

Mapping Unit	Factual Key Soil Class/ Profile Form	Properties	Associated Landforms	Mapping Unit	Factual Key Soil Class/ Profile Form	Properties	Associated Landforms
Cf3	Um1.3; Um1.4; Um2.1; Um4.1; Um4.2; Um5.1; Um5.2 if shallow; Um5.3; Um5.4; Um5.51; Um5.61; Um6.2	The shallow depth (< 60 cm) and thus low AWC of these loam soils limits their use. Inherent fertility is very variable.	From plains and stony rises to, more commonly, crests and steep slopes of plateaux, hills and ridges.	Cf5	Largely bare rock	Quaternary basalts with pockets of organic debris in rock crevices.	Broken terrain.
				O1	O	Organic soils ranging from peaty sand to peat. Their bulk density is low and AWC is very high. The organic material ranges from 30 cm to 3 m or more thick. SRT ranges from acid to neutral and alkaline. Inherent fertility is usually very low in the acid forms but moderate in neutral and alkaline forms. All require P and other nutrients but vary with individual occurrences.	Low-lying, poorly drained sites on tablelands and mountain crests, some hill slopes and coastal plains.
Cf4	Uf6.1; Uf6.2; Uf6.3	Permeable friable clay soils with AWC limited by their shallow depth (< 60 cm). SRT is mainly neutral to alkaline. Inherent fertility is variable; P is usually necessary.	Slopes and crests in rolling to hilly terrain but also on some plains.				

AWC: the Available Water Capacity of the soil This is an estimate of the soil's store of moisture. It is the difference between field capacity (upper limit of available water when the addition of more water is lost by drainage) and wilting point (lower limit of available water when water is so tightly held by the soil that plant roots cannot extract it, causing the plant to wilt).

SRT: Soil Reaction Trends, and refers to the general acidity-alkalinity (pH) changes with depth in the body of the soil. Three main trends are:

- Acid* when the subsoil has pH values less than 6.5.
- Neutral* when the subsoil has pH values between 6.5 and 8.0.
- Alkaline* when the subsoil has pH values higher than 8.0.

NUTRIENT ELEMENTS: the nutrient elements known to be required for plant growth are referred to by their chemical abbreviations as follows: nitrogen N, phosphorus P, potassium

K, sulphur S, iron Fe, calcium Ca, magnesium Mg, boron B, manganese Mn, copper Cu, cobalt Co, zinc Zn, and molybdenum Mo. Another element common in some soils is aluminium Al.

ESP: Exchangeable Sodium Percentages. Sodic and highly sodic soils have ESP of 6-14 and 15 or more. Soil permeability is influenced by its sodium ion content which, when high enough, causes soil clay to disperse (break into very tiny particles) and thus block the passage of water through the soil pores. Some of the acid duplex soils included in Cc and Cd may have ESP < 6, but their subsoils are equally impermeable. The reasons for this are not understood but may have something to do with their very low contents of metal ions (Northcote and Skene 1972).

NaCl: sodium chloride or common salt, which is often used as a measure of the salinity of Australian soils (Northcote and Skene 1972).

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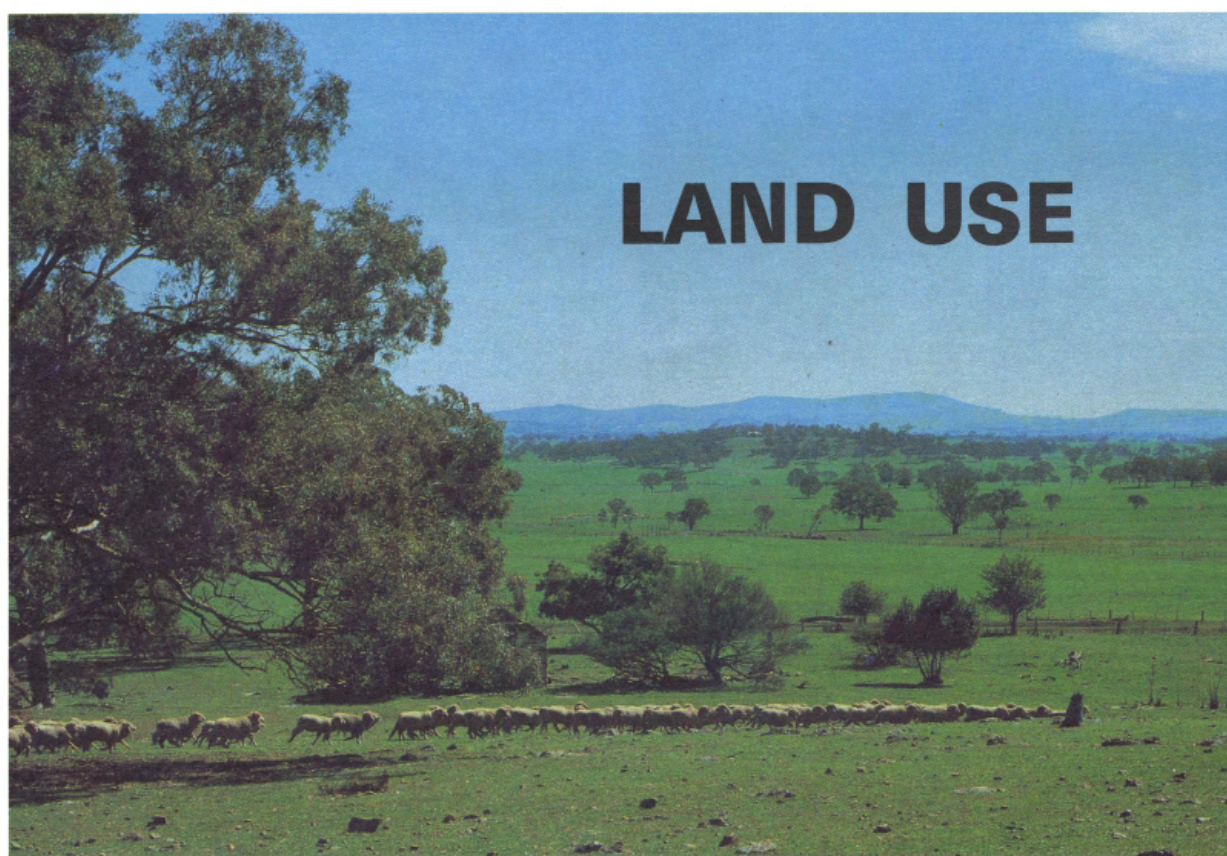
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INTRODUCTION

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

person to about 4 km² in the more humid coastal areas and the valleys of the few perennial streams to about one person to 300 km² 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

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.

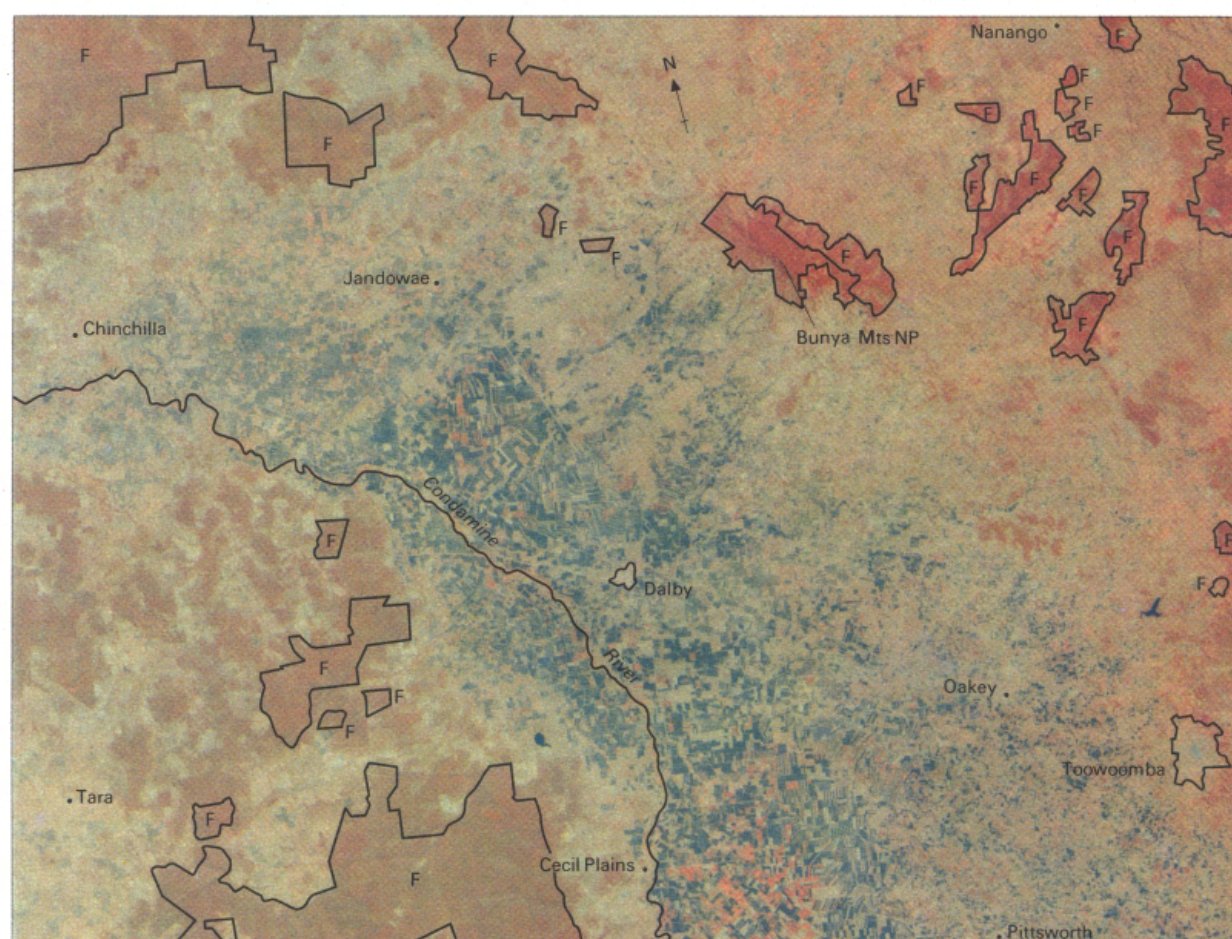


Figure 1. A 'false-colour' Landsat image (scale 1:1 000 000) of part of the main cropped area of the Darling Downs, Queensland, in late summer. In these images green vegetation shows as various shades of red to enhance differences in type and cover. (F= State forest; NP= national park.)

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 ('Kanaka') 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.

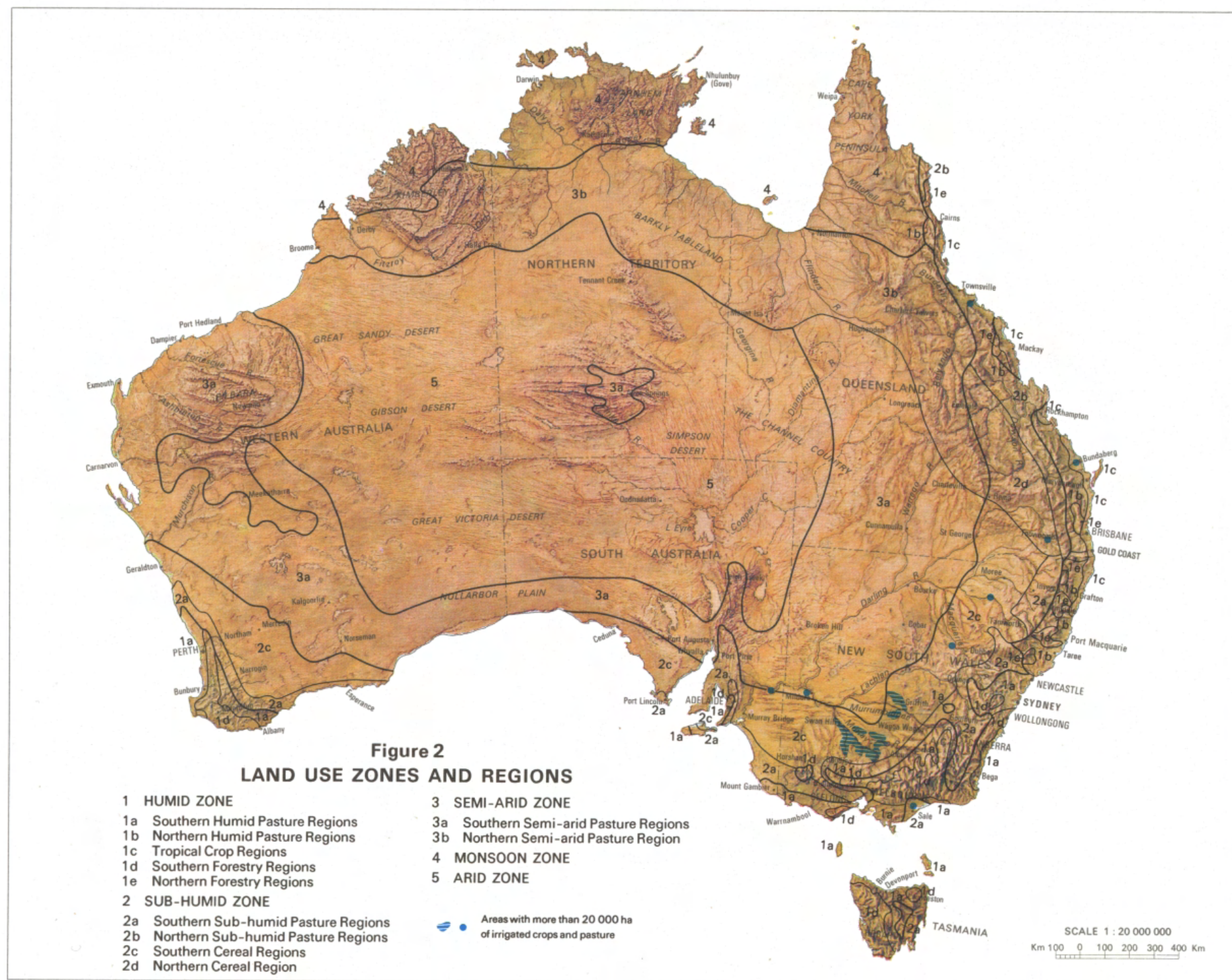
The most intensive use is *urban land*, which occupies about one million ha, only 0.13% of the total area, but is the land on which over 80% of Australians reside and work. This has increased directly with population (nearly 4 million in 1900 and nearly 14 million in 1976), generally at the expense of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

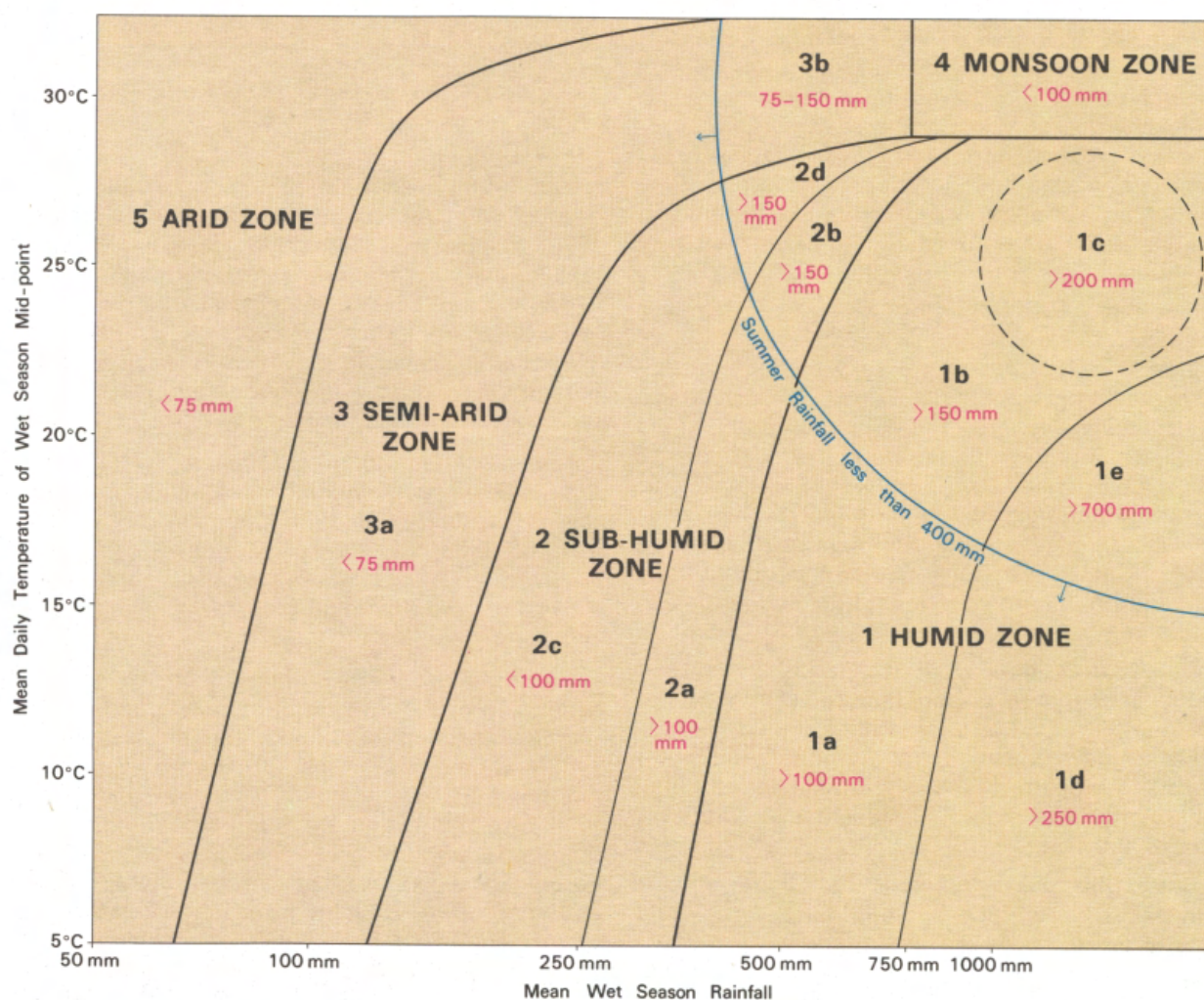
Today State forests are, in many cases, multi-use areas managed primarily for present and future timber production but also functioning wholly or in part as conservation and recreation areas, as annually licensed grazing land and, particularly near major urban areas, as water supply catchments.

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



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.

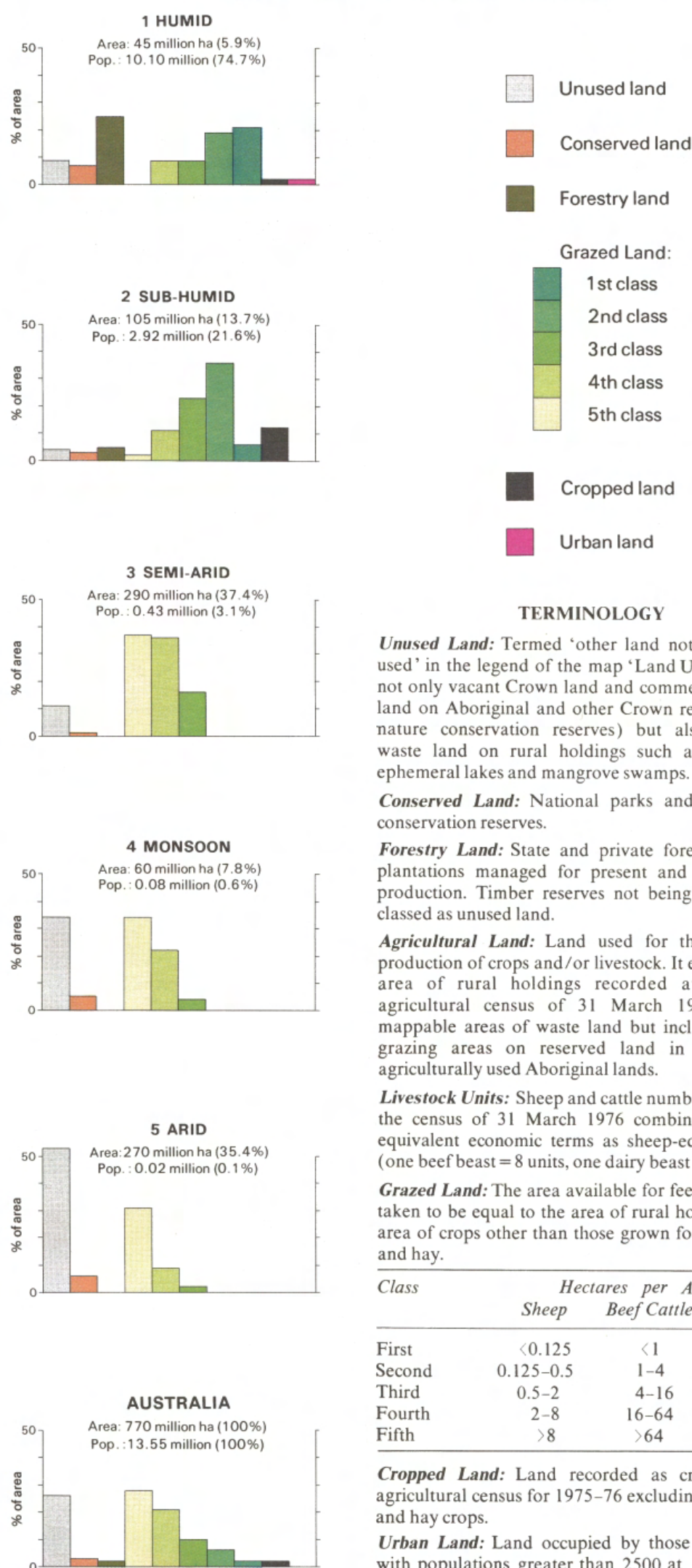
- About three-quarters of the population live in the small, generally narrow, and mostly coastal Humid Zone and all major urban areas lie within or close to its borders.
- The vast proportion of agricultural land is grazed. First-class grazing land is largely confined to the Humid Zone and first-class 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

Figure 4. Land Use Profiles and Terminology



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 northern 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

Australia's productive forests and its most visited national parks.

1a. Southern Humid Pasture Regions

These regions receive, on average, at least 400 mm of winter rain and 100 mm of summer rain. They consist of coastal plains, low hills, dissected uplands and some wetter areas of tableland.

All southern major urban areas lie within or near the borders of these regions and urban land occupies 3.8% of the regional area—a proportion equalled only by the Tropical Crop Regions. Forestry land (7.7% of the regional area) and conserved land (3.8%), which is also predominantly forested, tend to occupy the higher, more rugged and potentially least agriculturally productive areas. The forestry areas are similar to those of the adjacent, wetter, Southern Forestry Regions and are described below under 1d.

Half the agricultural land, which makes up 83% of the regional area, is under sown pasture (mainly rye grass and clover) and the average stocking rate is about one beef beast per hectare. Locally, as in west Gippsland (Vic.), this rises to about two dairy beasts per hectare, which is very high for Australia. First-class pasture land occupies half the agricultural area and second-class land makes up a further third. Cattle comprise about 70% of total livestock units as much of the regional land is too wet for successful sheep grazing, although important fat lamb areas occur on the drier inland margins in Victoria and New South Wales.



Figure 5. Southern Humid Pasture Regions: dairying on lush sown pasture in southern Gippsland, Victoria.

The large urban population creates a heavy local demand for dairy products and almost all southern non-irrigated dairying lies in these regions. Dairy cattle constitute 26% of the regional livestock units and occur almost exclusively in areas shown on the land use map as first-class grazing land with cattle predominant. Sown pasture makes up 95% of these dairying areas. Further away from the major cities beef cattle are more important, particularly on poorer pastures on higher ground.

Only 2.5% of the agricultural area is cropped, mostly intensive market gardening close to major cities and specialised fruit and vegetable growing where soils and local climate are particularly favourable. Much of Australia's temperate fruit (apples, cherries, plums and berry fruit) is grown in these regions.

Because of the high stocking rates, the strong emphasis on dairying, and the high value of most of the crops grown, these regions have a high value of production per hectare. Accordingly, farm sizes tend to be small by Australian standards, averaging about 270 ha. The mean size of dairy farms is about 140 ha. Fruit and vegetable farms are even smaller, averaging about 45 ha, although potato farms average about 100 ha. Beef and sheep farms are much larger, averaging about 500 ha.

1b. Northern Humid Pasture Regions

Climatically these regions are similar to their southern counterparts except that the rain falls mainly in summer and the winters are much warmer. They are also topographically similar except that those areas of coastal lowland that are sufficiently warm and wet in winter for the production of tropical crops have been put in a separate set of regions (see 1c below). Agricultural land covers 84% of the regional area. Forestry land (14%) is similar to that of the adjacent, wetter, Northern Forestry Regions, described below under 1e. Conserved land amounts to about 2%.

Like 1a, these regions are climatically well suited to livestock grazing. A much smaller proportion (about 15%) of the agricultural area is under sown pasture although much of the coastal pastures in northern New South Wales is dominated by introduced grasses, notably *Paspalum dilatatum*, which have spread naturally. Accordingly the mean stocking rate of one beef beast to about two hectares is only half that of 1a. First-class pasture areas occupy a quarter of the agricultural area and second-class areas make up a further third. These regions are too warm and humid in summer for successful sheep grazing.

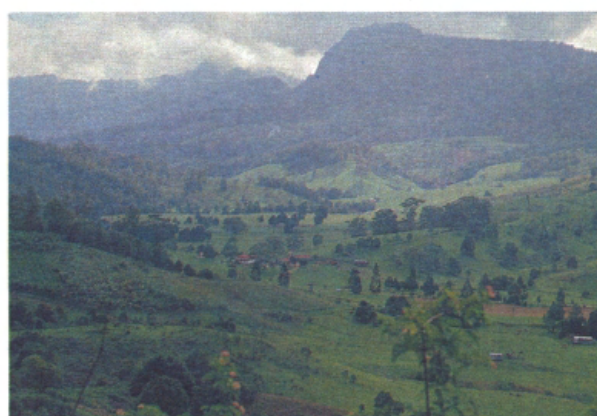


Figure 6. Northern Humid Pasture Regions: dairy and beef grazing land on the Atherton Tableland, northern Queensland.

Dairy cattle constitute about 28% of the livestock units and, as in 1a, occupy the better grazing land. Sown pastures make up a much smaller proportion of the dairy grazing land compared with 1a, constituting 40% in New South Wales and only 20% in Queensland. The hotter summers and the drier winters of these regions make them less suitable for dairying than 1a and milk yield per cow in northern New South Wales and southern Queensland is only 60% of that in Victoria. Beef cattle grazing forms the major land use, occupying all of the poorer grazing land and an increasing proportion of the better land as dairying declines.

Cropping accounts for only about 2% of the agricultural area. As in 1a, these regions are too humid for successful wheat grain production so that cropping is restricted to small areas of winter cereals, grown mainly for fodder, in the south; summer-grown cereals (mainly sorghum and maize) in the north; market gardening close to Brisbane (notably in the Lockyer Valley); and small areas of fruit and vegetables where the local environment is particularly favourable.

The most northern of these regions, the Atherton Tableland inland from Cairns, grows maize and peanuts and has a locally important dairy industry. Irrigated tobacco growing has developed on its northern border around Mareeba.

Farms tend to be larger than in 1a, averaging about 350 ha, reflecting the lower stocking rates. Dairy farms average about 150 ha in New South Wales and 180 ha in Queensland while beef farms average about 1000 ha, twice that of 1a.

1c. Tropical Crop Regions

Climatically these regions are very similar to 1b except that the winters are wetter and hotter. They consist of coastal lowlands and the lower foothills of the coastal ranges. These regions are well suited for sugar cane, many tropical fruits and early vegetables. About 67% of the area is used agriculturally and about 17% is forestry land, which is mostly confined to land too steep for cultivation as well as the poorer, sandy 'wallum' country of the south Queensland coast and adjacent islands such as Fraser and Bribie islands. About 6% is conserved land, which is mainly forested and includes a number of Great Barrier Reef islands. Some of the latter are also tourist resorts.

Urban land accounts for about 4% of the regional area and is increasing. Brisbane and Gold Coast make up most of this but other coastal settlements in southern Queensland and northern New South Wales are growing rapidly due mainly to the attraction of the winter climate for retired people and holiday-makers.

Despite its climatic suitability for tropical crops, 75% of the agricultural land is used for livestock grazing. Areas of first-class grazing land, predominantly sown pasture, make up nearly 25% and second-class land a further 45% of the grazed area. The mean stocking rate is one beef beast to about 2 ha, the same as for the climatically similar 1b regions. These regions are exclusively grazed by cattle since they are generally too hot and humid for sheep. Dairy cattle make up 20% of the livestock units and are mainly concentrated on first-class grazing land to the south, where they provide fresh milk and dairy products for the nearby urban areas of Brisbane and Gold Coast.



Figure 7. Tropical Crop Regions: sugar cane growing on the Barron River flats near Cairns, northern Queensland.

Sugar cane accounts for almost all of the 25% of the agricultural area that is cropped. It is grown on the fertile alluvial flats and, in a few places, on the less steep lower hill slopes where the soil is exceptionally good. Its local importance decreases with the increasing length of time the crop takes to mature, from one year in the north to up to two years in the south.

In the northernmost region, centred on Cairns, cane is grown on almost all suitable land to the near exclusion of all other crops and livestock. In the central region, centred on Mackay, cane is still the most important crop but is mixed with livestock grazing. (The irrigated cane in the Burdekin delta falls in 2b because of lower rainfall.) These northern areas contain 80% of the sugar cane area. Further south, from Rockhampton to the Burnett delta, no cane is grown and, apart from some pineapple cultivation near Rockhampton, this is primarily a livestock area. The Burnett delta centred on Bundaberg and the Childers area to the south are the southernmost major cane areas. Here cane is the dominant crop but is mixed with cattle grazing and small areas of fruit and vegetables. South of Maryborough cane is growing in relatively small areas as far south as the Clarence River (N.S.W.) but fruit (notably pineapples and bananas), vegetables (for the Brisbane and Gold Coast markets and as early crops for southern markets) and dairying are of greater importance.

Farm sizes are similar to those of 1b. Sugar cane farms average about 100 ha.

1d. Southern Forestry Regions

These are the wettest and coolest regions in southern Australia and are generally confined to the higher uplands where rainfall is locally increased orographically. The natural vegetation is mostly medium to tall forest dominated by various eucalypt species. However, a few areas are naturally unforested. One such area is the very wet heath and sedgeland in south-west Tasmania, which, although at a lower altitude than most of the rest of these regions, is unused agriculturally and much is now conserved land. Other generally treeless areas are the alpine grasslands above about 1500 m on the ridge tops of the Snowy Mountains (N.S.W.) and the Bogong High Plains (Vic). Now mostly conserved land, they are snow covered in winter and all Australian ski-resorts are located close by. Parts of this alpine area in Victoria are still annually leased for grazing beef cattle in summer, the animals being herded down to lowland pastures as winter approaches, but this practice has declined as alpine conservation areas have been increased.

Much of the natural forest remains. It covers the 42% of the regional area which is managed forest, and most of the 13% which is conserved land and the 22% which is unused land. Notable timber species are the jarrah (*Eucalyptus marginata*) and karri (*E. diversicolor*) of Western Australia and messmate stringybark (*E. obliqua*) and mountain ash (*E. regnans*) in Victoria, Tasmania and New South Wales. Forests are not confined to these regions and extend into all adjacent regions (notably 1a), generally in areas of low agricultural potential.

While the eucalypt forests in these and adjoining regions provide a plentiful supply of hardwoods, Australia is deficient in native softwoods. Plantations of exotic softwoods, predominantly *Pinus radiata*, have been established on the lower and generally drier margins of these regions, and extend into adjacent areas.

Catchment protection is particularly important in these regions because they include the upper catchments of the major river systems of southern Australia and contain the Snowy Mountains Hydro-electric Scheme, the largest integrated water storage scheme in Australia, and much of the Tasmanian Hydro-Electric Commission's storage system.

Only 23% of the regional area is agricultural land, largely confined to valley floors and lower hill slopes and predominantly grazing land, 20% of which is sown pasture. Nearly 85% of the livestock units are beef or dairy cattle, since these regions are generally too wet and cold in winter for successful sheep rearing. Dairy cattle make up about 15% of the livestock units and are grazed on sown pasture on the narrow valley floors. Elsewhere, particularly at higher altitudes, beef cattle predominate. The mean stocking rate is one beef beast to about two hectares.

Crops occupy less than 1% of the agricultural land. They are restricted to small areas of winter cereals grown for fodder and temperate fruit (chiefly apples), which are mostly confined to valleys cutting through the forested uplands.

Farm sizes are much the same as in 1a, averaging about 500ha, except that beef properties in the higher country are somewhat larger.

1e. Northern Forestry Regions

These regions consist generally of the higher and wetter parts of the eastern seaboard hinterland north of the Hunter Valley (N.S.W.). They differ climatically from 1d in that summer rain is generally more abundant than winter rain—a trend that increases northward. Like 1d the natural vegetation is mainly eucalypt forest although smaller areas of (non-eucalypt) rain-forest still exist, particularly in the north. About 82% of the regional area remains as forest, 73% as managed forest and 9% as forested conserved land.

As in 1d, State forests producing hardwood occupy most of the area. Various stringybarks and ironbarks and the spotted gum (*E. maculata*) are the most important timber species of the eucalypt forests. The rain-forests are composed of a large number of non-eucalypt species, many of which produce excellent timber for furniture and veneers. The native softwoods of these regions, notably the hoop, bunya and kauri pines (*Araucaria* spp.), are a small and diminishing natural resource. Hoop pine is now grown in plantations supplemented by an even larger area of the exotic slash pine (*Pinus elliottii*) and, to a lesser extent, *P. radiata*. This development has been most extensive in the drier marginal areas in south-eastern Queensland and adjacent areas of 1b, mainly between Brisbane and Maryborough.



Figure 8. Northern Forestry Regions: eucalypt forest in the New England National Park, on the eastern escarpment of the New England Tableland, New South Wales.

Only about 18% of the regional area is used agriculturally, predominantly beef cattle grazing. Sheep are almost completely absent except for a few on the drier inland margins of the southernmost areas. Dairy cattle make up about 15% of the livestock units and are restricted to sown pastures in valleys. Sown pasture occupies only about 6% of the grazing land and accordingly the mean regional stocking rate of one beef beast to about 3–4 ha is the lowest in the Humid Zone.

Cropping is negligible, amounting to about 0.5% of the agricultural area and mainly consisting of small areas of cereal fodder crops such as maize.

The mean farm size of about 500 ha is large for the Humid Zone and reflects the predominance of beef cattle grazing at relatively low stocking rates.

2. SUB-HUMID ZONE

Climatically this zone is transitional between the wetter coastal hinterlands and the semi-arid inland areas. The major part includes the drier inland slopes of the coastal ranges and tablelands and the wetter portions of the adjacent inland plains of eastern mainland Australia. Although it contains only 18% of Australia's agricultural land, this zone is the core area of agricultural production and the area where the major agricultural innovations of this century have had their greatest impact. It produces almost all the cereal grain, oilseeds and cotton and much of the irrigated fruit. It also provides grazing land for about 60% of the national sheep flock and about 40% of the national beef herd.

A very large proportion (89%) is agriculturally used. About 5% is managed forest while the remaining 6% is roughly equally divided between conserved and unused land. The latter mainly consists of uncleared mallee in poor sandy areas in Victoria and South Australia and sand plains on the drier margins of this zone in Western Australia.

Although the area of urban land is very small, this zone contains nearly half the urban centres with populations greater than 2500; most are small rural service centres.

2a. Southern Sub-humid Pasture Regions

These regions mainly occupy relatively narrow belts lying between the coastal humid zone and the drier cereal regions inland. They also include small coastal areas in Western Australia, South Australia and Victoria, while in Tasmania they include most of the central lowlands.

Although topographically diverse they mainly consist of tablelands and the adjacent inland-facing

slopes. In the south and west most of the rain falls in winter. In the north in central and northern New South Wales, where the rain is more evenly distributed, it is the winter rainfall that is the more effective for plant growth.

The Monaro region south of Canberra is included here, even though much of it is as dry as parts of the cereal regions (due to the rain-shadow effect of the Snowy Mountains), because it is generally too cold in winter for economic wheat production.

Most (86%) of the land is used agriculturally. Forestry land (3%) and conserved land (6%) are largely confined to higher and more rugged areas. Unused land, which makes up 4% of the regional area, is largely confined to part of the infertile sandstone plateau north-west of Sydney, much of which was proclaimed as a national park at the end of 1979. Urban land, mainly Canberra and the drier western portion of Melbourne, makes up the remaining 1%.

Livestock grazing predominates, to a large extent on sown pastures (mainly *Phalaris* grass and subterranean clover), which occupy about 40% of the grazed area. Nearly 75% of the grazed land is composed of first-class or second-class pasture areas although most is in the second class (see photograph on page 15). The mean regional stocking rate is one beef beast to about two hectares or four sheep per hectare. These regions are too dry in summer for the year-round maintenance on dryland pasture of dairy cattle, which account for only about 4% of the total livestock units and are mostly confined to small areas of privately irrigated river-flats. Sheep and beef cattle each make up almost equal proportions of the remaining 96% of the livestock units. Sheep predominate in the drier parts of these regions in areas of better pasture while beef cattle predominate in the wetter areas and in areas of poorer pasture, particularly in the more heavily timbered hill areas. However, in recent years beef cattle have increased in sheep areas and now many sheep farms (particularly those producing fat lambs) also run small cattle herds.

About half the sheep properties run merinos primarily for wool production while the remainder run non-merino breeds for the dual production of wool and fat lambs. Properties specialising in fat lambs consist almost entirely of sown pastures.

While cropping is much greater in total area than in the adjacent Humid Zone, it only amounts to about 4% of the regional area. Most of this is winter cereal cropping (mainly oats and barley for fodder) spilling across from the adjacent, drier, cereal regions. These sub-humid pasture regions are marginally too humid for successful wheat grain production, with rust a problem in wetter years.

Many of the vineyards producing high quality table wines are located within or very close to the borders of these regions. The largest concentrations are in the Barossa (S.A.) and Hunter (N.S.W.) valleys. Elsewhere there are vineyards at many scattered localities ranging from the Swan Valley north of Perth to near Mudgee in New South Wales. The vineyards take advantage of the climate, which is sufficiently wet to make irrigation mostly unnecessary, giving the grapes more flavour, while the summers are normally of sufficient heat and length for the production of grapes with optimal sugar content for quality wine-making.

The mean regional farm size is about 500 ha, similar to the least productive regions of the adjacent Humid Zone. Sheep properties average about 700 ha and beef properties, which are generally on poorer pasture, are about twice as large. Vineyards average about 25 ha.

2b. Northern Sub-humid Pasture Regions

The main region forms a narrow belt between the Humid Zone and the Northern Cereal Region in southern Queensland and extends north to include the drier coastal areas and inland to where the winter rainfall is, on average, just sufficient to keep pasture growing. The summers are much wetter than the winters—a characteristic that increases northward due to the strengthening monsoon influence.

Like their southern counterparts (2a), a large proportion (90%) of the regional area is agricultural land. About 7.5% is forestry land similar to that in 1e and about 2.5% is commercially unused reserved land.

In the agriculturally used area livestock grazing predominates. In contrast with 2a only about 10% of the grazed area is under sown pasture. This is largely restricted to areas adjacent to the Northern Cereal Region and in some of the more humid brigalow country, where panic grass (*Panicum maximum*) and Rhodes grass (*Chloris gayana*) are important. Elsewhere livestock graze on native pastures now largely dominated by spear grass (*Heteropogon contortus*). Beef cattle predominate, making up over 90% of the total livestock units. Dairy cattle make up almost all the remainder and are largely confined to valleys from the Burnett River southward. These



Figure 9. Northern Sub-humid Pasture Regions: beef cattle land, much of which is cleared brigalow country, near Biloela, central Queensland.

regions are too humid in summer for sheep. The mean regional stocking rate is one beef beast to about four hectares, which is only half that of 2a, due largely to the much smaller proportion of sown pasture.

Cropping occupies only about 1% of the agriculturally used land. The largest concentration occurs in the Burdekin delta, where 35 000 ha of irrigated sugar cane and 2000 ha of rice are grown. Without irrigation this area would normally be too dry for sugar cane cropping, although suitable in other respects. This is the only major cane area which is wholly dependent on irrigation. Nearby at Bowen there is a small but important area growing about 2000 ha of irrigated vegetables for southern markets.

Further south, citrus fruit and vegetables are grown in the Burnett Valley centred on Mundubbera, and Australia's largest concentration of peanut cropping is centred on Kingaroy. In this southern area sorghum, oats and maize are also grown for animal fodder.

The mean regional farm size of about 1400 ha, almost three times that of its southern equivalent, reflects the much smaller proportion of sown pastures. Beef properties are generally larger than 2000 ha while specialist crop farms are similar in size to those in adjacent regions of the Humid Zone.

2c. Southern Cereal Regions

These regions extend inland to the drier limit, in average years, of winter-grown cereal grains (predominantly wheat). Flat or gently undulating plains predominate, broken in places by low hill ranges.

Agricultural use predominates, occupying 92% of the regional area. Unused land, mostly vacant Crown land, occupies about 5% and is mainly confined to the drier margin in Western Australia and areas of uncleared mallee and poor sandy country in north-western Victoria and parts of South Australia. About 2% is conserved land and a further 2% is forestry land. The latter is mostly confined to New South Wales and southern Queensland and consists of dry eucalypt woodland of much lower productivity than in the more humid regions and, more importantly, areas of native softwood (cypress pine) extending from central New South Wales into Queensland.

Despite the large cropped area of these regions (11 million ha or more than three-quarters of the national total), about 80% of the regional agricultural area is grazing land. About 30% of the grazing land is under sown pastures, mostly based on subterranean clover in the more humid portions, annual medics (small mediterranean legumes) on the drier margins, and lucerne or rye grass in irrigated areas.

Regionally, stocking rates average about 2.3 sheep per hectare or one beef beast to 3.5 ha. Areas of first-class grazing land are confined to irrigation areas and make up only about 5% of the grazed land. Second-class pastures make up about 40% and are largely composed of subterranean clover. Third-class grazing land, composed of a mixture of poorer subterranean clover, medic and native pastures, makes up a further 30% and occurs predominantly on the drier margins.

Sheep have historically been strongly predominant throughout these regions. Recently they have been partly displaced by beef cattle, particularly in northern New South Wales and Queensland, so that by 1975–76 they constituted only 60% of total regional livestock units. The sheep, predominantly merinos, are kept primarily for their wool although lambs for meat are produced on the better pastures on the wetter margins and particularly in the Murray and Murrumbidgee irrigation areas. Wool and wheat production are strongly integrated. Over most of the regional area both enterprises are undertaken on most farms and, on average, contribute about equally to farm income. The average wheat-sheep farm has about 25% of its area under winter cereal crops (most commonly wheat) and a further 25% under sown pasture, rotated in a ley farming system.



Figure 10. Southern Cereal Regions: wheat stubble (yellowish) and improved pasture in central New South Wales. Railside wheat silos appear on the right.

Beef cattle make up 35% of the regional livestock units and have increased throughout these regions in the last decade. Much of the increase has occurred on wheat-sheep farms as a subsidiary enterprise. This trend has been greatest in Queensland, New South Wales and Victoria. However, beef cattle are only predominant in the wetter areas in northern New South Wales and in small areas on the less productive fringes of mallee country in Victoria and South Australia.

Dairy cattle, which make up 5% of the regional livestock units, are largely concentrated in the irrigation areas of north-central Victoria. Here they form the largest inland concentration of dairying and are the predominant livestock type although sheep kept mainly for prime lamb production are also locally important. There are much smaller dairy concentrations in the Murray irrigation areas in New South Wales and on irrigated river flats near the Murray mouth in South Australia.

The 20% of agricultural land cropped is proportionally exceeded only by the much smaller Tropical Crop Regions. Although, in the early days of farming, there was considerable correspondence between crop distribution and areas of inherently better or more fertile soils, today there is little. This is due to a better understanding of soil management, including the widespread use of superphosphate fertiliser and the much increased practice of ley farming based on nitrogen-fixing exotic legume pastures. Gaps in the distribution of cereal crops are still apparent where gross soil defects occur, such as on the deep sands of relic sand-dune areas in the Victorian and South Australian mallee and on saline soils along ancient streamlines in Western Australia.

Two-thirds of the cropped area is under winter-grown wheat. Barley and oats make up the bulk of the remainder in Western Australia, Victoria and southern New South Wales. In South Australia barley makes up a large proportion of the non-wheat cropland, oats being relatively unimportant. This is the only State in which barley occupies nearly as much land as wheat, on Yorke Peninsula occupying about three times as much land. In northern New South Wales barley is less important and grain sorghum, grown during the wetter summers of this area, replaces oats as a grain crop secondary to wheat, although a considerable area of oats is grown for green fodder.

Few farms are completely dependent on cereals, the crops being rotated with sown or volunteer pasture as well as with each other. The sown pastures are grazed for three to four years then put under a crop for two to four years. This ley farming system has significantly decreased the proportion of fallow land and, therefore, the problem of soil erosion. Fallowing is still necessary where good perennial clover-based pastures cannot be maintained, as on the drier margins and on the plains of northern New South Wales and Queensland.

Although occupying a small proportion of the cropped area, irrigated crops are locally very important in New South Wales and Victoria. The large irrigation areas of north-central Victoria are mostly under pasture but contain areas of fruit, grapes and vegetables. The irrigation areas lower down the Murray between Robinvale (Vic.) and Cadell near Morgan (S.A.), which lie just inside the Semi-arid Zone, have a different land use system.

The irrigation areas in southern New South Wales using Murray water and centred on Deniliquin are, like their Victorian neighbours, mostly under pasture. Further north the Murrumbidgee Irrigation Areas (M.I.A.), centred on Griffith and Leeton, and the newer Coleambally Irrigation Area to the south use Murrumbidgee water and have much larger areas under crops than under pasture. Together they produce the bulk of Australia's rice crop. Rice (a summer crop) is grown in rotation with wheat and pasture and this rotation system makes up the largest proportion of the irrigated land in both areas. The M.I.A. also has considerable areas of orchard fruit and of grapes used mainly for the production of wine.

Further north in New South Wales and in southern Queensland, where the summer growing season is longer and hotter, cotton is the predominant crop on the smaller and newer irrigation areas on the Macquarie, Namoi and Balonne rivers. Much of the cotton is grown on a large scale by a few highly capitalised companies.

These regions, while unified by the near-ubiquity of the wheat-sheep farm, nevertheless encompass a variety of rural land use systems and so farm sizes vary accordingly. The mean regional farm size is about 750 ha and the average wheat-sheep farm is about 1000 ha, while those devoted exclusively to livestock average about 1200–1400 ha. Farms producing irrigated fruit and grapes average less than 50 ha while those specialising in rice are generally between 100 and 300 ha.

By Australian rural standards these regions have a dense transport network required to move the wheat harvest efficiently. The wheat is trucked to the nearest storage silo and then most of it is railed to the nearest wheat port, between 70% and 80% of the crop being exported. This transport network and the many small service towns form distinctive features of the regional landscape although occupying only a small proportion of the total area.

2d. Northern Cereal Region

This region is sufficiently wet in winter, with carryover of soil moisture from summer, for the growth of cereals such as wheat and, unlike most areas of the Southern Cereal Regions, is sufficiently wet in summer for the growth of sorghum.

It consists of a sequence of fairly broad valleys with relatively fertile soils separated by ridges and dissected plateaux with shallow and much less fertile soils. Much of this region was covered by brigalow forest, and clearance and intensified development are recent and continuing.

About 23% of the regional area is forestry land and about 2% is conserved land, confined almost entirely to the more rugged upland areas of plateaux and ridge tops. Much of the forestry land is low-grade eucalypt woodland which gives way in the south and south-west to cypress pine forest.

The remaining 75% is agricultural land, a much smaller proportion than that of the Southern Cereal Regions, and about 90% of this is grazed, predominantly by beef cattle. The mean regional stocking rate is one beef beast to about five hectares—considerably lower than that of the Southern Cereal Regions. This is due mainly to the lower (though rapidly increasing) proportion of sown pasture—only about 12% of the agriculturally used land in 1975–76, to which may be added a further 2% under annual forage crops. The latter are mainly confined to the fertile cropland areas of the Darling Downs in the south. The main sown pasture species are Rhodes, panic and buffel grasses and their area is increasing as more brigalow is cleared. The native pastures range from the better blue grass (*Dichanthium sericeum*) on the heavy self-mulching soils in the larger valleys, through spear grass (*Heteropogon contortus*) on intermediate country, to a mixture of poor pasture species in uncleared woodland in upland areas. About half the grazing land is second class and the bulk of the remainder is divided fairly equally between the third and fourth classes.

This region, with its hot and humid summers, is mostly unsuitable for sheep, which constitute only about 2% of the regional livestock units. They are confined to the drier south-western edge and small pockets associated with cropped land further north in the Central Highlands. Dairy cattle make up about 5% of the livestock units and are concentrated on the wetter eastern edge of the Darling Downs and along the Condamine River near Dalby.

Beef cattle make up 93% of the regional livestock units and are the sole enterprise of almost all farms outside the crop-growing areas. Within the densely cropped area of the Darling Downs many farms run small beef herds, grazing them on forage oats and sorghum supplemented by hay and silage.

This region has considerable areas of soils requiring little or no phosphatic fertiliser. However, a crop-pasture rotation involving a nitrogen-fixing perennial legume suitable throughout this region has not yet been developed (in contrast with the use of subterranean clover in the Southern Cereal Regions), so nitrogen deficiency persists. The major cropped area lies in the south in the more fertile portion of the Darling Downs centred on Dalby where, locally, more than 60% of the agricultural land is cropped. This is the largest single area in Australia where extensive cropping covers more than half of the agriculturally used land (see Figure 1).

Winter-grown wheat and summer-grown sorghum are the main crops. On the Darling Downs barley and

forage oats each occupy, in winter, nearly as much land as wheat but they are unimportant in the northern parts of this region. Oilseeds are important summer-grown crops in the northern areas and to a smaller extent on the Darling Downs. Irrigated cotton is grown on the new Emerald irrigation area and to a much smaller extent at Cecil Plains on the Darling Downs.

The mean regional farm size is about 1700 ha. A wide variation exists between crop farms on the Darling Downs, which average about 250 ha, and the much larger beef properties elsewhere predominant, which average between 5000 and 6000 ha.

An important non-agricultural land use is open-cut coal mining. This has increased rapidly in recent years and is likely to expand further. Seams of black coal occur near the surface in many places in the north and the recent surge in their exploitation has created small but rapidly expanding towns at Moranbah, Dysart, Blackwater and Moura.

3. SEMI-ARID ZONE

This zone epitomises the Australian 'outback'. It is normally just wet enough to produce plant growth sufficient for the maintenance of extensively grazed livestock but generally too dry for crops and sown pasture. Broad plains interspersed with low stony ridges predominate although in the Alice Springs, Pilbara and Kimberley areas the topography is more varied, with higher and more rugged dissected plateaux and hill and mountain ranges. Surface water is scarce and ephemeral so that settlement and land use are highly dependent on underground supplies. Fortunately the Great Artesian Basin underlies much of this zone in Queensland and northern New South Wales and a variety of other aquifers supply bore water elsewhere, though commonly limited in amount and only suitable for livestock.

The agricultural use of this zone is almost completely dependent on the natural vegetation, in contrast with the more humid zones described above. Mallee dominates in the extreme south, giving way northwards to low acacia (mulga) woodland interspersed with areas of saltbush. North again, in the summer rainfall areas, extensive, generally treeless, Mitchell grass plains extend in a broken arc from the Kimberley area to northern New South Wales. Northward from these grasslands low open eucalypt or melaleuca woodlands extend into the Monsoon Zone. Where the soil is shallow or deep and sandy in these northern areas, hummock grass (spinifex) is common.

Only about 12% of the Zone is unused. This is largely confined to areas with shallow or sandy soils in Western Australia, the Northern Territory and South Australia where seasonal drought is a virtual certainty. There is little unused land in the eastern section, where some rain may fall at any time of the year. Conserved land accounts for about 2% of the area and a few small areas of forestry land—mostly cypress pine—lie near the wetter, eastern border.

Extensive grazing (beef cattle in the north and sheep in the south) predominates throughout and crops are virtually absent except in a few irrigation areas along the Murray River on the south-eastern border. Most agricultural land is leased from the Crown and pastoral holdings are very large due to the low carrying capacity of the native pastures.

In the early days of settlement of this zone, in the 1880s and 1890s, overstocking was common, particularly on the arid margins, due to lack of experience in this climatically erratic semi-desert environment. The prolonged and severe droughts at the turn of the century brought disaster so that, for example, stocking rates in north-western New South Wales are now considerably lower than in the early 1890s. Even today, despite improved management, overgrazing during droughts is usually impossible to avoid. This history of spasmodic overgrazing has led to a general deterioration of the native pastures. Areas of bare ground ('scalds') have increased, leading to soil erosion, and valuable perennial species such as the saltbushes have diminished.

Although much research and extension work in recent years has led to limited improvements, pastoral productivity has, at best, remained stable and in many places has declined. This is in sharp contrast to the great improvements in productivity in the more humid zones.

The extensive nature of the land use system and the resultant highly dispersed pattern of settlement has created the need for a two-way radio school system ('School of the Air') and a 'flying doctor' medical network. Towns that are purely rural service centres are few and, outside the irrigation areas in the south-east, widely scattered. Most of the larger urban centres owe their existence to mining, both open-cut, as in the Pilbara, and underground, as at Mount Isa, Broken Hill and Kalgoorlie. Open-cut mining, notably iron ore in

the Pilbara and near Whyalla (S.A.), is an important land use although it occupies a minute proportion of the zonal area.

3a. Southern Semi-arid Pasture Regions

Over most of the regional area the rain falls mainly in winter except in the Pilbara, around Alice Springs and in Queensland. In these northern areas, however, the effectiveness of summer rain (which is normally less than 400 mm) for plant growth is considerably reduced by the very high summer temperatures, but winter rain is sufficient to separate these areas from the Arid Zone.

Plains and low stony ridges predominate but higher and more rugged hill ranges occur in the Pilbara and Alice Springs area and in the northern extension of the Flinders Ranges.

About 14% of the regional area is unused and about 1% is conserved land. Most land in these two categories occurs in the south and west, in areas of sandy mallee plains, waterless limestone plains, salt lakes and much of the higher and poorly vegetated country in the Pilbara. Forestry land is negligible, consisting of a few small areas of cypress pine near the eastern border in central New South Wales and river red gum along the Murray.

Agricultural land makes up about 85% of the regional area and is devoted almost exclusively to extensive livestock grazing on native pastures. Sown pastures cover less than 1% of the grazed area and are confined to the wetter edges. The largest concentration is centred on Blackall (Qld), where an increasing area of buffel grass is being sown on the southern fringes of the Mitchell grass plains.

The mean regional stocking rate is one sheep to about three hectares but a wide variation exists depending on the quality and quantity of the native pastures. The best are the large areas of Mitchell grass in central Queensland and northern New South Wales, and the saltbush country in the Riverina (N.S.W.). These are third-class grazing land, which makes up 15% of the grazed area, with a stocking rate of one sheep to slightly less than two hectares. They are associated with self-mulching cracking clays which retain moisture well. Fourth-class grazing land makes up about 45% of the grazed area and much of this is short grass - forb pasture, with sparse acacias above, extending over much of the regional area in New South Wales, Queensland and around Alice Springs (see Figure 2 on page 5 of the topic 'Soils'). The acacias (mostly mulga trees and shrubs) form useful browse during severe droughts: tree branches are lopped and larger shrubs are pushed over to make the foliage available to the livestock. Similar pasture covers much of the region in South Australia and Western Australia but, because it occurs on shallower soils and in areas where summers are normally very dry, its carrying capacity is much lower than in the east. Much of this is fifth-class grazing land, with stocking rates of one sheep to more than ten hectares. Here the ancient watercourses, despite their saline soils, provide better grazing (on perennial saltbushes and salt-tolerant ephemeral species) over a longer period than the sparse pastures of the mulga country on higher ground.

Sheep, almost exclusively merinos, make up slightly more than half the regional livestock units. They predominate over most of the southern and western areas but are mixed with beef cattle in central and southern Queensland and on the more humid margins in New South Wales, notably in the Riverina. Beef cattle predominate on the drier margins and in the outlying region around Alice Springs.

A specially constructed dog-proof fence protects the sheep areas of Queensland from dingoes (feral dogs probably introduced by the Aborigines), which are largely uncontrolled in the cattle areas. A similar fence runs along the New South Wales boundaries with Queensland and South Australia and, in the latter State, cuts across the Arid Zone to protect the sheep areas to the south. In Western Australia a dog-proof fence system protecting much of the northern sheep area is now largely abandoned and what remains largely protects the sheep in the Cereal Region.

Cropping is absent except for small areas of wheat extending from the adjacent cereal regions and the Murray irrigation areas between Robinvale (Vic.) and Cadell near Morgan (S.A.). The land use system of these differs from the Murray irrigation areas in the more humid Cereal Region in that irrigated pasture is almost absent and irrigated crops (mainly grapes, citrus fruit and peaches) predominate. These irrigation areas produce the bulk of Australia's dried fruit, chiefly dried grapes. The long hot dry summers give the fruit a high sugar content and provide ideal natural drying conditions.

Property sizes in these irrigation areas are small, averaging about 20 ha. Elsewhere the extensive grazing properties are large with a regional average of about

20 000 ha. Locally, mean sizes range from 5000–10 000 ha in the more humid areas in New South Wales, through 15 000–20 000 ha in the Mitchell grass plains of Queensland, to 30 000–50 000 ha on the drier margins in the east and even larger in South Australia and Western Australia.

3b. Northern Semi-arid Pasture Region

This region is the drier inland extension of the Monsoon Zone and rainfall is restricted almost exclusively to the summer, when high temperatures severely reduce its effectiveness for plant growth. The topography varies widely, ranging from the sharply dissected ridge and valley systems of the Kimberley area through the plains and low tablelands of the Northern Territory and north-western Queensland to the hill ranges and valleys in central Queensland.

Only about 5% is unused land and less than 1% is conserved land. The unused land consists mostly of marginal sandy desert country and some of the more inaccessible, sparsely vegetated uplands in the Kimberleys and Barkly Tableland. A group of large pastoral leases in the upper Ord River basin are presently unused to allow the regeneration of vegetation and hence prevent rapid siltation of Lake Argyle, recently created by the construction of the Ord Dam near Kununurra.



Figure 11. Northern Semi-arid Pasture Region: a watering point, using bore water, on Brunette Downs, a 1.2 million hectare cattle station on the Barkly Tableland, Northern Territory.

The 94% of the regional area used agriculturally is almost entirely devoted to extensive beef cattle grazing on native pastures. Sown pasture accounts for a minute proportion of the grazed land and consists of small areas of Townsville stylo near the wetter regional borders in the Kimberleys and the Queensland Gulf Country and some larger areas of buffel grass (*Cenchrus ciliaris*) in the extreme south of this region in central Queensland.

The mean regional stocking rate is one beef beast to about 25 to 30 ha. The best native pastures are those dominated by the perennial Mitchell (*Astrelba* spp.) and blue (*Dichanthium* spp.) grasses on self-mulching, cracking clay soils. These grasslands are mostly third-class grazing land, which makes up about 25% of the grazed area. The poorest pastures are the extensive areas of hummock grassland (spinifex) on the sandy desert margins and on the shallow soils of the stony ridges and tablelands. These are generally fifth-class grazing land and make up about 40% of the grazed area, with stocking rates of one beef beast to 70 ha or more. The remainder, predominantly fourth-class grazing land, are pastures associated with low open acacia (commonly mulga) woodland to the south of the Mitchell grass plains and open eucalypt woodland with spinifex to the north.

Sheep, only marginal in this region, are restricted to the northern extensions of the Mitchell grass plains in Queensland. Early attempts to run sheep in the Gulf Country of Queensland and in parts of the Northern Territory were unsuccessful and properties which ran sheep in the West Kimberleys until recently now concentrate entirely on cattle. Thus this region is now almost exclusively devoted to beef cattle, which are run on very large holdings leased from the Crown. The scale of operations is accordingly large and generally beyond the financial and labour resources of the typical Australian 'family farm' enterprise so that most leases are operated by large pastoral companies.

The large size of holdings and dispersed distribution of livestock create a number of problems. Livestock pests and diseases are prevalent and difficult to control. Mustering cattle on these large holdings is a lengthy operation involving many stockmen on horseback. The recent use of helicopters in this work has made considerable savings in time and in the number of stockmen needed, particularly for mustering in rugged, wooded country. The annual turn-off for slaughter is generally less than 10% except in the better areas, and transport of these cattle to sale-yards and abattoirs has always been a major expense, up to 30% of the total cost of production in the more remote areas. A federally funded scheme for improving the transport network by

the construction of all-weather 'beef roads' was begun in 1961 and has resulted in the upgrading of most of the major roads. Movement of cattle by trucks and road-trains is now much easier, particularly in the wet season, when road transport used to be very difficult and often impossible.

Cropping is almost non-existent. Following the local demise of cotton growing in 1974–75 the Ord irrigation area, centred on Kununurra, produced less than 2000 ha of crops in 1975–76, mostly grain sorghum, rice and peanuts.

The mean size of rural holdings is about 125 000 ha and a number in the Northern Territory and Western Australia are over a million hectares, reflecting the low carrying capacities of much of this region.

4. MONSOON ZONE

This zone has a typical monsoon rainfall regime with a very wet period confined to the summer and almost rainless winters. Both seasonal excesses lead to land use problems. Dissected plateaux and hill ranges predominate in the west, generally with shallow soils except in the valley floors, while on Cape York Peninsula gently sloping plains form a large proportion of the area.

About 34% of the Zone is unused and a further 5% is conserved land. About three-quarters of the unused land lies in Aboriginal reserves and some of this is used occasionally for traditional hunting and gathering. However, the Aborigines run beef cattle on many of their reserves; these areas are accordingly shown as grazing land. Although much of the wetter northern coastal areas are under eucalypt woodland, there is little forestry land.

The remaining 61% of the area is agriculturally used, nearly all of it for extensive beef cattle grazing almost exclusively on native pastures. Only a very small proportion (0.3%) of the grazed land is under sown pastures—the tropical legume Townsville stylo—most of which is in the Northern Territory. However, the area has declined in recent years, for example in the Northern Territory from 146 000 ha in 1972–73 to 112 000 ha in 1977–78. The predominant native pastures are tall or mid grasses under low open eucalypt or melaleuca woodland. These grasses grow vigorously in the wet season but dry out rapidly during the dry season with a sharp decline in nutrients causing a considerable loss in the weight of cattle. Pasture burning is a common management practice in the dry season to stimulate a small amount of more nutritious regrowth.



Figure 12. Monsoon Zone: tropical tall grass drying off during the winter dry season in Arnhem Land, Northern Territory.

The mean zonal stocking rate is one beef beast to about 50 ha, which is inferior to that of the adjacent semi-arid region. This is due to the particular pasture problems of this zone and the lower proportion of pasture equivalent in quality to the Mitchell grasslands. All the problems of that region apply to this zone as well. In particular transport on and off cattle stations is very difficult during the wet season. However, the 'beef road' construction program has brought about some improvements.

Cropping is virtually non-existent and is declining, for example the cropped area of the Northern Territory, which is largely confined to this zone, declined from 12 000 ha in 1972–73 to 1000 ha in 1977–78. Commercial attempts to produce peanuts on the Daly River and rice near Darwin have all ended in failure and the large-scale production of grain sorghum on the drier edge of this zone in the Northern Territory effectively ended in 1975–76.

The mean size of pastoral leases is about 100 000 ha, slightly smaller than that of the Northern Semi-arid Region because there are fewer extra-large leases of over a million hectares.

5. ARID ZONE

This is the driest zone, with a very low and erratic rainfall. Winter rain is slightly more likely and reliable in the southern portion while the central and northern portions generally receive more summer rain, which is

much reduced in effectiveness by the very high summer temperatures.

The widespread areas of sand dunes, which are mostly formed into long parallel ridges, cover 35% of the Zone. The remainder has a varied landscape of generally low relief consisting of sand plains, salt lakes, low rocky hills and gently undulating stony 'downs'. In the east the flood plains of the Channel Country of Queensland are of particular land use significance.

Surface water is scarce and ephemeral. Although parts of watercourses fill during local heavy rains, running streams seldom form. A major exception occurs in the Channel Country, where in most years floods flow down the Georgina, Diamantina and Cooper towards Lake Eyre in late summer as a result of monsoonal rains on their upper catchments in the adjacent Semi-arid Zone. The extent of the flood flow into the Arid Zone varies greatly from year to year and very rarely reaches Lake Eyre although this did occur in 1974. However, throughout this zone, human settlement and livestock are heavily dependent on groundwater.

Due to the hostile environment about 53% of the total area is unused land and a further 6% is conserved land. Aboriginal reserves make up a quarter of the unused land, occupying large desert tracts in Western Australia, the Northern Territory and South Australia. Large areas of conserved land in the deserts of Western



Figure 13. Arid Zone: Innamincka, a large cattle station on Cooper Creek in the Channel Country of South Australia near the Queensland border. The homestead buildings are on the left, just above the timbered and better pastured flood-plain, which is bordered here by stony downs (fifth-class grazing land).

Australia have only recently been converted from vacant Crown land. The remaining 41% of the Zone is used as grazing land. Only a small proportion of the sand dune area is used, mainly those parts on the fringes of large pastoral leases and only in years of good rainfall.

Extensive livestock grazing on large pastoral leases is the exclusive agricultural land use of this zone. Beef cattle predominate almost everywhere but sheep, which

make up 15% of the livestock units, are run on the wetter fringes, notably in the south. The livestock are completely dependent on the sparse native vegetation so the mean zonal stocking rate is accordingly low: one beef beast to about 64 ha. Fifth-class grazing land makes up 75% of the grazed area and much of this is dominated by spinifex (hummock grass), the characteristic ground cover of this zone. Spinifex grasses (*Triodia* and *Plectrachne* species), which are evergreen perennials with hard leaves rolled into spines, usually grow in circular hummocks throughout the sand dune country and on the shallow soils of rocky hillsides but are only eaten by cattle when more palatable annual species are not available. Higher stocking rates occur along watercourses where rainfall accumulates to give more pasture than on the surrounding higher ground. The best pasturage in this zone occurs after floods have receded in the Channel Country, although once this vegetation (mostly a variety of annual grasses, Mitchell grass and saltbushes) has dried off it is hardly better than surrounding areas.

The very low stocking rates inevitably mean that pastoral leases are very large, averaging about 200 000 ha. Apart from the widely scattered rural population, settlement is restricted to a few small mining towns such as Leigh Creek (S.A.) and Tennant Creek (N.T.), a number of small Aboriginal settlements, and the small town of Woomera serving the nearby rocket range.

FURTHER READING

- Atlas of Australian Resources*: Maps with accompanying booklet commentaries 'Dominant Land Use' (1957, scale 1:6 000 000) of the 1st Series and 'Land Use' (1973, scale 1:6 000 000) of the 2nd Series of the *Atlas*, together with other map-sheets on agriculture and forestry.
- Australian Bureau of Statistics, current and past year-books for Australia and individual States.
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