial Acts	Loss of public land; clearing, cultivation, and removal of indigenous flora and fauna
1851 to 1860	5.	Gold-mining and associated settlements	Clearing, timber extraction; mining-sludge deposition; erosion; water pollution; flooding
1860 to 1887	6.	Extensive loss of public land	Extensive loss of public land; widespread clearing, cultivation, and removal of indigenous flora and fauna
1888 to 1970	7.	Mallee settlement and other leasehold	Leasing and later alienation of the mallee country; other new ateas opened for selection; effects as above
1888 to 1970	8.	Gradual alienation of public land	Loss of public land and its values as for 4 and 6 above
1919 to 1970	9.	Closer, soldier, and rural settlement schemes	Some areas of public land developed by the State and alienated for farming; effects as above
1960s	10.	Little Desert, Big Desert and other land settlement schemes	Limited areas settled
1970s to 1990s	11.	Withdrawal of agricultural leases from some public land, including Little and Big Deserts	Increase in the area of 'protected' public land

Source: Adapted from Land Conservation Council, 1988.

fertile parts of Australia have a much higher proportion in freehold tenure. For example, about 60 per cent of land in the wheat–sheep zone is privately owned.

Governments reserve about 30 per cent of Australia's land for forests, urban, transport and other purposes, while approximately 53 per cent is made available for commercial use under Crown leases. These are commonly long-term or perpetual and are mostly taken up by agricultural and pastoral interests. Such land is generally secure in tenure and marketable. In management terms, there appears to be little practical difference between freehold and long-term or perpetual leasehold land.

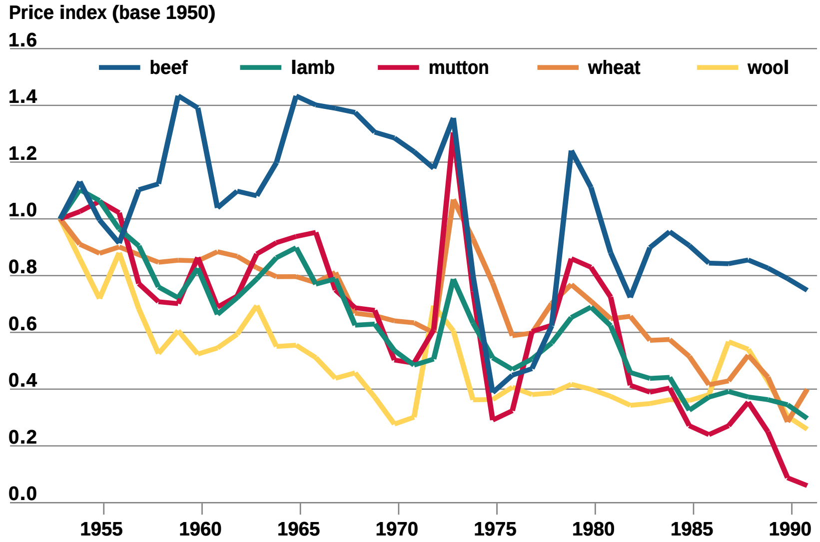
Australian governments have gradually increased the area of 'protected' publicly owned land. Protected areas include land within national or State parks and wildlife or conservation reserves.

The main changes in land tenure in recent times have arisen from recognition of Aboriginal claims. The *Aboriginal Land Rights (Northern Territory) Act 1978* gave freehold title to 240 000 sq km of former reserve land. In 1990, approximately 11 per cent of Australia, in the form of reserves, freehold and granted land, was held by Aborigines, predominantly in the Northern Territory, Western Australia and South Australia (ABS, 1992). The Commonwealth *Native Title Act 1993* will almost certainly lead to more significant changes in land tenure.

Is Australian agriculture sustainable?

Sustainable agriculture is based on the principles that: the supply of necessary inputs is sustainable; the quality of basic natural resources is not degraded; the environment is not irreversibly harmed; and the welfare and options of future generations are not jeopardised by the production and consumption activities of the present generation. There is a further objective, which is to maintain or improve yield. Clearly, sustainability is a complex issue that cannot be easily evaluated for modern agricultural systems.

Figure 6.24 Index of product prices adjusted for inflation



Source: Hone, 1994.

Sustainability of resources and ecosystems

The use of land for agriculture inevitably changes land qualities and processes from the natural state. Habitats on the site itself are destroyed or altered through land clearing and other sites may be damaged, for example, through sediment deposition in streams. These changes to the basic qualities of the resource, although often imperceptible against the effects of seasonal fluctuations, incur an on-site cost to the producer and an off-site cost to the community. If these costs rise, eventually agricultural practices may need to be adjusted to maintain economic viability of farms and quality of life for communities.

The condition of land resources is fundamental to sustainability since it is the key to the capacity of the land to sustain future uses. Many soil properties, such as organic matter content, soil structure, nutrient availability, water-holding capacity and acidity, influence productive capacity. A major difficulty when trying to assess sustainability in terms of the condition of land resources is the lack of an agreed set of indicators, without which we cannot assess either condition or trend in a consistent and comparable way. National efforts are being made to develop sustainability indicators. However, even when key sustainability indicators are selected and data collected regularly, it will be difficult to separate gradual permanent changes from seasonal variations. We need to be able to predict the accumulated effect of changes and to separate these permanent changes from temporary effects.

Crop yield integrates the effect of many different factors, including changes to basic soil properties. However, it is not a reliable short-term indicator of soil quality. Farmers seeking higher yields will use management inputs (such as new varieties and fertilisers) to improve conditions for plant growth. These inputs change over time and their effect, which is in a sense the sum total of the impact of advances in agricultural technology, may completely mask any tendency for yield to decline due to soil degradation.

The question of sustainability is one of time scales. It is difficult for individuals to see beyond the next few years based on their recent experience. But the threats to sustainability may develop insidiously over many years. For example, in Mesopotamia, an average decline in yield of less than 0.1 per cent per year due to salinisation, over 700 years from 2400 BC, eventually made irrigated cereal production unsustainable (Gelburd, 1985). This was despite adoption of new technologies such as salt-tolerant crops.

One way to assess sustainability is to choose a fundamental measure of soil condition — say, water-holding capacity — and assess the impact of the most powerful degrading process, such as soil erosion. Using computer-based simulation models (see the box on page 6-38), researchers can forecast the likely effects (including the effect on yield) of various management options.

Economic viability of agricultural production

The economic viability of Australia's agricultural production has been under pressure for four decades because of our heavy dependence on competitive export markets. While nominal (undeflated) agricultural commodity prices in these markets have risen, 'real' prices (market prices deflated by the Consumer Price Index) have declined (see Fig. 6.24). Real per-unit prices of inputs have also fallen, but at a slower rate. As a result, the real net income per farm in Australia has fallen steadily over the past 40 years and is now only about 60 per cent of its level in the 1950s. But the number of farms has also fallen, resulting in a fall in the total real value of agricultural production to 40 per cent of its level in the 1950s (see Fig. 6.25).

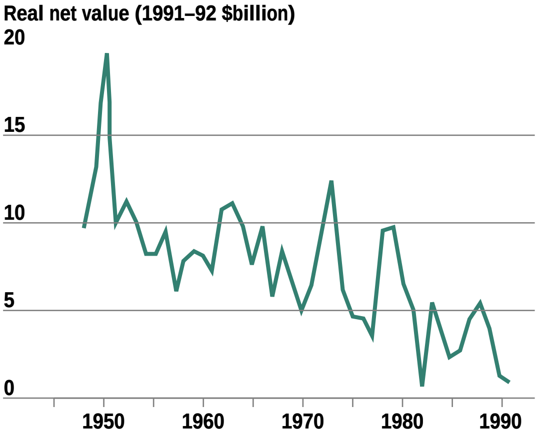
These changes to economic viability are due to market forces, which have placed enormous pressure on farmers to increase their productivity by applying new technologies that will make production more efficient while not necessarily accounting for any adverse changes in resource condition. As these economic pressures can be expected to continue, we can examine past productivity trends to assess the overall resilience of Australian farming systems, as shown by trends in wheat yield and agricultural productivity.

Trends in agricultural yields

Analysis of mean Australian wheat yields for each decade since 1870 suggests that early agricultural practices were unsustainable (Donald in Hamblin and Kyneur, 1993), but since about 1900 yields per unit area have steadily increased (see Fig. 6.26). Yield data provided by the Australian Bureau of Statistics (ABS) and the Australian Bureau of Agricultural and Resource Economics (ABARE) for coarse grains, oilseeds, rice and cotton also show increasing trends.

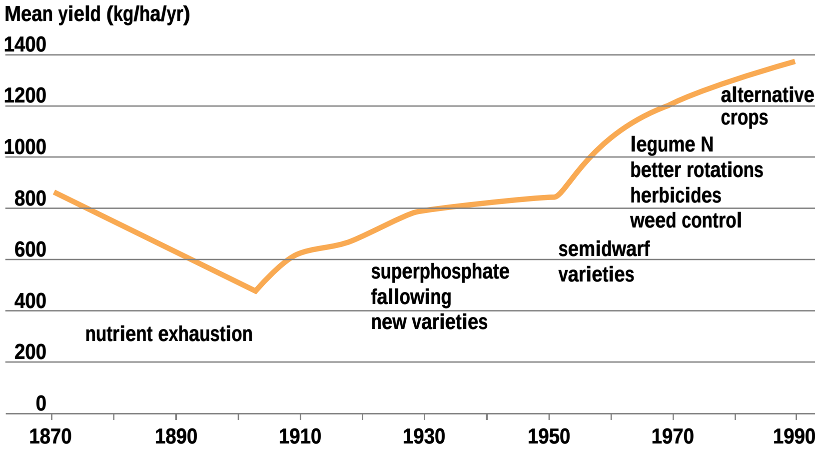
However, increasing trends in overall yield may hide negative trends in some areas (Hamblin and Kyneur, 1993). Any such negative trends suggest that enhanced technologies either are not being applied or are not compensating for adverse changes in soil resources. In the sugar industry, for example, ABS and ABARE data and observations by researchers (Henzell, 1992) indicate that a yield plateau has occurred for the last 20 years, despite the adoption of potentially higher-yielding varieties. These negative trends or lack of expected response to yield-enhancing technology inputs may indicate that the system is becoming unsustainable.

Figure 6.25 Net value of farm output adjusted for inflation



Source: Chisholm, 1992.

Figure 6.26 Trends in wheat yields since 1870



Source: Hamblin and Kyneur, 1993.

Trends in agricultural productivity

Yield data provide one measure of productivity, but they ignore the resources, other than land, required to produce yields. 'Total factor productivity' (TFP) is an index of productivity growth that attempts to incorporate all the resources (or factors of production) used and all products for an industry. Estimates of TFP provide a measure of the overall productive capacity of agriculture.

A viable long-term agricultural system could be defined as one where TFP and output over time are constant or increasing. It would be difficult for agricultural industries to meet this criterion if substantial land degradation was occurring. For example, severe erosion would normally result in reduced crop yields or an increased need for fertilisers, or both, leading to reductions in TFP. On the other hand, the discovery of a trace element deficiency that is severely limiting yields and that can be overcome at little cost would lead to increases in TFP and output.

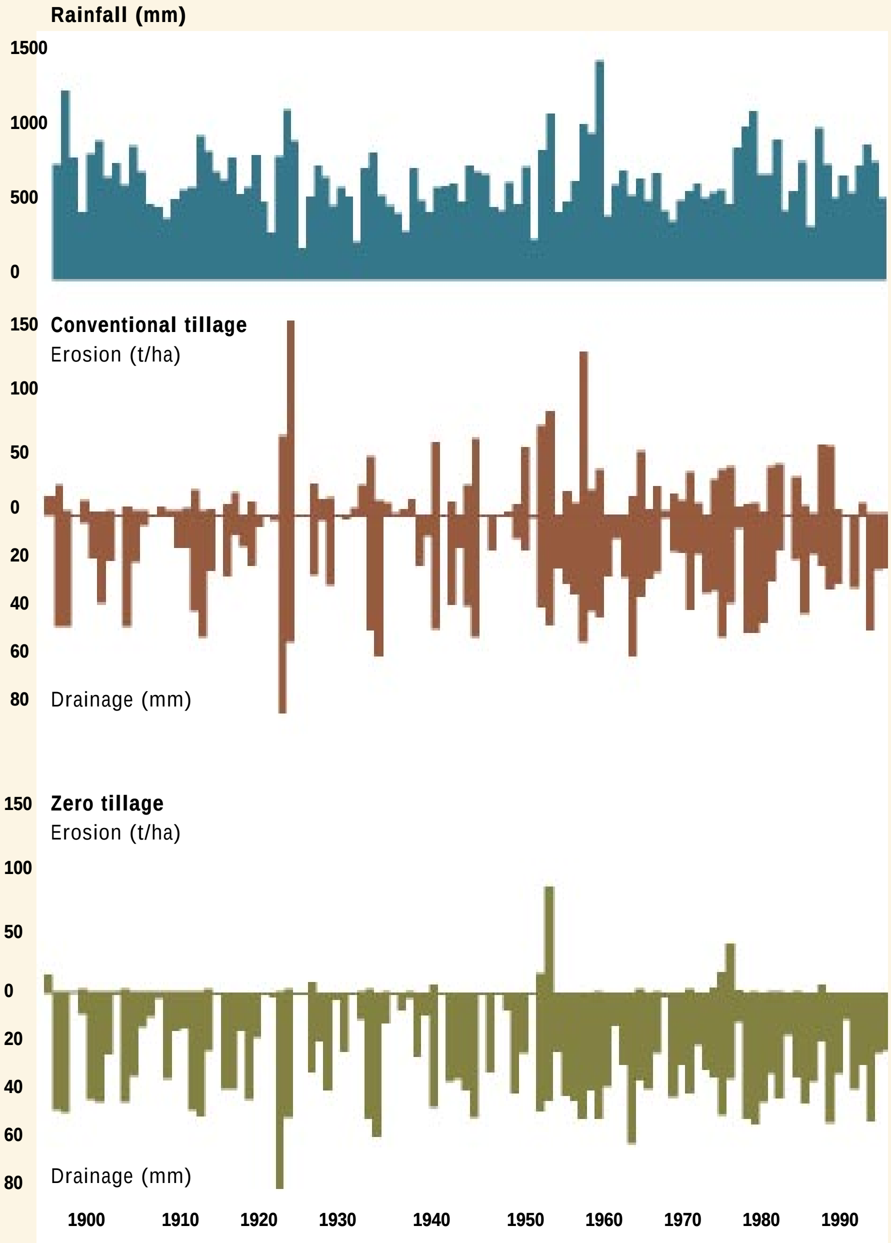
Over the last 40 years, substantial increases in TFP have occurred in agriculture, both globally and in Australia (Chisholm, 1992). Knowledge is the key resource accounting for the increase (Crosson and Anderson, 1992), which has been accompanied by only a modest expansion in the quantities of land and water devoted to agricultural production (Chisholm, 1994). The increases in global productivity have been the main cause of the decrease in real commodity prices.

Over the 40-year period from 1950 to 1989, farm output in Australia increased two and a half times,

Computer models as a guide to resource sustainability

Australia has a strong tradition of scientific research into environmental constraints and innovative agricultural management practices. However, climatic variability means that field experiments have to be run for several years to sample a representative range of seasons. For example, records show that much soil erosion by water occurs in infrequent and episodic catastrophic events. Thus, field investigation of the effect of erosion on sustainability is expensive. In recent years computer-based models have been used to simulate natural systems. This approach integrates data from many experiments, and knowledge from many sources, into mathematical equations. Data such as long-term daily rainfall records are entered into the model, which generates predictions that can be used to compare sustainability of systems under various land management options, without the time and expense of field experiments.

For example, the bar charts generated by the PERFECT (Productivity Erosion Runoff Functions to Evaluate Conservation Techniques) simulation model (Littleboy *et al*., 1989) show the episodic nature of events and the need to consider more than one aspect of soil degradation. The simulation results show that zero tillage greatly reduces soil erosion. On the other hand, it increases deep drainage, which could increase shallow water tables and salinity, although this is not yet a problem. Opportunity cropping (not shown) is another option in which sowing is timed to optimise use of water stored in the soil: it shows the importance of timing sowing to use available soil water. This option reduces deep drainage but increases erosion slightly. On balance, opportunity cropping is considered to be both more profitable and less degrading of soil resources.



A simulated comparison of two management practices showing effects of erosion and drainage.

Source: Littleboy, M., unpublished.

or about 2.5 per cent per year, while real per-unit costs of production declined. The rate of increase in output per unit of land over the last three decades has been higher than for any other OECD country (Alston *et al.*, 1993), reflecting the skill and effectiveness of Australian scientists and farmers to develop and apply enhanced technologies to sustain agricultural production systems.

The relationship between land degradation, conservation and productivity growth is complex. As productivity increases, land quality may remain unchanged, improve or decline, depending on the nature of the technology. While land is included in the calculation of TFP, it is not measured in a way that fully captures any decline or improvement in its quality. Nor are off-site degradation effects included in the calculation.

Until we know more about the damage to other ecosystems, we should not draw firm conclusions about the sustainability of agriculture.

Research and development will be increasingly important to the international competitiveness and sustainability of Australian agriculture. If the industry cannot retain competitiveness in a sustainable way, we can expect to see large changes in the way rural land is managed. As in the case of mining, we may see some land move in and out of agricultural production as technology and prices change. Other land may be permanently allocated to non-agricultural uses.

Response

The Australian community's responses to the perceived state of land resources reflect public perceptions of national needs and priorities of the times. Earlier concepts of land are part of our culture and heritage. In recent times the community's focus has moved from establishing productive industries in a pristine but harsh environment, and populating a vast land, to concern about sustainability of industries, the land resources they use, keeping land for conservation purposes, and the impact of increasing populations. It is not surprising that this change has occurred as we approach the limits of land development for agriculture and other purposes including conservation. Concern about the state of the nation's land resources has led governments, industries, communities and individuals to respond in a variety of ways.

Responses may be designed either to change the pressures on a particular resource and thus affect its future condition or to directly change its current state. They vary in their effectiveness: some are inappropriate and may become pressures in their own right — for example, the introduction of pasture plants that become weeds and drought-relief measures that encourage inappropriate risk-taking behaviour.

Governments, industries and communities have all responded to problems relating to land resources. The responses include soil conservation measures, codes of practice for mining and forestry operations, educational programs, drought relief and rural adjustment schemes. Some responses have encouraged land clearing while others have restricted it.

In recent years, the overall nature of the 'response' has changed. People are increasingly aware of the need for sustainable resource development and use within the whole community. Whereas in earlier times, government was seen as the custodian of natural resources, a range of other stakeholders now take greater interest in resource use. Individuals and community interest groups wish to be involved in decisions on allocation and use and in monitoring and evaluation. Also, users, including industry, are expected to act responsibly and to develop and apply sound codes of practice. Governments are expected to compile data on resources and resource uses and to ensure that there is accountability in their allocation and use. This results in a 'whole-of-community' involvement, but also means that individual resource-users or groups of users are taking more of the responsibility.

Many of the responses relating to land resources also affect other components of the environment, and are covered by other chapters in this report. This chapter highlights a series of responses, selected because they are important for determining the state of our land resource, because they provide a historical perspective to our attitudes or because they represent current trends in public and private responses.

Land clearing

Throughout our agricultural history, governments have used various means to encourage land clearing. Some land purchase agreements required it, taxation incentives encouraged it and Departments of Agriculture provided advice on how to clear. At the same time, these Departments were encouraging farmers to plant trees for shade, shelter and wood products, particularly in regions that were naturally treeless. By the 1980s concern about land degradation and the decline in native vegetation had become widespread. This resulted in the Commonwealth Government establishing the National Tree Program in 1982 to reverse tree decline by promoting action at individual, community and government levels to conserve, regenerate and plant trees. In 1989, the Commonwealth Government established the 'One Billion Trees' and 'Save the Bush' programs to protect and enhance native land cover. In 1992 these programs were brought under the administrative umbrella of the National Landcare Program.

To date, $12 million has been spent under the 'Save the Bush' program. Of this, $6.4 million has been provided to community groups for projects involving protection and management of native vegetation. A further $31 million ($3.7 million as community grants) has been spent under the 'One Billion Trees' program, with an estimated 550 million trees being planted or regenerated. However, there has been little assessment of how these programs have affected the extent of tree cover or conservation of bushland. At best, they make a relatively modest contribution.

By the mid 1980s to mid '90s, concern about the rate of disappearance of native vegetation, and associated land degradation problems resulted in the establishment of legislative or regulatory controls on land clearing in most States (see Table 6.8). Statistics for South Australia and Western Australia indicate that, for these States, clearing controls have resulted in retention of significant areas of native vegetation that would otherwise have been cleared. For example, in Western Australia over the period 1986–94, notices of intent to clear were received for 271 784 ha; 24 per cent of this area was retained. This includes additional areas retained (other than the area notified) as a condition of clearing. In South Australia, 97 per cent of the applications to clear relatively intact native vegetation with an understorey received under the *Vegetation Management Act 1985* (which provided compensation for those refused consent) were refused. Under the *Vegetation Act 1991* the few applications received for broadacre clearance have been refused. About half the applications to clear scattered trees have been approved, with approvals invariably tied to conditions such as the replanting of at least 10 trees raised from local seed and the removal of domestic stock from areas of native vegetation, to encourage regeneration.

The need to compile information at a continental level for the first National Greenhouse Gas

Inventory in 1994 highlighted the lack of data available on land cover. Victoria, South Australia and Western Australia have mapped their tree cover recently and a major program is under way to map the vegetation of the Murray–Darling Basin. However, in the other States, no land cover data were available, and only Victoria was monitoring changes in land cover. The results of the inventory indicated that recent land clearing for agriculture could be much more extensive than previously recognised, and may make a major contribution to Australia's greenhouse gas emissions (see page 6-13). In responding to the findings of the inventory, the Commonwealth Government has provided funding for a State–Commonwealth program to assess agricultural land cover change across the continent between 1990 and 1995. The information produced from this program will reduce some of the uncertainties in estimating national emission levels and help develop further policy responses to land clearing.

Pest animals and plants

Community, government and industry all address problems caused by pests at a number of levels. The main channel for the wider community to contribute directly is Landcare (see page 6-43). The Australian Trust for Conservation Volunteers provides opportunities for local and international visitors to devote time to special projects. Both groups, for example, have assisted with rabbit control and weed management programs. Clearly, the whole community contributes indirectly through payment of taxes and levies.

The Commonwealth Government is active in many spheres. The Bureau of Resource Sciences runs a vertebrate pest program, which deals with pest animals in agricultural production. The Australian Nature Conservation Agency (ANCA) has a feral pest program, which addresses the problems of pest management for conservation purposes. The government has also established national bodies like the Australian Plague Locust Commission to deal with specific pests.

Commonwealth funding supports many institutions that are researching pest management — for example, the Vertebrate Biocontrol Centre and the CRC for Tropical Pest Management. The CSIRO is funded federally and also, for pest research, by other agencies and industries. Its Division of Entomology, for example, is

Table 6.8 Summary of land clearing regulations

	Most recent significant changes	Summary
South Australia	1985 and 1991	Consent required to clear any native vegetation; heritage agreements with some financial assistance available for areas not approved. Agreements in place for 600 000 ha cost $70 million in compensation for first six years. No broadacre clearing approved since the Act came into force.
Western Australia	1986 and 1995	Permission required for clearing of areas larger than one ha of native vegetation. No compensation provisions. More than 80 per cent of requests approved and conditions tightened in 1995. Some funding available to maintain remnant vegetation for soil conservation. Technically, Conditional Purchase Lease system still applies over 800 properties, requiring them to be half cleared before they can be converted to freehold.
Victoria	1989	Clearing of blocks of native vegetation larger than 0.4 ha is subject to approval. No provision exists for compensation but heritage agreements may provide financial assistance.
Queensland	1995	The Government has released a preliminary policy for tree clearing on leasehold lands which will be proclaimed under the Lands Act, 1994 when local guidelines have been finalised. A satellite monitoring program has also been established. These restrictions are opposed by some land-owner groups. Many piecemeal measures are administered by State and local governments.
New South Wales	1995	A State environmental planning policy was introduced in August 1995 to control clearing on freehold land. Following community consultation, the Government will consider further amendments, options or alternatives to this policy. Previously existing controls include the Western Lands Act, provisions under the Soil Conservation Act and regional and local environmental plans.
Northern Territory	1992	Commercial activity involving the destruction of vegetation on Crown land or leasehold must be licensed. Some provisions exist under the Pastoral Land Act. Few measures are in place for private land.
Tasmania		Few measures exist, other than at local government level and some provision for private reserves.
ACT		There is no freehold land; vegetation protection is usually incorporated in lease provisions.

Source: Derived from DEST.

investigating major insect pests of crops, pastures and livestock, as well as biological control of weed species. ANCA researches the management of environmental weeds, many of which also have an economic impact. The Commonwealth Government provides further support for weed research through organisations like the Land and Water Resources Research and Development Corporation, the International Wool Secretariat and the Meat Research Corporation. Federal and State agencies are finalising the National Weed Strategy, which will provide guidelines for better weed management and will integrate the efforts of governments, industry, landholders and land managers, community groups and the general public.

State and Commonwealth governments have developed legislation relevant to pest management. Some Acts — such as the Commonwealth's *Quarantine Act 1908*, New South Wales *Noxious Insects Act 1934* and Victoria's *Vermin and Noxious Weeds Act 1958* — relate directly to pests. Other legislation important to pest management includes the Commonwealth's *Agricultural and Veterinary Chemicals Code Act 1994* and various State Acts on soil and land conservation. The Commonwealth Government provides taxation relief for management activities like woody weed clearance.

Departments of Agriculture, Primary Industry, Land and Conservation share responsibility for pest management at State government level. Arrangements differ between States. Some have Agriculture or Pasture Protection Boards to promote research and provide management support for pest control. In some cases, control activities are undertaken through cost-sharing with landholders. For example, an agency may provide equipment and skilled personnel while the landholder contributes financial support.

Industries support pest and weed research through organisations like the Meat Research Corporation and the International Wool Secretariat. Within particular industries, land-owners, managers and land users spend much money, time and effort controlling pests and diseases. They work as individuals and within groups like Landcare, and they contribute to research and development through industry levies on their commodities.

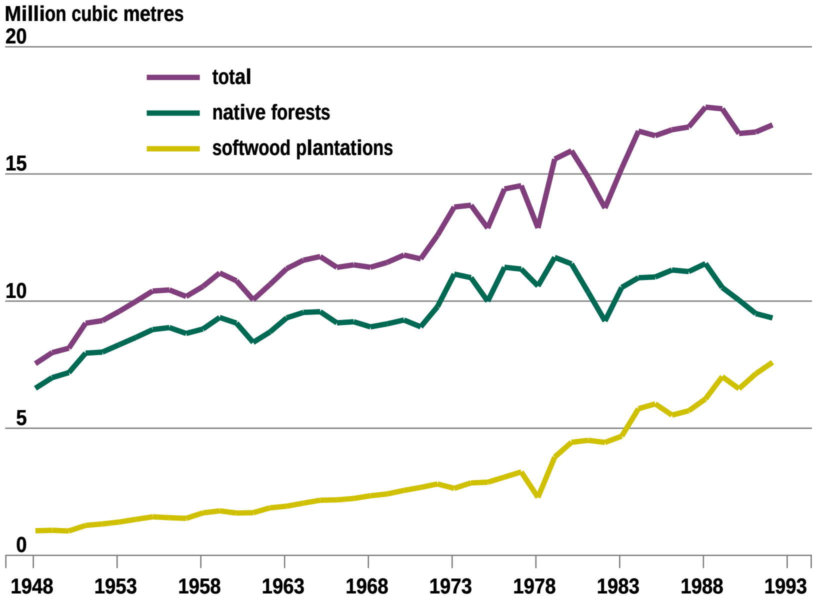
Forests

Forests have always been a major source of food and shelter for Australia's human inhabitants. Aborigines made significant use of forested areas before Europeans arrived. With the arrival of the First Fleet, many of the most valuable timber trees were selected for cutting. The colonists sent the first exports from Australia in 1791 and many settlements were positioned to exploit nearby timber resources. In the early 1800s, the government introduced regulations to control timber-getting and to raise revenue.

The gold rushes of the mid 19th century greatly increased the demand for timber and agricultural land, and large areas of forest around major diggings were clearfelled. South Australia, the State with the smallest forested area, was the first to adopt legislation designed to manage the forest resource. In the 1870s, the State provided incentives for land-owners to plant trees, set up conservation reserves and began establishing radiata pine plantations. Other States soon followed. After Federation, the States retained responsibility for forest resources and by the 1920s all had set up forest management agencies. During the 1930s, these agencies adopted the principles of multiple use. Forests were to be managed to contribute to timber production, watershed protection, recreation, conservation and grazing. World War II was a turning point in forest management. The demand for timber products increased greatly in the post-war years and State governments instructed their forest agencies to service that demand. Large areas of public and private native forest were felled, while agencies increased the establishment of softwood plantations (see Fig. 6.27). New technologies, such as chainsaws and tracked vehicles, became more readily available. The volume of timber extracted from native forests almost doubled in the 20 years following World War II. Since then the volume harvested has increased by only a small amount, some of which is due to new technology allowing a greater log yield per area harvested. The greatest gains have been in harvests from softwood plantations.

Meanwhile, public interest in conservation increased during the 1960s and 1970s and most States established government agencies specifically responsible for conservation. Conflict increased between organisations (both government and non-government) supporting conservation on the one hand and timber production on the other, leading to a series of confrontations over forest-use issues. These disputes often overflowed into the Commonwealth–State arena because, although

Figure 6.27 Harvesting from Australian forests



Source: ABARE.

The national drought policy

In 1992, Commonwealth and State Ministers agreed to a national drought policy based on principles of sustainable development, risk management, productivity growth and structural development in the farm sector. Its objectives are to:

- encourage primary producers to adopt self-reliant approaches to climatic variability
- maintain agricultural and environmental resources during periods of extreme climate stress
- ensure early recovery of agricultural and rural industries, consistent with long term sustainable levels

The policy includes measures to: encourage farmers to become more self-reliant; ensure the longer term profitability and sustainability of farming; provide welfare assistance for marginally profitable farmers; help re-establish unprofitable farmers; and provide special funding support in extreme drought.

Defining drought, in its various intensities and extent, has long been a contentious issue for those forming drought policy. The Commonwealth Government has now adopted a national system for considering drought declarations by State and Territory governments. The Commonwealth can also make 'exceptional circumstances' declarations for drought. The criteria to be taken into account by both the Commonwealth and the States when considering cases for drought 'exceptional circumstances' declarations are: meteorological conditions, environmental impacts, agronomic and stock conditions, farm income levels, water supplies and scale of the event.

Policy measures available to farmers to deal with drought include:

- Income Equalisation Deposit and Farm Management Bond schemes to increase self-reliance
- a drought-preparedness investment allowance
- Landcare, for maintaining and protecting the resource base
- the Rural Adjustment Scheme to improve farm productivity

Drought is a natural and recurrent feature of the Australian climate.

- the Farm Household Support scheme to improve farmers' welfare
- drought relief payments to assist farmers in extreme drought

A drought research program focuses on three main issues that will allow farmers to anticipate and prepare for drought and respond quickly and appropriately when faced with drying conditions: climate forecasting, drought-risk monitoring and decision support for farm risk management.

Destocking early in the onset of drought is the best way to protect natural resources on grazing lands. However, there are difficulties in providing financial support at an appropriate time to ensure that resource degradation does not occur and that bad management through overstocking is not rewarded.

Large areas of Australia have been suffering extreme drought in recent years. Consequently it will take some time for the country to feel the full impact of the new policy as many producers still have to develop the capability for self-reliance. Even so, the policy, which focuses predominantly on farm business issues, only partially addresses core issues of sustainable land management.

forest management is a State responsibility, the Commonwealth has powers in relation to international agreements such as World Heritage and to export licensing (in particular, woodchip exports), and responsibilities with respect to the National Estate.

Woodchipping, especially woodchipping for export, is a contentious issue in Australia. All States maintain a forest policy that is 'sawlog driven'. That is, logging operations are supposed to be justified only by the sawlogs they produce. But logging waste (branches and unsuitable logs) are also sold for woodchips. The issue provokes such intense debate because it is the value of woodchip sales that makes the logging of many coupes financially viable. Also, whereas almost all timber products are retained in Australia, most woodchips are exported. This allows the Commonwealth to exert an indirect influence over the choice of forests to be logged (usually a State matter) by controlling woodchip export licences.

The disputes over forest use culminated in the Resource Assessment Commission (RAC) Inquiry into the Forest and Timber Industry which reported in 1992. This Inquiry was conducted against a background of opposition by conservation groups and large sections of the community to the logging of native forests, and pressures from other sectors for more secure access to develop and expand forest-based industries. The RAC did not make specific recommendations but identified and evaluated options. Its report addressed such questions as the environmental impacts of wood production on native forests, the sustainability of timber production, the role of plantations, the options for managing old-growth forests and the impacts of pulp mills (see the boxes on pages 6-18 and 6-20). Among the most important outcomes of the Inquiry were its conclusions that there were insufficient grounds to halt logging in native forests in general, but that logging old-growth forests potentially violates the precautionary principle, in that it destroys an irreplaceable resource.

The Ecologically Sustainable Development process occurred in parallel with the RAC Inquiry and included a working group on forest resources. Both processes influenced the contents of the National Forest Policy Statement to which the Commonwealth and States agreed in December 1992 (Tasmania signed in April 1995). The Statement outlines agreed objectives and policies for the future of Australia's public and private forests and sets broad national goals in relation to forest management and the forest industry. In 1991 the National Plantations Advisory Committee prepared a series of recommendations to accelerate the development of plantation forestry. An important conclusion was that while plantation forestry should be subject to appropriate codes of practice, it should not be subject to controls that would not apply to agricultural industries.

In summary, the approach outlined in the National Forest Policy Statement is that governments will set the regulatory framework for the use of native forests in order to achieve social and environmental goals, but within that framework market forces should determine the extent and nature of resource use. Two of the strategies being pursued by governments to meet the conservation goals are the establishment of a 'Comprehensive, Adequate and Representative' (CAR) reserve system, and the development of codes of practice to ensure that both commercial and non-commercial uses of public forests do not adversly affect the forests' ecological base. Each major forest region will have a Regional Forest Agreement between the States and Commonwealth that establishes the obligations and objectives of both governments. The agreement may specify land-use boundaries, forest management guidelines, and consultative arrangements between governments. These agreements will run for 10–20 years subject to regular reviews and are expected to create a more stable forestry environment.

A major goal of the National Forest Policy Statement was that the States and Commonwealth reach agreement over the reserve system, including the protection of old-growth forests. Progress in reaching these agreements has been slow and the deadline specified in the Statement of a completed comprehensive and adequate reserve system by 1995 for public lands was not met.

However, the process is being accelerated; criteria for the reserves are being set and the Commonwealth has made $53 million available in 1995–96 to ensure progress of the regional forestry agreements.

In mid 1995 the Commonwealth recommended as a broad benchmark for a CAR reserve system that at least 15 per cent of the pre-1750 extent of each forest type should be in secure reserves. Old-growth forests are to be given additional protection ranging from 100 per cent for the rarest and biologically most important to 60 per cent in more extensive forest types.

The first stage in the Regional Forest Agreements process was to identify, before the 1996 round of woodchip licence renewal negotiations, interim protection areas (deferred forest areas) to protect areas of high conservation value for a CAR reserve system. The negotiation of Regional Forest Agreements will occur over the following three to four years. States which fail to set aside the necessary areas and to enter into and progress negotiations on the agreements will suffer a 20 per cent per year reduction in export approvals.

The State of the Forests Report, being prepared by the National Forest Inventory, is expected to provide information on the history, ownership, size, composition and biodiversity of the national native forest and plantation estate. Other topics include forest-based industries, water quality, carbon inventory, social values, cultural heritage, research activities and broad management initiatives.

Land conservation legislation

All States established soil conservation agencies before World War II and all have long-standing soil conservation legislation. However, its effectiveness is difficult to assess without established criteria. Some researchers (Bradsen, 1992) conclude that it has generally been ineffective and that legislation revised in the 1980s contains weaknesses.

The role for individual land-users gained new momentum with the formation of land conservation district committees under the 1982 Western Australian legislation. Other States also recognised the importance of increased community involvement, as shown by the Landcare movement (see below).

The focus of concern has moved from 'soil' as a relatively narrow issue to a whole-system approach, where 'land' is used to embrace a range of issues. For example, South Australia passed the *Native Vegetation Management Act* in 1985 and the *Soil Conservation and Land Care Act* in 1989. This trend recognises that use and impacts of all resources are interlinked. The legislation being developed in Queensland (see the box on page 6-50) is another example of this trend.

Landcare — a community response

Concerns over soil erosion by water and wind in the 1930s prompted the development of government soil conservation programs. Farmers were involved in these programs through statutory boards and similar bodies, but the schemes were largely government-driven and focused on single issues such as designing and erecting earth structures to control run-off. Advances in technology — biological control of rabbits, improved pastures, clover ley rotations and machinery for soil conservation works — also reduced erosion. Despite these efforts, erosion continued and more insidious long-term problems — such as soil salinity, acidification and the decline of soil structure and fertility — emerged.

A measure of the progress of responses to past problems can be obtained by comparing some of the recommendations on land resources issues in the 1974 National Estate Report (Commonwealth of Australia, 1974) with the progress of the responses to those recommendations.

Table 6.9 The historical effectiveness of responses

1974 National Estate Report recommendations	Twenty years later
Removal of taxation concessions for clearing.	The Commonwealth Government has removed tax concessions for land clearing but anomalies remain.
Establishment of a system of national parks, especially near the larger cities, together with State parks, nature reserves, urban parks and other classes of reserves.	The number of reserves has increased but progress towards a Comprehensive Regional Assessment program has been limited.
Woodchipping and other operations involving clearfelling of large areas of forest should be discontinued until the environmental effects are better known and properly assessed.	Resource Assessment Commission Inquiry into the Forest and Timber Industry completed in 1992 and National Forest Policy Statement released. Woodchipping from any areas not subject to a Comprehensive Regional Assessment will be phased out by 2000.
There is an urgent need for expanded research into biology of feral species.	An eradication program has substantially reduced the water buffalo numbers in northern Australia and consequently improved the environment there. Government agencies have undertaken surveys of other vertebrate pests and control programs are being developed.
Management of forests to include multiple use and conservation objectives, including rainforest conservation.	Most of the remaining areas of rainforest in Australia are now protected in national parks and listed as World Heritage areas. The Commonwealth and States have signed the National Forest Policy Statement to address issues of sustainable forest management.
A review of Australian Government lands on the coast to see which areas may be included within Coastal Heritage Parks.	The Resource Assessment Commission (1993) has finalised a report into management of the Australian coastline, but few policy decisions have been announced as a result of the report (see Chapter 8).

It became clear that a single-issue approach was inadequate and that government legislation and regulation would not control land degradation unless land-users as individuals accepted responsibility for the effect of their land management practices.

Changing roles of government and community

In the 1980s, the role of State soil conservation programs began to change from one that tried to provide leadership to one that encouraged community-led programs, with agencies involved in a collaborative partnership. For example, in 1982 the Western Australian Soil Conservation Act was revised to encourage greater rural community involvement in land conservation by forming Land Conservation District Committees. Since 1982, 137 committees, encompassing most of the State, have been formed.

During the same period in Victoria, the Garden State Committee and the then Victorian Farmers and Graziers Association sponsored the establishment of farmer-led farm tree groups. In 1986, the Victorian Government, with the support of the Victorian Farmers Federation, established a new land protection program called ‘LandCare’. The first Victorian LandCare group was established at Winjallok in the Wimmera in 1986 and by the end of 1987 at least 30 groups existed.

In 1988, The National Farmers’ Federation and the Australian Conservation Foundation proposed a national land management program. Its key elements were funding for Landcare groups and for property management planning. The Commonwealth Government designated the 1990s as the Decade of Landcare and supported it with funding for the National Landcare Program. The broad objective of this program is to foster the development and implementation of systems of land use and management that will sustain individual and community benefits now and in the future. It does this by encouraging Landcare and community groups to participate in land management projects. Other programs target increased application of property management planning as a process to build landholders’ skills to improve production, reduce degradation and manage risks (such as drought).

The growth of Landcare

While other community groups focus on conservation issues, Landcare groups have a particular emphasis on rural lands and contain people who want to work with others to improve the long-term health of the land. Landcare is voluntary; the agenda for each group is set by the members and each group operates according to its own plan. A facilitator usually helps the group determine priorities. Landcare groups allow people to see that they have the capacity, within their own community, to deal constructively with issues that seem too big for individual families.

The groups have two key areas of influence — immediate impact on people’s attitudes, and subsequent impacts on land-management practices as new attitudes lead to change.

The Decade of Landcare plan set a target of 22 000 Landcare groups by the end of the decade. However, this target was passed in late 1994. More than 325 000 people are actively involved in Landcare. A 1992–93 ABARE survey estimated that 28 per cent of broadacre farmers and 19 per cent of dairy farmers were members of Landcare groups. Surveys by Charles Sturt University show that the proportion of properties with a Landcare group member varies between States; for example, in Victoria, Western Australia and Tasmania it is about 50 per cent and in Queensland it is about 33 per cent. Studies show that Landcare members have significantly higher levels of adoption of 'best-bet' land management practices than non-members (Curtis and DeLacy, 1994; ABARE, 1994). They also spent an average of $2500 on Landcare activities during 1992–93.

Challenges and prospects

The Landcare movement faces a number of challenges (Campbell, 1994; Sustainable Resource Management Committee Working Group, 1994). It is difficult to find enough people in rural areas with the skills required to lead and facilitate groups, plan and implement farm and catchment strategies, tackle all degradation problems in all areas and develop remedies for difficult technical problems. Groups need to adopt a 'working together to develop sustainable systems' approach rather than a 'fix land degradation problems' approach. They need to develop an effective collaborative partnership to meet the interests of all rural and urban community stakeholders and to develop and adopt practical and profitable sustainable farming technologies and land management systems. The links between social and economic wellbeing of a community and the quality of its land management need greater recognition.

The major challenge for Landcare is to have all land-users adopting best-management practices to ensure sustainable use of resources. This difficult task will involve widespread changes to routine land management practices. Such changes may be resisted, particularly in difficult economic circumstances. There are high expectations for Landcare and evaluations of the Decade of Landcare will assess whether these are being achieved.

The level of success of the Landcare movement will have wide implications for society. It may be used as a model for other 'care' programs to enlist stakeholder commitment to sustainable resource use. If the voluntary approach embodied in Landcare does not succeed, consequences may include continued resource degradation, declining community benefits and a more regulatory approach.

Integrated natural resource management policy

Increasingly, people are recognising that natural resource management issues are interlinked. However, policy and legislation are often based on a single issue. Queensland's initiative to remodel existing legislation to underpin sustainable resource development illustrates the trend towards a more integrated framework.

The initiative recognises that:

- natural resources need to be protected from further degradation
- resource condition influences the economic prosperity and social well-being of the community
- community involvement in the decision-making process is vitally important
- individuals play a critical role in management of natural resources

To help develop the policy, the government has implemented an extensive community consultation process with over 50 public meetings around the State and has also established a policy advisory council.

The initiative addresses three critical areas:

- allocation of resources between productive use and environmental needs
- sustainable management of natural resources using Codes of Practice backed by legislation
- identification of Special Management Areas with specific management needs — degraded environments, critical remnants, run-off control structures and floodplains

The proposed legislation will fold nine existing Acts, covering the management of water, soil and forests, into one. The mandatory provisions of the new Act will be designed to regulate unsustainable management practices that cause rapid resource degradation. Non-mandatory provisions will encourage and support community and whole-of-government involvement in sustainable resource management programs. It will complement integrated catchment management, Landcare, property management planning, Waterwise and Treecare programs.

Table 6.10 Summary

Element/Key pressures	Impact / State	Adequate Info.	Responses	Effectiveness of responses
Clearing of native vegetation/ forest removal				
Agricultural land use	Loss or fragmentation of most of native vegetation, exposing area to many of the soil issues listed below and contributing substantially to greenhouse gas emissions	✓✓	Legislation and controls on tree clearing; monitoring; One Billion Trees program; Landcare	Effective in many areas but not implemented in others; the efficacy of the recovery programs is not tested
Forestry operations	Short term exposure of soil to risks of compaction and erosion and loss or dramatic modification of habitat.	✓✓	Agreement not to decrease the forest estate; Codes of Practice to cover forestry operations and regeneration; Regional Forest Agreements (RFAs)	Mostly effective; RFAs not yet completed
Urban expansion	Permanent loss of habitat; modifications to regional hydrology	✓✓	Local planning regulations	Varied
Forest habitat conservation				
Forestry operations; changed fire regimes	Fragmentation of forest habitat (via roading and areas of operation); alteration of age structure of the forest	✓	National Forest Policy Statement; Codes of Practice to cover forestry operations; Regional Forest Agreements; Comprehensive and Adequate Reserve systems; encouragement of plantation development.	Most important responses still being implemented
Condition of the rangelands				
Pastoralism	Changes in the density and species composition of vegetation; widespread establishment of weeds and feral animals	✓✓	Research and extension; legislation; leasehold conditions (animal stocking rates, soil status); National Strategy for Rangeland Management; inventory and monitoring; Landcare; structural adjustment programs; multiple use policies.	Only limited success through lease administration; localised successes in weed and feral animal control but little progress in many areas; variable trends in vegetation on a regional basis
Tourism	Localised trampling and vehicle damage; infra-structure; pollution	✓✓	Planning regulations; rehabilitation programs; public education	Major re-organisation and rehabilitation in some areas (e.g. Uluru); little effect in others
Soil structural decline				
Agricultural land use and especially tillage systems that lead to loss of soil organic matter	Reduced permeability and increased runoff and erosion; poor root vigour leading to reduced productivity	✓✓	Soil conservation research and extension especially into improved farming systems; Landcare	Increased awareness of the issue, but problem is still widespread
Salinisation				
Clearing of agricultural and grazing land; over irrigating	Rising groundwater levels; in some areas salt is mobilised leading to dryland salinity and stream salinisation	✓✓✓	Landcare and catchment planning, Murray-Darling Basin Commission; salt quotas and Saltwatch; monitoring; expenditure on salinity management	Only minor and localised successes through planting and changed management. Regional-scale responses are inadequate

Table 6.10 Summary (continued)

Element/Key pressures	Impact / State	Adequate Info.	Responses	Effectiveness of responses
Soil erosion				
Agricultural land use and especially those leading to the loss of soil cover	Loss of soil depth; loss of nutrients; off-site effects such as siltation	✓✓	Land management research and extension; expenditure on structural works; Landcare	Uptake of advice still inadequate in most areas
Forestry operations	Localised erosion during harvesting and regeneration	✓✓	Codes of Practice relating to operations and streamside buffers	Significant improvements but continuing debate about effectiveness in some areas
Soil nutrient decline				
Agricultural land use and especially excessive cultivation	Decline in soil organic matter and major nutrients (N and P)	✓	Research and extension on cropping systems, rotations and fertiliser use; promotion of N utilisation, fertiliser application rates, fertiliser imports (t/yr)	Varies from successful farming systems incorporating legume rotations, to reliance on artificial fertilisers, to little effective response
Forestry operations	Loss of major nutrients through harvest losses, erosion or frequent burning	✓✓	Improved forestry practice	Mostly effective but limited information for many areas
Pastoralism	Wind and water erosion leading to widespread redistribution (and loss) of nutrients	✓✓	Improved stock management, fencing and water distribution	Varies from property to property
Soil nutrient accumulation				
Intensive agriculture and horticulture	Accumulation of nutrients with risk of water pollution.		See Inland Waters chapter	See Inland Waters chapter
Soil acidification				
Agricultural land use and especially inappropriate legume rotations, the overuse of fertilisers, removal of plant products and natural processes in some areas.	Increased soil acidity (low soil pH) and the release of toxic levels of aluminium and manganese in some soils; poor root growth. Some calcareous soils benefit from higher acidity	✓	Research and extension; liming and changed fertiliser practices	Very poor uptake of appropriate measures
Soil contamination				
Various agricultural and pastoral land use	Impacts include cadmium (Cd) contamination from phosphate fertilisers; increased herbicide use in minimum tillage systems; pesticide pollution in cattle and sheep dipping sites	✓	Reduction in Cd levels in fertilisers and use of cultivars that restrict its uptake; regulations on pesticide and herbicide use; education	Cd levels are generally low by world standards; much more work needs to be done in identifying and rectifying other contamination problems
Food quality				
Farming practices with respect to hormones, pesticides and fertilisers	Food contamination	✓✓	Legislation; new farming practices, integrated pest management; reduction in pesticide use	Successful in most cases, but risks of accumulation of residues poorly known

Multiple use of rangelands

The dry outback is the best-known part of Australia's rangelands, which cover three-quarters of the country (see Fig. 6.8). After little more than a century of pastoralism, vegetation change and soil erosion are widespread, the mix of native fauna has changed and feral animals and plants are well established. Nevertheless, the rangelands are still largely natural ecosystems, important on a world scale.

By area, about 60 per cent of the rangelands is used for grazing, 15 per cent for Aboriginal homelands and four per cent for conservation reserves; the remaining 21 per cent is technically unoccupied but much of it is under claim by Aboriginal people. Other land uses like mining and tourism may not occupy large areas, but have a disproportionately high economic value (see the Table below). In addition, recreational use is having an increasing impact on more-remote areas.

Our rangelands are also valued for their international, cultural and scientific interest. The outback is a part of Australia's national identity. Its scientific interest lies not only in its unique flora and fauna (which include, for example, the world's greatest diversity of reptiles), but also in the opportunity to develop an understanding of ecological processes in an arid land that has not had thousands of years of agricultural use, as is the case in Asia and Africa.

Although pastoralism has been the most extensive commercial land use since European settlement, its future supremacy is no longer assured. The industry as a whole has largely operated at a loss over the last decade, due to low commodity prices and high costs (Wilcox and Cunningham, 1994). Many landholders seek alternative sources of income, through different land uses as well as off-farm investment.

The wider community wants to maintain the conservation value of these publicly owned rangelands, regardless of how they are used. For large areas of rangelands, conservation and sustainable pastoralism are compatible. However, some key areas for pastoralism can be very important for conservation and need special protection. Decisions regarding land use should be made at the appropriate level; for example, economic production can be optimised at the level of the individual holding, while conservation priorities should be set within a regional context. Further, decisions should be made after considering all the private and public benefits and costs of various uses.

In the foreseeable future, pastoralism is likely to remain the major use for the rangelands. In places where it is not viable in the long term, the emphasis will shift towards alternative or multiple uses and, even where grazing is viable, other uses may prevail. Tourism is rapidly developing as an option across the rangelands, both as a general enterprise and at individual landholder level, and already is worth more than the pastoral industry. Conservation is formally incorporated with pastoralism in areas like the Innamincka Regional Reserve. Mining and pastoralism co-exist on many Western Australian leases, and dryland cropping occurs on the eastern fringe of New South Wales pastoral country. Traditional Aboriginal uses are combined with pastoralism on leases held under Aboriginal freehold title. Other uses being developed include kangaroo- and emu-farming, horticulture and hunting. The 1992 High Court decision in the Mabo case affects the rights of Aboriginal people to land, but the implications for land use are unclear.

Government, industries and the community have responded to changing land-use priorities and will need to make further accommodations in future. Lease tenure and conditions need to be tailored to allow a variety of uses — not necessarily by the titleholder alone — while protecting conservation value. Decisions on land uses that affect interests beyond the landholder need to involve the wider community in order to minimise conflict. Dryland cropping, for instance, which occupies less than 0.4 per cent of New South Wales rangelands, has given rise to a high level of concern about the impacts of land clearing. Structural adjustment will need to continue, and public funding will have to be allocated equitably so as to balance support for commercial enterprises and the public's interest in maintaining conservation values and social equity in a region.

Value of rangeland commodities 1991–92

	$ million	% of Australian total
Cattle sold	527	17
Sheep sold	22	4
Wool sold	274	12
Tourism	3 000	8
Mining	10 000	38

Source: Stafford Smith, 1994.

Food quality

Agriculture depends heavily on inputs of agricultural and veterinary chemicals to enhance productivity and minimise losses caused by pests, weeds, pathogens and post-harvest spoilage. Pesticide contamination, arising from deliberate administration, over-use or chance contact with residues, may compromise food quality. Heavy metals such as cadmium, lead and mercury occur in rural commodities because plants take up trace amounts from the soil, supplemented in some cases by impurities in fertilisers and sewage sludge (see page 6-32). Excessive levels of these also adversely affect food quality.

Australia produces most of its food and exports large amounts. We only import about six per cent by value. The results of Commonwealth, State and industry-sponsored monitoring programs indicate that misuse of agricultural and veterinary chemicals is low. Most analyses record no residues or residues below established limits. The Australian Market Basket Survey (National Food Authority, 1992) determined that dietary intake of agricultural and veterinary chemicals and heavy metals was within the safe limits set down by the World Health Organisation.

A large survey in New South Wales (Edge, 1993) examined 1509 samples of fruit and vegetables for up to 24 pesticides, involving a total of more than 25 000 chemical analyses. Most did not yield any evidence of pesticides and no sample contained more than one chemical residue above the Maximum Residue Limit (MRL). While 25 samples returned a residue above the MRL, 10 of the breaches were almost certainly attributable to traces of the pesticides benzene hexachloride and dieldrin remaining in soil from applications made some years earlier. Thus the violation rate for chemicals intentionally applied to the sampled commodities was 0.7 per cent.

In a 1993 survey, the Victorian Department of Agriculture found that 98 per cent of 448 fruit and vegetable samples were within residue limits for all chemicals tested. Results from the National Residue Survey (NRS, in press), the largest monitoring program for chemical residues and heavy metal contaminants in Australia, are also encouraging.

Among the heavy metals of concern, cadmium regularly exceeds the Maximum Permitted Concentration (MPC) in offal and potatoes. The National Residue Survey reports that eight per cent of offal samples in 1991 and 1992 exceeded the established MPC. More than 10 per cent of samples in the Victorian clean agriculture produce monitoring program of 1992–93 had cadmium levels above the MPC, with violations detected in carrots, potatoes, silverbeet and safflower. None of the samples had lead or mercury exceeding 50 per cent of the MPC.

Contamination of Australian seafood is generally well below permissible levels, although some organochlorines and heavy metals may concentrate in sharks and other predatory fish higher up the food chain (see Chapter 8). The situation should improve with time, since most organochlorines are no longer available for use within Australia.

Australian food quality, as judged by standards for pesticide residues and for heavy metal contamination, compares favourably with that of international produce.

Responses to food quality issues

All agricultural and veterinary chemicals used in Australia must be registered by the National Registration Authority for Agricultural and Veterinary Chemicals. The Authority was established by the Commonwealth in 1993 to consolidate activities previously carried out by State governments. In consultation with the Department of Human Services and Health and other relevant authorities, the National Registration Authority sets MRLs for chemicals in food commodities. After public consultation, the MRLs are adopted into the Food Standards Code of the National Food Authority and individual State governments incorporate them into State food laws. Imported foods must meet domestic standards for both chemical residues and heavy metals.

The National Food Authority also sets standards for MPCs of heavy metals, taking account of both the concentrations that occur in foods and the varying contributions that different foods make to the average diet. Taking cadmium as an example, the MPC for most foods is set at 0.05 mg/kg, while the limits for prawns and lobsters, other shellfish and kidneys are 0.2, 2.0 and 2.5 mg per kg respectively.

Concern about cadmium is such that government authorities and industry have taken steps to limit dietary intake by regulating cadmium inputs from phosphatic fertilisers and sewage sludge, by eliminating the feeding of phosphate supplements containing high levels of cadmium to cattle and by banning the sale of offal from aged sheep and cattle likely to contain elevated levels of cadmium.

The popularity of organic produce could tempt unscrupulous operators to capitalise on premium prices. This prospect underlay the formation of the Organic Produce Advisory Committee and the adoption of the National Standard for Organic and Biodynamic Produce. The Committee reports to the Department of Primary Industries and Energy and the Australian Quarantine and Inspection Service regularly audits organic organisations enforcing the standard.

All States except Tasmania and the Australian Capital Territory and Northern Territory have established monitoring programs for agricultural and veterinary chemicals, and some selectively survey for heavy metals as well. The Australian Market Basket Survey monitors the intake of pesticides and contaminants in food prepared to a table-ready state in the diets of adults, children and infants — both male and female. The survey samples 'market baskets' of over 60 food types for about 50 pesticides, arsenic, cadmium, copper, lead, mercury and aluminium. The National Residue Survey monitors chemical residues and heavy metals in raw food commodities, largely those destined for export. The National Antibacterial Residue Minimisation Program monitors levels of antibacterials in meat and alerts producers to the risks to trade if levels are violated.

Education is the key to developing responsible use of agricultural and veterinary chemicals. It is integral to the Commonwealth's clean-food export program and to a diversity of initiatives by producers, processors, chemical industries, educators and peak industry bodies. Efforts to decrease dependence on pesticides are being made through research and development into integrated pest management systems while genetic engineering is being used to develop plants and animals with resistance to pests and pathogens.

Rural adjustment in the mulga lands

In the Western Division of New South Wales and the mulga lands of south-west Queensland, 2650 pastoral holdings cover 64 million ha of rangeland and in 1991–92 they produced $450 million worth of agricultural products. The issues facing the mulga region illustrate the links between pressure, state and response on a regional and inter-State scale.

Pressures

Large stations in this region were subdivided under closer-settlement policies, with many of the smaller properties being established after World War I to provide blocks for soldier settlement (Passmore and Brown, 1992). When subdividing these large properties and regulating land management, land administrators did not adequately account for the impact of the variable climate, changing economic conditions and the importance of retaining native pastures.

The main agricultural industries are sheep and wool production from native pastures, with some beef production and cropping in favourable areas. The minimum economically viable property size varies with location, seasonal conditions and wool prices. Because more than 40 per cent of properties are too small to be economically viable, landholders are under intense pressure to extract financial returns through more-intensive land use (Young, 1985). Variable seasons and several droughts between 1957 and 1994 have exacerbated these pressures.

Terms of trade for the wool industry have declined steadily for the past 40 years. In the sheep-grazed rangelands the decline has been faster than for the whole industry and gains in productivity have been slower.

Native species such as mulga, which were used as fodder, helped to maintain excessive stock numbers during drought periods. The discovery of artesian water in the 1880s was important in the development of the region. Producers drilled many bores and established extensive systems of drains. The network of watering points, plus control of dingoes, has increased numbers of kangaroos, goats, pigs and rabbits, and consequently the total grazing pressure.

State

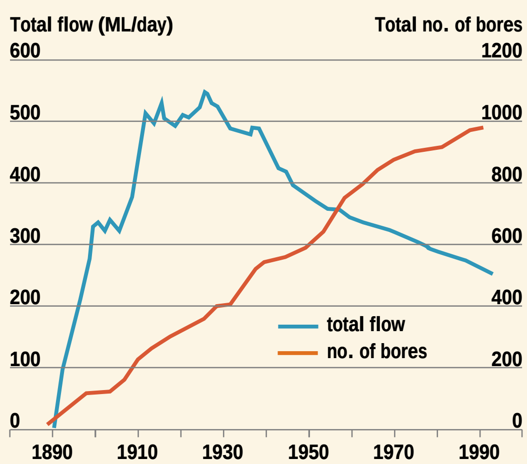
Land condition is inversely related to property size (Young, 1985). Stocking pressures have reduced soil cover, which in turn has increased soil erosion. A 1985 survey showed that in south-west Queensland, bare ground made up 60 per cent of the area and serious soil erosion occurred on 10 per cent. Similar levels of erosion were found in the Western Division of New South Wales (Soil Conservation Service of NSW, 1988). Wind erosion occurs periodically on exposed sandy soils.

Vegetation has also changed due to heavy grazing and altered fire regimes, and woody weeds are increasing. A 1985 survey in south-west Queensland showed that woody weeds had heavily infested 44 per cent of the area. In the Western Division of New South Wales, about 37 per cent is moderately to severely encroached by woody weeds; a further 25 per cent displays low-level infestation but is potentially vulnerable, and only 37 per cent is unaffected (Soil Conservation Service of NSW, 1988).

Kangaroo numbers in the region are estimated at 10–12 million and studies suggest that feral goats number more than one million. Depending on conditions, kangaroos, goats and rabbits can account for 30–70 per cent of total grazing pressure.

Water pressure in the Great Artesian Basin has been declining across the region (see figure below). In south-west Queensland, flow rates from bores have dropped from 600 megalitres per day in the early 1900s to an average of 260 megalitres today. These are projected to fall further, to 80 per cent of current levels over the next 20 years and 60 per cent over 50 years (Barson *et al*., 1993). Nearly one-fifth of bores in south-west Queensland have ceased to flow and it is estimated that 90 per cent of water is lost to evaporation and seepage from drains. The Great Artesian Basin inter-State

Bore numbers and flow



Source: QDPI.

working group of 1992 estimated that capping all bores would result in annual water savings of 250 000 megalitres in Queensland alone.

Many enterprises in the region are unprofitable. For example, projections based on production and cost figures for properties in four areas of the Western Division showed all were non-viable under the wool prices existing in the early 1990s. Although 8000 sheep is generally considered a minimum carrying capacity for long-term viability in this area, up to 40 per cent of properties do not meet this criterion. In south-west Queensland, the minimum property size for long-term viability is 35 000 ha and preferably more than 45 000 ha. Stock numbers vary according to season and pasture conditions, but at least 10 000 sheep are needed for economic viability. About 75 per cent of south-west Queensland properties do not meet these minimum standards.

Mulga is a valuable source of fodder but woody weeds are encroaching on some areas.

Response

The region has suffered economic and resource management problems for many years. The drought and the depression in the wool industry in the early 1990s aggravated the situation. Government agency studies between 1970 and 1990 resulted in some specific initiatives — for example, bore capping and piping projects, research studies of vegetation and fauna, and projects to improve land management. Other responses have varied between the two States.

In Queensland, the Mulga Land Use Advisory Group was formed in 1991 to devise measures to stop land degradation and improve viability of the pastoral industry. It consisted of representatives from industry, government, financial institutions and community interest groups. The group started the ‘land degradation voluntary property build-up scheme’ in 1992. Eligible applicants could obtain loans at concessional rates to buy land to increase the size of their holding or to finance development in accordance with an agreed property management plan.

In 1993, eight working groups began to devise a strategy for the mulga region. They found that economics, land degradation and social problems were interrelated and should not be considered in isolation. Property viability was the key to ecologically sustainable use, and a regional program was needed to adjust property sizes, improve resource management and increase landholder self-reliance.

In 1992, the New South Wales Department of Conservation and Land Management (CaLM) initiated a community consultation process known as WEST (Working for Equitability and Sustainability Together). It convened a ‘search conference’ to bring together representatives of all stakeholders in the Western Division to put forward ideas to help achieve a ‘desirable and achievable’ future. More than 1000 people from pastoral communities and government agencies were briefed on the recommendations developed by the conference and had opportunities to contribute to the recommendations (CaLM, 1993).

The similarity of problems and developments in both States, and recognition of the need for a regional approach, prompted a joint New South Wales–Queensland proposal. The Standing Committee on Agriculture and Resource Management, the Rural Adjustment Scheme Advisory Committee and the Murray–Darling Basin Commission agreed to treat the region as a case study for sustainable rural development. The integrated regional adjustment and recovery program for south-west Queensland and the Western Division of New South Wales will cost government an estimated $91 million over seven years. About $12 million of these funds have already been made available through the National Landcare Program and the Rural Adjustment Scheme.

The program has three components:

- property reconstruction — to assist non-viable producers to re-establish elsewhere, assistance for build-up of viable properties, enhanced business management and planning support, coordinated commercial lending activities, communication and promotion activities and supportive land administration arrangements
- natural resource management — to promote sustainable resource use by reducing total grazing pressure, applying best management and production practices, developing property management plans, applying risk-management practices to minimise pasture degradation, enhancing the network of reserves and voluntary on-property conservation initiatives to secure biodiversity and improving water, stock, pest and pasture management by bore capping and piping
- integrated regional development — to facilitate ongoing adjustment and self-reliance by supporting regional initiatives to develop and manage the strategy, developing a more robust and reliable economic base, coordinating ongoing provision of government services, assisting those who exit industries to find alternative employment, ensuring networks of support and information services are available and balancing the rate of adjustment.

Source: QDPI and NSW CaLM, 1994.

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Acknowledgments

The following people reviewed the chapter in draft form and provided constructive comments.

Colin Chartres (CSIRO Division of Soils)

Ann Hamblin (CRC for Soil and Land Management)

Ted Henzell (formerly CSIRO Institute of Plant Production and Processing)

Jamie Kirkpatrick (University of Tasmania)

Judith Lambert (Community Solutions)

Henry Nix (Australian National University)

John Williams (CSIRO Division of Soils)

We especially thank the following individuals who assisted in the preparation of this chapter:

Roger Armstrong (WA Conservation and Land Management)

John Blackstock (Victorian Department of Agriculture)

Tim Boneyhady (Australian National University)

Mike Braysher (Bureau of Resource Sciences)

Julie Burke (Murray-Darling Basin Commission)

Tony Chisholm (La Trobe University)

Joanne Daly (CSIRO Division of Entomology)

Geoff Edwards (La Trobe University)

Graeme Evans (Bureau of Resource Sciences)

Rohan Fernando (Australian Nature Conservation Agency)

Peter Hairsine (CSIRO Division of Soils)

Quentin Hart (Bureau of Resource Sciences)

Peter Helman (Consultant)

Phil Hone (Deakin University)

Rai Kookana (CRC for Soil and Land Management)

Louise Laurence (CSIRO Division of Entomology)

Mike McLaughlin (CSIRO Division of Soils/CRC for Soil and Land Management)

Grant McTainsh (Griffith University)

Richard Merry (CSIRO Division of Soils)

Vicky Passlow (Bureau of Resource Sciences)

Alan Payne (Agriculture WA)

Keith Porritt (Bureau of Resource Sciences)

Sandy Radke (Bureau of Resource Sciences)

Simon Ransome (Victorian Land Conservation Council)

Alison Saunders (Australian National University)

Andrew Taplin (Australian Nature Conservation Agency)

Nick Uren (La Trobe University)

Neil White (Vertebrate Biocontrol Centre)

In addition, Commonwealth Government departments and members of the Commonwealth/State ANZECC State of the Environment Reporting Taskforce also helped identify errors of fact or omission. Their assistance is also gratefully acknowledged.

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