

## INTRODUCTION

The accompanying folded map at 1:5 000 000 shows, in broad terms, the type and intensity of present land use in Australia. Within the commercially used land, which is overwhelmingly agricultural, the very large range of intensity of use from the desert fringes to the humid coastlands is shown by an increasing intensity of colour and concentration of symbols.

Much of the agricultural information mapped was derived from the annual agricultural census carried out by the Australian Bureau of Statistics for the year ended 31 March 1976. These were the most recent available statistics when map compilation began and, fortunately, covered a year of largely average weather. The information on public lands (national parks, State forests, vacant Crown land etc.) refers to early 1979.

Because Australian agriculture is, in area terms, predominantly livestock-based, livestock type and density are shown throughout the agriculturally used area. Livestock densities were based on statistics for each local government area and modified using information from a variety of sources and from an interpretation of broad pasture types using Landsat satellite imagery (see Figure 1).

Although crops are shown by symbols representing areas, each symbol also represents approximately the same gross value of production. The symbols are superimposed on the mapped livestock information in much the same way as occurs in reality. Australian wheat, for example, is almost everywhere grown on farms for which livestock are of equal importance and on which pastures occupy the larger proportion of land. However, in those small areas where crop growing (generally intensive crops) is the more important economic activity, the crop symbols are designed, by their size and density, to almost obliterate the underlying livestock information.

Australian land use has progressed through three broad phases. The first was the Aboriginal phase, a simple hunting and gathering subsistence economy which lasted for several tens of thousand years. The second, which covered just over a hundred years of European colonisation from 1788, supplanted the first and saw the pioneering of commercial land use over most areas economically usable by the colonists. The third phase, which began at about 1900, has seen a consolidation of the pioneering efforts, and an intensification of land use and large increases in land productivity wherever new scientific or technical discoveries could be applied. This phase has also been one of growth of government management of forestry land and dedication of land for the protection of scenery and wildlife.

## LAND USE TO 1900

When European colonisation began in 1788 Australia was inhabited by about 300 000 Aborigines living in numerous small tribal groups utilising the entire land surface for hunting and gathering. The natural productivity of the land is low for this type of economy and population densities accordingly ranged from one

*PHOTOGRAPH ABOVE: Sheep grazing on sown pasture near Canberra.*

*This photograph and Figures 5, 6, 7, 11 and 12 by Australian Information Service; Figures 8, 9, 10 and 13 by F. T. Bullen.*

*Figure 1 reproduced by courtesy of EROS Data Centre, Sioux Falls, North Dakota, U.S.A.*

person to about 4 km<sup>2</sup> in the more humid coastal areas and the valleys of the few perennial streams to about one person to 300 km<sup>2</sup> in the central deserts.

As European pastoralists swept across the continent during the 19th century the area left to the Aborigines for their traditional economy diminished. Their numbers have decreased to about 120 000 and an increasing proportion—now about half—live in urban areas. Of the remainder only a few occasionally follow the traditional way of life. Thus an all-pervading, homogeneous pattern of land use that had persisted for tens of thousands of years disappeared in less than two hundred.

The first European use of Australia was as a British penal colony occupying, in 1788, a small area now within urban Sydney and later, in 1803, an equally small area near Hobart.

In these early days the spread of European land use was slow. Before 1815, it was confined to small areas of relatively fertile soil on the coastal plains west of Sydney and a narrow belt in the central lowlands of Tasmania. These areas supplied—usually inadequately—the basic food requirements (maize, wheat and meat) of the predominantly convict population of less than 15 000. However, with the founding of the town of Bathurst (N.S.W.) in 1815 on the inland side of the Great Dividing Range and beyond the infertile barrier of the Blue Mountains, the stage was set for settlement of the vast interior of mainland Australia.

## Development of Sheep Grazing

The fine merino wool trade with Britain, which began in 1821, offered an economic use for the extensive inland plains and tablelands. This provided the first real motivation for free settlers to make the long and hazardous voyage from Europe and caused pastoral land use to expand rapidly in response to the growing British market.

The large profits to be made from wool caused settlement in New South Wales to expand beyond the limits of legal tenure—the 'Nineteen Counties'. Despite attempts to prohibit squatting, it was eventually legalised in 1836 by instituting an annual fee of £10 for the land (some claims exceeded 100 000 ha) and a halfpenny for each animal.

New settlements were established in the more humid coastal areas at Brisbane (1824), Perth (1829), Melbourne (1835) and Adelaide (1836). Thus by 1840 the development of all the present largest urban areas had begun. The core areas of the Humid and Sub-humid zones (see Figure 2) of Western and South Australia were under pastoral use, as was much of the usable land in these zones in Victoria and Tasmania. In New South Wales, pastoral use had extended inland to at least the present arid edge of the wheat belt and expansion was beginning northwards into the Darling Downs of southern Queensland.

A slump in wool prices in the mid-1840s and the discovery of gold in New South Wales and Victoria in the early 1850s slowed down the spread of rural land use by inducing many settlers to try their luck on the goldfields. However, gold had a dramatic impact on the economy by stimulating investment and migration from Britain. Between 1851 and 1860 over 600 000 immigrants arrived, more than doubling the population, and overseas trade increased almost fivefold in value. Penal settlement, which had ended in

1840 in New South Wales, ended in 1853 in Tasmania, but in 1850 the young colony of Western Australia, faced with a serious labour shortage, introduced convict transportation, which lasted until 1868.

Exploration and political development were equally stimulated. In the late 1850s and early 1860s expeditions by the Gregory brothers, Stuart, Burke and Wills, Landsborough, and McKinley sketched in much of the geography of the vast interior and pastoralists followed closely on their heels. Victoria and Queensland were separated from New South Wales in 1851 and 1859 and the political map began to resemble the present one.

As the gold fever subsided the expansion of European-style land use accelerated in the 1860s. Much more was now known, albeit in general terms, about the natural environment and its problems. The extreme aridity of most of the centre and the highly unreliable rainfall of most of the rest were known. On the mainland, perennially flowing rivers were restricted to the south-east and the wetter coastal areas elsewhere. Good soils were rare and the native pastures, which had evolved in the absence of heavy ungulate grazing (unlike most other parts of the world), could not sustain high stocking rates of sheep and cattle. Even in high rainfall areas one sheep to about 1.2 ha was the highest average stocking rate that could be sustained during the 19th century and this was only improved when exotic pastures were established.

Squatting, though now legalised, was still a problem in the more populous colonies of New South Wales and Victoria, with a few settlers locking up large areas and preventing closer settlement. In 1844 a maximum holding area of 20 square miles (5180 ha) and a requirement to purchase part of it after five years was proposed. However, in 1847 political pressure from the squatters caused the granting of 14 year leases and preferential rights to purchase improved land. This created conflicts between land selectors and squatters when leases began to expire in the early 1860s. Acts in 1857 and 1861 limited purchases per person per year to 640 acres (260 ha) in Victoria and 320 acres in New South Wales; but through such ruses as the use of relatives and 'dummy' names, many squatters managed to purchase the land they were occupying very cheaply. Many new settlers were forced to look to the north and the more arid interior because the acquisition and development of land in the more humid southern regions now required larger amounts of capital.

## Development of Cropping

Crops had been grown since settlement began. Wheat had been grown with varying success on the New South Wales coastal plains to provide for local needs but the British varieties then grown suffered badly from rust under the hot, moist conditions and caterpillar plagues caused serious damage. Maize proved a more reliable crop but it was an alien food to the settlers and wheat had to be imported from Tasmania, where British wheat varieties were grown under more suitable climatic conditions, and from Chile. As settlement advanced inland, wheat cropping advanced with it to cater for local needs. Also, legislation aimed at creating denser settlement by yeoman farmers, such as that of Victoria in 1862 requiring the cultivation of at least 10% of recently purchased land, encouraged the expansion of wheat cropping. Fortunately, by 1860 an early maturing variety known as 'Purple Straw' had emerged which was suited to the hotter, drier inland conditions and a system was developed of fallowing between crops to conserve soil moisture. From this point the Australian wheat belts, as we know them today, began to take shape and wheat cropping in the more humid coastlands began to decline.

Wheat growing for intercolonial trade and overseas export, as opposed to farming for local needs, began primarily in South Australia assisted by legislation that favoured small farmers at the expense of large-scale pastoralists. The 1847 squatters rights legislation did not apply in this colony. By making a distinction between 'agricultural' (within proclaimed Hundreds) and 'pastoral' land (outside Hundreds), squatters in the former were given six months notice to leave and the land was then sold in small parcels. Here, too, in 1843 a mechanical wheat stripper was invented which solved the labour problems of harvesting the large areas needed to produce a profitable harvest under the low-yielding local conditions. By 1844 South Australia was producing a surplus of wheat for trade to other colonies, and by 1860 (with only 11% of total population) had 43% of the total Australian wheat area. By the mid-1860s South Australia was exporting wheat to Victoria, New South Wales, Queensland, Mauritius, South Africa and sporadically to Britain.

It was in South Australia that wheat cultivation first crossed, in the 1870s, the normal arid limit of wheat

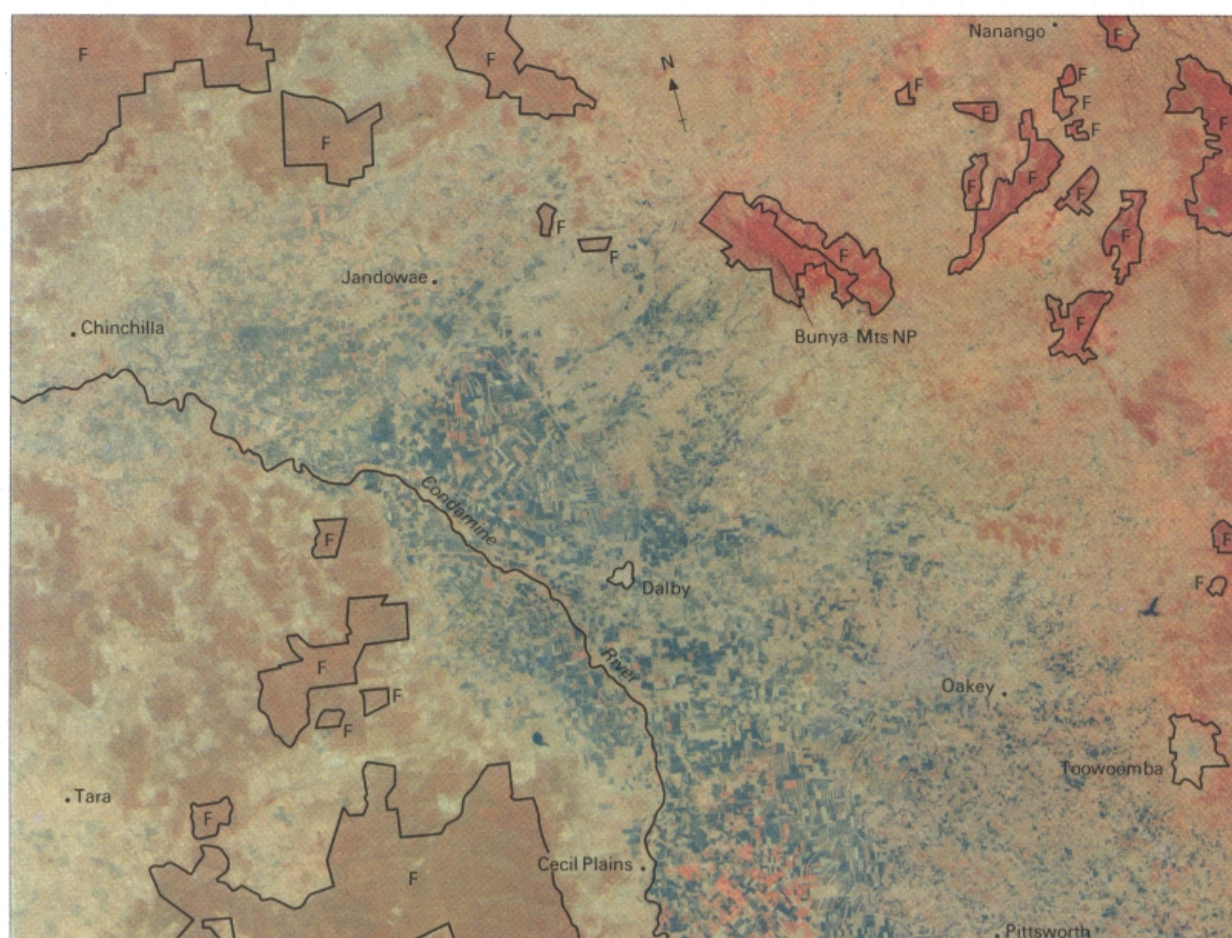


Figure 1. A 'false-colour' Landsat image (scale 1:1 000 000) of part of the main cropped area of the Darling Downs, Queensland, in late summer. In these images green vegetation shows as various shades of red to enhance differences in type and cover. (F=State forest; NP=national park.)

The bluish areas are ploughed land in which winter wheat, barley and forage oats will be sown. This is one of the densest concentrations of cereal cropping in Australia, the small area around Tara being more typical. The red areas east of Cecil Plains are mainly irrigated sorghum and pasture with smaller areas of oilseeds and cotton. The forests and pasture of the more humid land to the east appear redder than those on the drier western edge, where large areas of cypress pine forest show as brown.

production, probably because the transition zone between humid coastal climates and the arid interior is narrower here than elsewhere in Australia. This advance was encouraged by above-average rainfall in these marginal areas and ignored the boundary drawn in 1865 by Goyder, the State Surveyor-General, defining the seaward edge of drought-prone areas. This boundary, drawn using very limited meteorological data, proved substantially correct when severe droughts recurred in the early 1880s. Wheat farming, which had spread to north of Hawker in the central Flinders Ranges, was forced to retreat southwards to about its present position. Today 'Goyder's Line', as it has become known, defines very closely the arid edge of the South Australian wheat belt and, therefore, the inland boundary of closer rural settlement.

Other crops requiring more intensive cultivation and generally wetter climates than wheat, notably fruit and vegetables, had been grown on a small scale close to the main urban centres since the early days of settlement. These expanded as the urban population grew and the export of apples from Tasmania began in the 1880s but it was not until large-scale irrigation projects were undertaken in the 20th century that large exportable surpluses of fruit were produced.

The 1860s also saw the beginning of another major rural industry—sugar cane—utilising the wetter tropical coastal lowlands. Cane growing on a commercial scale began in the Moreton Bay area near Brisbane, where the first mill began operating in 1862. In 1864 cane was grown on the Clarence River in northern New South Wales but the main thrust of expansion was northward along the tropical coast of Queensland. In 1868 the first mill was built in the Mackay area and four years later sugar milling began in the Bundaberg area—two main centres of present production. Originally developed as a relatively large-scale plantation crop using cheap Chinese and Pacific Island ('Kanakan') indentured labour, a change to smaller, family farms became necessary when this labour became scarce and, finally, when the importation of non-white labour was effectively prohibited by the new federal government in 1901.

#### Development of Extensive Cattle Grazing

By 1870 the broad pattern of land use, as it exists today, was generally established. Only the tropical monsoon lands of the far north and a large portion of the arid interior remained unused, although their eventual use as grazing land was already predictable.

Cattle were important multi-purpose animals for the early settlers, providing meat and milk, hauling drays and pulling ploughs. Early specialisation in dairy farming grew around the major cities, for example on the Illawarra coastal plain south of Sydney and in Gippsland east of Melbourne, in response to the growing urban needs for large quantities of fresh milk and butter, which could only be carried over short distances before the invention of refrigerated transport.

In the early 1870s wool prices climbed and cattle were sold off the now well-established southern sheep

areas. They were bought by the Queensland pioneer settlers needing stock to establish new leases in the north and west. Most of the land still available was unsuitable for sheep or crops and the establishment of cattle properties required, at this time, less capital investment. Between 1875 and 1885 cattle numbers declined in New South Wales but doubled in Queensland. The first grazing leases in the Gulf Country of Queensland were taken up in about 1865, only four years after the Burke and Wills expedition had reached the same point. Meanwhile in the Northern Territory, then under South Australian jurisdiction, pastoralists were thrusting northward along the line of the overland telegraph which, extending north from Port Augusta to the newly established port of Darwin, was completed in 1872. By 1881 most of the Northern Territory was under pastoral lease or licence, a much larger area than at present, although it is doubtful whether more than one-third was actually stocked. Initially sheep grazing was tried but with little success except in the south. Cattle graziers now became the dominant pioneers of the remaining central and northern areas and so the northern beef industry began.

Between 1880 and 1900 cattle grazing expanded to occupy most of the land presently used with the exception of some of the least productive land in the Northern Territory, Western Australia and Cape York Peninsula so that, by the turn of the century, the pioneer stage of Australian land use was almost over.

#### Discoveries Affecting Later Developments

The main aspect of land use development in the 20th century has been the increase in productivity of land already settled. Several discoveries and technical improvements in the last quarter of the 19th century greatly assisted this development. Experiments in South Australia in the 1880s and 90s on the response of wheat yields to superphosphate proved very encouraging. Wheat breeding experiments in New South Wales in the 1890s were the first scientific attempts to produce wheat varieties specifically suited to Australian conditions and the first was released commercially in 1901. The combined application of these two discoveries reversed the downward trend in national wheat yields, which had declined from just over a tonne per hectare in the 1850s to half a tonne in the 1890s. They also enabled wheat to be grown in other climatically suitable areas with poorer soils.

The value of subterranean clover (an accidentally introduced species) to pasture improvement was first realised at Mount Barker (S.A.) in the 1890s. Other significant contributions to pasture improvement made at this time were the introduction of the grasses *Paspalum dilatatum* in 1881, which quickly improved the coastal pastures of New South Wales, and *Phalaris tuberosa* in 1884, which, with subterranean clover, became the basis for pasture improvement in sub-humid southern regions. Together with the application of superphosphate, pasture improvement has raised carrying capacities, on average, by at least

fourfold, permitting an equivalent increase in livestock numbers.

The development of large-scale irrigated croplands was pioneered on the Murray River at Mildura (Vic.) in 1886 and Renmark (S.A.) in 1887. Although initially unsuccessful economically, these efforts led to later, much larger, government-sponsored irrigation schemes along the Murray and Murrumbidgee rivers which have considerably altered the land use and increased the productivity of these areas.

The discovery in 1879 of artesian water near Bourke (N.S.W.) and the realisation in the 1880s that extensive artesian basins lay beneath much of semi-arid and arid inland eastern Australia greatly assisted the pastoral development in these areas, where surface water is very scarce and ephemeral.

The invention of refrigeration plants for warehouses and ships led to the first export of refrigerated meat in 1879. This advanced the development of the meat and dairy industries, breaking their dependence on local markets.

#### LAND USE SINCE 1900

None of the agricultural innovations made at the end of the 19th century was immediately adopted and universally applied due, in part, to lack of capital and to rural conservatism. Severe and widespread droughts at the turn of the century, two world wars and the economic depression of the 1930s also tended to hold back development. However, the eventual sponsorship of most of these new ideas by State governments and the Commonwealth Scientific and Industrial Research Organization (formed in 1926) gradually brought about their further development and wider adoption.

Change became much more rapid after 1950, when the earlier retarding effects had passed and a peak in wool prices increased the capital available for development, particularly pasture improvement in the areas producing wheat and wool. These innovations led to the expansion of the wheat belts (particularly in Western Australia) and an increase in irrigated farming, and have substantially increased productivity wherever they have been applied. Since 1900 national wheat yields per hectare have almost trebled, sheep numbers have doubled and cattle have increased almost fourfold. Virtually all livestock increases are directly attributable to the massive increase in sown and fertilised pasture; indeed numbers have decreased in some previously overstocked, more arid areas where pasture improvement is not technically or economically feasible (for example, the Western Division of New South Wales).

#### Agricultural Land Use

Since 1900 the total area of rural holdings (Table 1) has increased from 340 million ha to 500 million due largely to the expansion of extensive grazing lands in Western Australia, Queensland, the Northern Territory, and South Australia. The area of rural holdings diminished slightly in the more densely populated states of New South Wales, Victoria and Tasmania for several reasons, notably losses caused by increases in urban land, sub-commercial hobby farming near urban centres, and the acquisition of farm land for conservation. The net increase in grazing land has, however, contributed little to the increase in livestock numbers as it mostly occurred in areas with very low carrying capacities.

Table 1. Area of Rural Holdings (million ha)

State	1901	1951	1976
Queensland	120.0	145.5	155.6
New South Wales & A.C.T.	70.8	68.3	68.8
Victoria	16.5	15.4	15.1
Tasmania	2.6	2.6	2.5
South Australia	38.0	61.4	63.6
Western Australia	43.4	86.3	116.3
Northern Territory	45.8	52.4	78.8
AUSTRALIA	337.1	431.9	500.7

Source: Australian Bureau of Statistics, Commonwealth year-books.

#### CROPS

Only in Tasmania has the cropped area decreased (Table 2). This has been due to the virtual demise of cereal grain cropping in this State—the granary of early colonial settlement—and the concentration on intensive crops such as apples, berry fruit, vegetables, hops and more recently oil poppies.

The largest crop increase (absolute and proportionate) has occurred in Western Australia, resulting from the massive expansion of the wheat belt from a relatively narrow area along the wetter edge of the present belt, where 30 000 ha of wheat was grown in 1900, to the present large area, in which 3.2 million ha was grown in 1975–76. By 1930, when wheat covered 1.6 million ha, the wheat belt had expanded to its present limits in the central area but, due to

economic depression and the Second World War, the crop area then declined. Expansion recommenced at the end of the War and has continued, particularly in the south near Ravensthorpe and Esperance and, in the north, on the coastal plains and beyond Geraldton. This expansion has been facilitated by the development of suitable subterranean clover varieties, which form the basis of a ley-farming system rotating sown pasture with wheat and other cereals.

Table 2. Crop Area ('000 ha)

State	1900-01	1950-51	1975-76
Queensland . . . . .	185	841	2 010
New South Wales & A.C.T. . . . .	990	1 929	4 285
Victoria . . . . .	1 260	1 836	1 852
Tasmania . . . . .	91	117	60
South Australia . . . . .	959	1 543	2 116
Western Australia . . . . .	81	1 882	4 208
Northern Territory . . . . .	..	..	8
AUSTRALIA	3 567	8 148	14 540

Note: Includes fodder crops, which amounted to 1 140 000 ha in 1975-76.

Source: Australian Bureau of Statistics, Commonwealth year-books.

The second-largest proportionate increase in cropped area has occurred in Queensland due to a twentyfold increase in wheat and sorghum and an eightfold increase in sugar cane. Wheat growing in the now heavily cropped Darling Downs began in a small way at the turn of the century but it was not until the late 1930s that the cropped area increased appreciably. More recently wheat has expanded westward into drier areas and northward into the Central Highlands.

Crop expansion in the Central Highlands has been due to a large extent to the clearance of brigalow (*Acacia harpophylla* forest). This dense association of trees and shrubs, which generally grows on fertile soil, had resisted successful clearance until a government-funded scheme began in 1962. Using new mechanical clearance techniques and a newly discovered weedicide to prevent regrowth, previously a major problem, progress has been rapid. Although most of the cleared land is under sown pasture, cropping (mainly sorghum, wheat and oilseeds) in this area has increased more than fourfold since 1962 to about 250 000 ha.

Increases in the cropped areas of New South Wales, Victoria and South Australia have been due partly to the development of irrigation farming but mainly to the increase in wheat area. In New South Wales, as well as a general increase in cropped area within the wheat belt as it existed in 1900, an expansion has occurred into marginal land on the drier edge, particularly in the northern plains. In north-western Victoria and southern South Australia some increase in wheat area has occurred in newly cleared mallee areas.

Mallee is a plant association dominated by tall eucalypt shrubs which have a number of slender trunks stemming from the same root point and, like brigalow, has been difficult to clear. Unlike brigalow it generally occurs on poor sandy soil but the application of superphosphate combined with a rotation of wheat with subterranean clover or medic sown pastures has increased agricultural use. In South Australia barley has contributed as much as wheat to the increase since the Second World War in crop area, which in particular has expanded westward along the coast from Eyre Peninsula.

The area of irrigated crops has increased from a negligible area in 1900 to 550 000 ha in 1975-76. Of this nearly 200 000 ha are in large government-sponsored irrigation schemes along the Murray and Murrumbidgee rivers. These developments began when the first stage of the Burrinjuck Dam on the Murrumbidgee was completed in 1912 and were able to expand following an agreement in 1914 formalising the allocation of Murray River water between the riparian States. The First World War slowed early development and it was not until the mid-1920s that much progress was made.

These areas now grow fruit, rice, wheat and vegetables although sown pastures occupy the largest area. Rice, first grown commercially in the Murrumbidgee Irrigation Areas in 1924, is now an important crop there and in other, newer irrigation areas of the New South Wales Riverina, covering a total of 72 000 ha in 1975-76.

Some other locally important but much smaller irrigation schemes developed since the Second World War mainly grow cotton. These are on the Namoi and Macquarie rivers (N.S.W.) and at St George and Emerald (Qld). The Ord River scheme in the Kimberleys (W.A.), opened in 1963, also grew about 4 000 ha of cotton until 1974, when pest control became too costly and the payment of a cotton bounty ceased. Trials are still in progress to determine a commercial

use for this irrigation area which, with the completion of the Ord River Dam in 1972, could amount to 70 000 ha.

In contrast with the generally successful developments in the south, crop growing ventures in the tropical monsoon areas of the far north have generally failed. Rice (near Darwin), cotton (on the Ord), peanuts (on the Daly River and Cape York Peninsula) and sorghum (on the Ord and elsewhere) have all been tried but with little economic success. This has been due to a variety of pest and weed problems and economic ones such as the distance to southern markets.

#### SOWN PASTURES

The massive expansion of sown pastures from less than 0.5 million ha recorded in 1900 to nearly 28 million in 1975-76 (Table 3) has considerably increased the intensity of land use. Most of this expansion has occurred in the wheat belts and the adjacent more humid regions. As part of a crop rotation system, the nitrogen-fixing legume species which form the basis for most sown pastures have increased soil fertility and allowed the expansion of wheat farming into areas previously considered unsuitable. Sown pastures also have decreased fallowing wherever a suitable legume-based pasture has been developed and have consequently reduced soil erosion. In all they have increased the livestock carrying capacity of the land, on average, fourfold. While they have not greatly altered the geographic distribution of land use types—except where they have assisted the expansion of cereal cropping—they have considerably increased the intensity and productivity of land use wherever they have been introduced.

From early and largely haphazard introductions in the 19th century, a more scientific approach this century has introduced a wide range of new species and varieties of existing ones specifically suited to local conditions. The expansion of sown pastures has accelerated with most of the increase occurring since the end of the Second World War (20 million ha increase since 1950). Most notable have been the development of subterranean clover (*Trifolium subterraneum*) varieties for the wetter wheat belt regions and annual medics (small legumes of the genus *Medicago*) for the drier margins; perennial grasses such as panic, Rhodes and buffel grass adapted to a relatively low and variable summer rainfall for central Queensland; and Townsville stylo (a tropical legume) for tropical monsoon areas.

Table 3. Sown Pastures ('000 ha)

State	1900-01	1950-51	1975-76
Queensland . . . . .	10	500	3 584
New South Wales & A.C.T. . . . .	190	1 503	5 788
Victoria . . . . .	70	2 550	6 234
Tasmania . . . . .	130	350	935
South Australia . . . . .	10	1 000	3 589
Western Australia . . . . .	1	1 453	7 463
Northern Territory . . . . .	..	..	116
AUSTRALIA	411	7 368	27 709

Source: Australian Bureau of Statistics, Commonwealth year-books.

#### LIVESTOCK

Table 4 shows the large increases in number of livestock that have occurred since 1900 in all States. By 1976 cattle had increased from 8 million in 1901 to 33 million, and sheep from 70 million to 148 million. These increases have been almost entirely due to the increase in sown pastures, fertiliser use and irrigation. The remarkable tenfold increase in Western Australia has been mainly due to the increase in sheep numbers in the much-expanded wheat and sown pasture belt.

Until recent years the areas dominated by each of the three major livestock types (dairy cattle, beef cattle and sheep) had altered little since 1900. A major exception was the development of dairy farming earlier this century on large irrigation areas in north-central Victoria on land which had been predominantly sheep country.

Dairy farming initially increased on the areas of better soils of the more humid southern and eastern coastlands following the invention of a cream separator in 1886, the development of co-operative butter factories (the first was established at Kiama near Wollongong in 1883), and refrigeration. Small-scale family dairy farms were initially encouraged by government support to promote denser rural settlement and protected by complex marketing legislation and export subsidies. However, this small-scale farming became uneconomic as increased capital for sown pastures and mechanisation became necessary. Worst affected were districts only marginally suitable for dairying, notably the Queensland and northern New South Wales coastal areas, where summers tend to be too hot and winters too dry for dairy farming.

Dairy cattle numbers have declined in recent years, a trend that began in New South Wales in 1935 and Queensland in 1943. In eastern and south-eastern Australia dairying has contracted towards the humid (or irrigated) lowlands of Victoria and Tasmania and locally to areas with the best pasture. Beef cattle have generally replaced dairy cattle where these changes have occurred, since most dairy country is too humid for sheep.

Table 4. Livestock (sheep and cattle) in Sheep-equivalent Units  
1 beef beast = 8 units, 1 dairy beast = 12 units

State	Number (millions)			Sheep (% of total units)		
	1901	1951	1976	1901	1951	1976
Qld . . . . .	43.0	71.4	104.4	24	24	13
N.S.W. & A.C.T. . . . .	55.9	84.1	126.6	72	65	42
Vic. . . . .	23.7	37.7	72.3	46	53	35
Tas. . . . .	3.0	4.4	11.5	56	50	37
S.A. . . . .	7.1	13.6	32.4	74	75	53
W.A. . . . .	5.1	18.1	56.0	47	63	62
N.T. . . . .	2.1	8.2	12.8	2	..	..
AUSTRALIA	139.7	229.8	416.1	51	49	36

Source: Calculated from livestock numbers given in Commonwealth year-books, Australian Bureau of Statistics.

For a hundred years before 1965 the ratio of sheep to cattle, expressed in equivalent terms (Table 4), has remained almost constant at about 1:1 and the areas of sheep or cattle predominance had remained largely unchanged. Since 1965 cattle numbers have almost doubled, despite the decrease in dairy cattle, and sheep numbers have declined by 11%, so that the sheep-to-cattle ratio is now about 1:2.

While proportionate cattle increases have occurred fairly evenly in all States, changes in sheep numbers have been more variable. The largest decreases occurred in the northern, more marginal areas. Numbers actually increased slightly in Tasmania and considerably (by 42%) in Western Australia due to the expansion there of the sown pasture-wheat area. Regionally, beef cattle have increased in areas traditionally used for sheep grazing so that the area of sheep predominance has declined, notably in Queensland and northern New South Wales.

#### Non-agricultural Land Use

While agricultural land use presently occupies the largest area (500 million ha or 65% of Australia) many other uses have also developed. Although all these began before 1900, their expansion has mainly occurred this century.

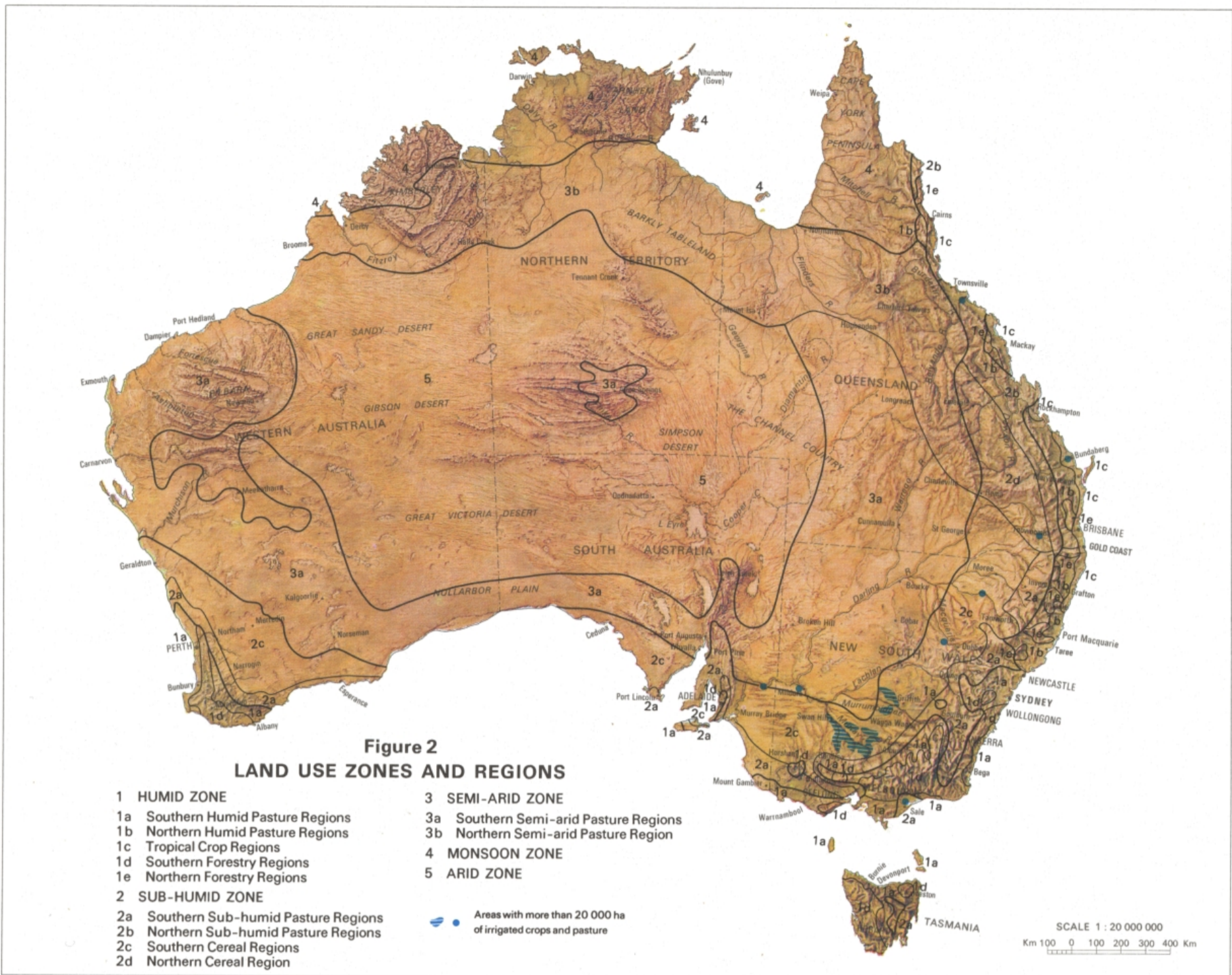
The most intensive use is *urban land*, which occupies about one million ha, only 0.13% of the total area, but is the land on which over 80% of Australians reside and work. This has increased directly with population (nearly 4 million in 1900 and nearly 14 million in 1976), generally at the expense of agricultural land.

Recently there has been a marked increase in the subdivision of rural land particularly within commuting distance of the larger towns and cities and in coastal areas favoured for holidays. These holdings have been occupied, usually by city people, for such purposes as full-time residence while still working in nearby towns, hobby farming, holiday homes and retirement. No comprehensive data are available on the areas involved although an indication is given by the fact that 40 000 rural holdings totalling about 10 million ha may conservatively be regarded as sub-commercial (with annual incomes from agriculture of less than \$1500).

*Transport routes* (roads, railways, stock routes) may be roughly estimated to occupy about 9 million ha. They have expanded in relation to increases in population and industry and as an integral part of rural land development. The expansion of the wheat belts, in particular, led to a large increase in railways in those areas, notably during the first 25 years of this century. Travelling stock routes, which make up at least half of the total area, were originally developed for driving stock over long distances before the advent of motor transport. They are now little used for that purpose except over short distances and as an extra source of fodder during severe droughts.

*Open-cut mines and salt evaporators*, while forming only a minute proportion of the total area, nevertheless constitute a distinctive land use of very high value per unit of land. Most of the largest and most important (Pilbara iron ore, northern Australian bauxite and central Queensland coal open cuts) have been developed within the last twenty years.

The area of *forestry land* managed for timber production, which amounts to about 15 million ha (2% of the total area), is mostly State forest. Although government control over forestry began in the late 19th century, the concept of State-managed forests was largely a 20th century development.



In the early years of European settlement, forests were regarded as barriers to settlement so that management and conservation were not contemplated. In some areas, notably the North Coast of New South Wales, timber cutters were the first pioneers, clearing the way for the farmers who followed them. But in the 1870s and early 1880s it was realised in all States that some government control was needed although, in the first instance, this was largely to obtain revenue by licensing timber cutters. It was not until after the First World War and in the early 1920s that State forest services were set up and began long-term management of large forest areas (presently about 12 million ha).

A small but important forestry component (covering about 500 000 ha) has been the comparatively recent development of exotic softwood plantations to make up Australia's natural deficiency of this type of timber. South Australia, the State with the smallest area of native forests (which were largely cut out by the late 1860s), made the first moves towards establishing government plantations in 1870 and began planting six years later. Initially these were native hardwoods but the first planting of the North American conifer *Pinus radiata* was made in South Australia in 1877. This softwood has subsequently become the predominant plantation species due to its remarkable growth rate under southern Australian conditions. It is not so well suited to northern Australian conditions and in southern Queensland the slash pine (*P. elliottii*) and native *Araucaria* pines cover much larger areas than *P. radiata*.

The swing towards softwood plantations began in South Australia in 1909 and vigorous development occurred there and in all other States in the 1920s and 1930s. From 1966 faster expansion over a ten year period was facilitated by federal government support aimed at achieving an annual planting of 30 000 ha. Although most coniferous plantations are State-owned, about 140 000 ha are privately owned, mainly by the paper-making industry.

Today State forests are, in many cases, multi-use areas managed primarily for present and future timber production but also functioning wholly or in part as conservation and recreation areas, as annually licensed grazing land and, particularly near major urban areas, as water supply catchments.

National parks and other nature conservation reserves occupy about 27 million ha (3.6% of the total area).

While the first national park (the Royal National Park just south of Sydney) was declared in 1879, it was not until after the First World War that large areas were dedicated. Expansion has been most rapid in the last decade. Large areas of vacant Crown land, particularly in the arid interior, have been declared as national parks or wildlife conservation areas while, in the settled areas, leased rural holdings and some forest reserves have been converted.

Other commercially unused land covers about 200

million ha or a quarter of Australia. Much consists of sandy desert in the interior, sandy mallee country in the south, and some of the more rugged and inaccessible land in the tropical north. About a third of this unused land is reserved for Aborigines. (Reserved land used by them in a European fashion—mostly beef cattle grazing—is counted here as agriculturally used land and is shown on the accompanying folded map in the same way.) The agriculturally unused Aboriginal reserves, the largest of which are in the arid centre and tropical

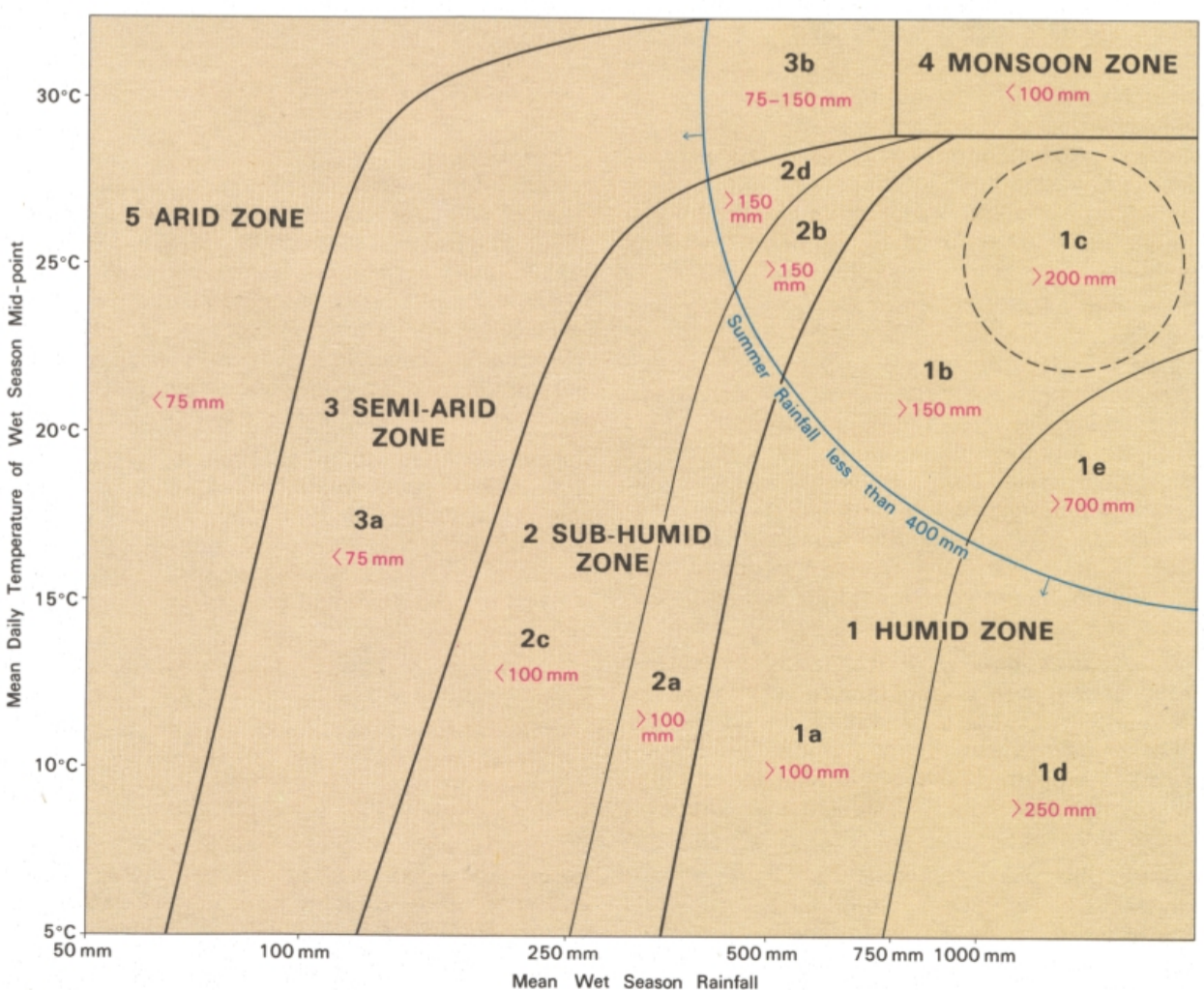


Figure 3. Criteria for Land Use Zones and Regions

The wet season, here defined as the wettest six consecutive months, more or less corresponds with summer (November-April) towards the top of the diagram and with winter (May-October) towards the bottom. An indication is given (in red) of dry season rainfall. The Tropical Crop Regions (1c) are separated from 1b regions by higher winter temperatures (mean daily temperature greater than 15°C) and slightly higher winter rainfall.

monsoon areas in Western Australia, the Northern Territory, South Australia and Queensland, contain Aboriginal settlements and are, in part, used occasionally by a few people for traditional hunting and gathering of 'bush tucker'.

#### LAND USE ZONES AND REGIONS

The pattern of land use in Australia, as elsewhere, has been moulded by political and economic forces working within the environmental constraints set by the combined effects of climate, topography, soils and vegetation. Of the environmental factors, climate, particularly rainfall, has had the most potent effect on the broad pattern of land use.

Topography generally has imposed local restraints on agricultural use, for example by precluding steep or rugged terrain from cultivation. Only a small proportion of Australia is sufficiently high for the altitudinal effect of temperature reduction to influence land use. Australian soils are generally poor in comparison with those in Europe and North America. Although variations in inherent soil quality strongly influenced early agricultural development, the present widespread use of fertilisers and better soil management have evened out their effect on the land use pattern. Australian native vegetation proved more of a hindrance than a help to European colonisation. The forests of the humid south and east coastal hinterlands were a barrier to early agricultural development. Further inland some forests and shrublands were difficult to clear. The native pastures have generally low grazing capacities and improvement was only possible when exotic species were introduced.

Figure 2 shows climatically based land use regions grouped into zones. The regions were broadly conceived from an inspection of the 1:5 000 000 map and then graphs were plotted of seasonal rainfall against mean seasonal temperature to determine their limits more precisely. Hence regional boundaries, in the main, reflect effective seasonal rainfall, much more rain being required in summer than in winter to achieve an equivalent amount of plant growth—see Figure 3.

Irrigation areas are atypical of the regions in which they occur since they are obviously better watered than the surrounding country and therefore have land use systems typical of more humid regions. The larger and more important are shown in Figure 2.

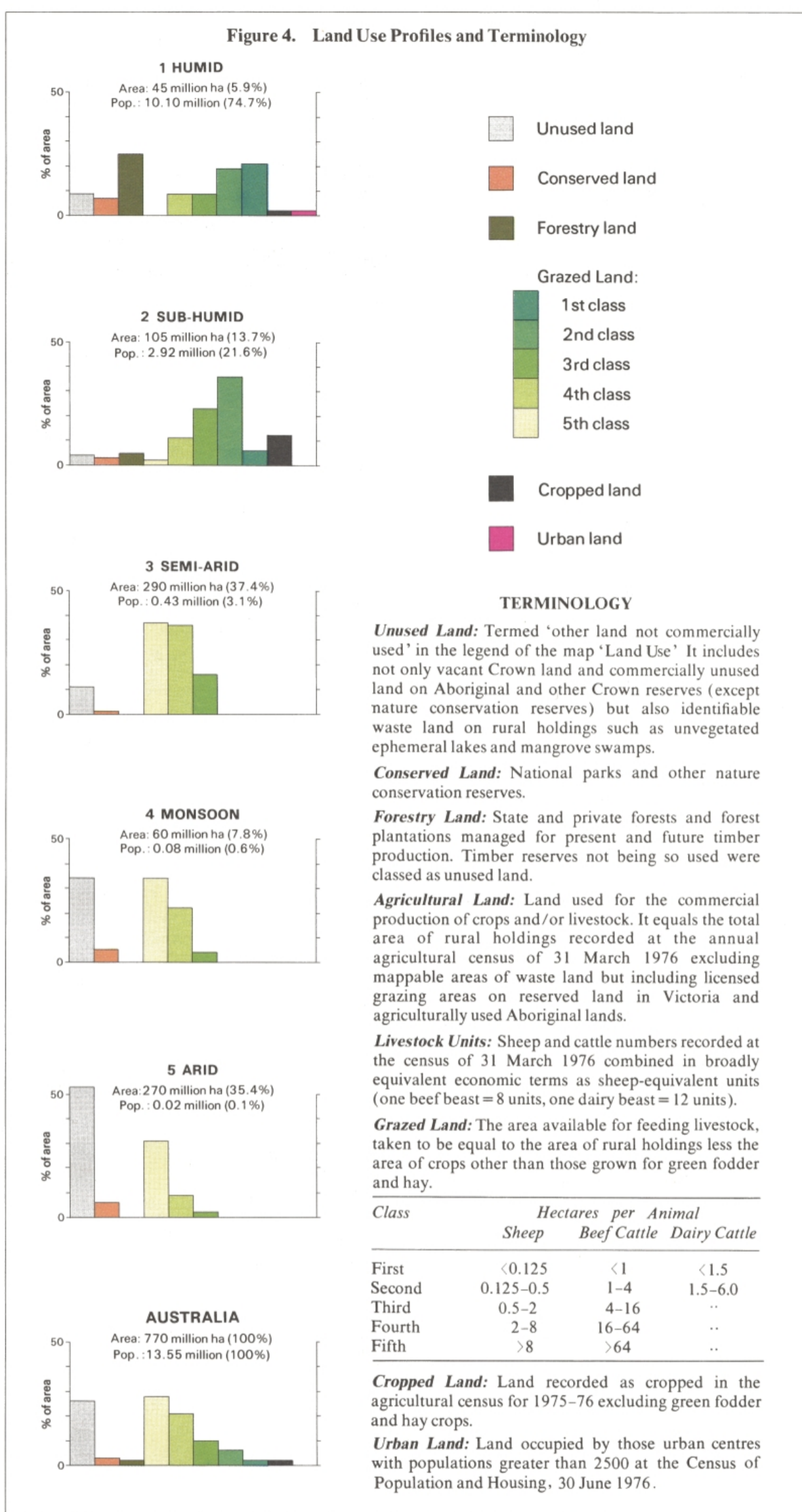
Figure 4 shows the broad land use differences between the zones, together with their areas and populations. It illustrates the quintessence of Australian land use patterns.

- About three-quarters of the population live in the small, generally narrow, and mostly coastal Humid Zone and all major urban areas lie within or close to its borders.
- The vast proportion of agricultural land is grazed. First-class grazing land is largely confined to the Humid Zone and first-class and second-class grazing land, largely composed of exotic sown pasture species, is concentrated almost entirely in this and the adjacent Sub-humid Zone.
- Cropped land is largely confined to these same two zones. Although of great agricultural and economic importance, it occupies only a small proportion of the Sub-humid Zone, and an even smaller proportion of the Humid Zone.
- Almost 70% of forestry land occurs in the Humid Zone and almost all the rest is in the Sub-humid Zone.
- Conserved land occupies a small proportion of all zones but is least represented in the Sub-humid and Semi-arid zones, which are the most agriculturally used.
- The Semi-Arid, Arid and Monsoon zones together cover 80% of the total area. Agriculturally they are almost exclusively devoted to extensive grazing on native pastures but much of the Arid and Monsoon zones is unused land.

Some of the terms used in the descriptions of the land use zones and regions are defined in Figure 4. A number were created for descriptive convenience and their use is not meant to imply any authority. For example, the classes of grazing land defined here are not in common or official use.

In the following descriptions reference is made to the average area of farms (rural holdings). Most farms (92%) are run by families or sole operators so their size tends to be the area of land needed to provide a living for a family. Farm sizes, therefore, are good indicators of the productivity of the land, ranging from a few tens of hectares for intensively cultivated crop farms in humid coastal regions to over a million hectares for some extensive grazing leases in the arid interior.

The proportions of zones and regions occupied by a specific land use were calculated from areas measured on the land use map by counting grid dots. Due to this



method of estimation and because only those areas larger than about 5 000 ha were mapped, the percentage figures presented are accurate to about 0.5%. There is an inbuilt bias towards under-estimation of classes, such as forestry and conserved land, that include a large number of small areas unmappable at the scale of 1:5 000 000.

#### 1. HUMID ZONE

This is climatically the most favourable zone for agriculture and forestry, with an annual rainfall generally greater than 500 mm and, by Australian standards, a relatively low variability from year to year. While rain may fall at any time during the year, most falls in summer in the north and east and in winter in the south and west. This zone includes the wetter coastal lowlands—which are nowhere very extensive—and adjacent hills and uplands.

The first European settlements were sited on the seaboard of this zone and land use was restricted to it until about 1820 in New South Wales and Tasmania

and 1840 or later in other States. About three-quarters of the population now live in this zone and all major urban areas (with populations greater than 100 000) have developed within or close to its borders even though it makes up only about 2% of the total land area. This, together with the location in this zone of most of Australia's coastal and alpine resorts and major water catchments serving the largest cities and irrigation areas, creates strong and conflicting pressures on the land.

Most grazing land is improved pasture, and livestock carrying capacities approach those of the better temperate European grazing lands in the more temperate coastal areas of Victoria and Tasmania. Sugar cane covers by far the largest area of all crops grown in this zone although restricted to the tropical coastal lowlands of Queensland and northern New South Wales. Fruit and vegetable growing are locally important near the larger urban centres and in small localities elsewhere with especially suitable environment. This zone also contains the bulk of