# Australia's Vegetation. Why is it so ?

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## An Introduction to Australia

Australia extends from 11°S to 43°S latitude and is amongst the driest lands in the world. It was once linked to Africa, India and South America in the great land mass called Gondwanaland. We have now been isolated from the other continents for millions of years but we were connected by land to New Guinea in recent glacial times when the sea level was very low. At that time 8000 years ago, the island of Tasmania was also joined to Victoria. In this isolation the marsupials, *Eucalyptus* trees and phyllodineous *Acacias* thrived while the relatively primitive monotremes (Platypus and Echidna) survived. No large mammals or rodents or carnivores bigger than a dog existed when the first Europeans arrived to settle in 1788 A.D. but giant marsupials are known from recent fossil records. Birds (particularly parrots) and reptiles are abundant.

## GEOLOGY AND LANDFORMS

Our continent lacks altitude (only 5% is above 600 m). Exceptions are found in Tasmania, N.E. Queensland near Cairns and the S.E. corner around Mt. Kosciusko which, at 2230 m, is our highest peak. Very little of Australia receives any snow and then only on the high areas in S.E. Australia and Tasmania. Tasmania is the only region where the results of Pleistocene glaciation, e.g. cirques and lakes, can be seen clearly. We have no glaciers, no active mainland volcanoes, few major earthquakes and no perennial inland rivers.

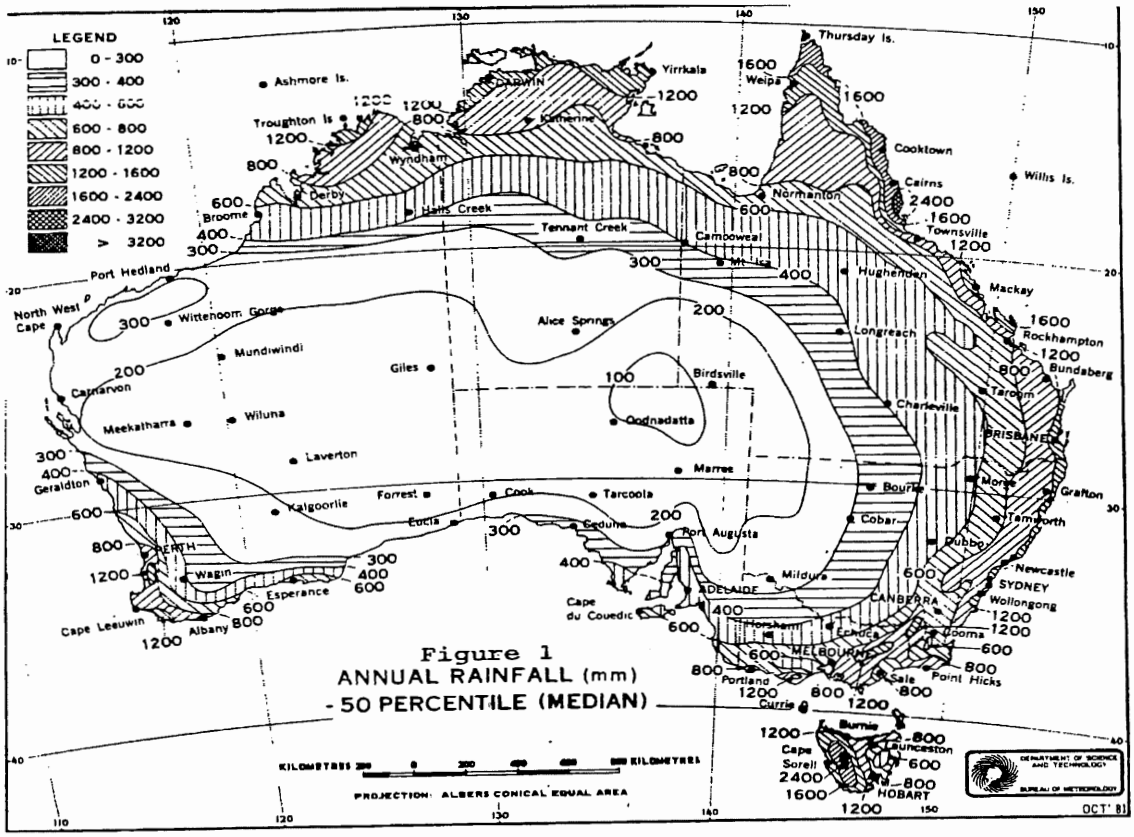
Most of the western half of Australia has been above sea level and stable since Pre-Cambrian times (>600 million years ago). The Great Dividing Range, which runs the entire length of the East Coast, was the last major zone of uplift (370 million years ago). About 50 million years ago, Australia began to drift north and lay astride 40° S by 37 million years B.P. By 7 million years B.P. the mainland lay astride 30 S where it is today. The dominance of red and yellow coloured rocks and soils reflects the extensive lateritisation which occurred in the middle Cainozoic (30 to 40 million years ago). The aeolian sand dunes and deserts of Central Australia are of very recent origin, being developed during the drier times of the ice ages in the last million years. Loess and glacial deposits are very rare. Australia is blessed with large reserves of underground water in its drier areas. The most notable artesian basin is the Great Artesian Basin which underlies most of inland Queensland and parts of N.W. New South Wales and N.E. South Australia. The water is generally warm to hot and contains 500 to 1,000 mg/1 of dissolved solids, mainly sodium carbonate. Hence it is suitable only for stock and human consumption.

## CLIMATE

Since the mid-Miocene the tendency has been towards increasing aridity in cycles which have increased in frequency. The early Pliocene saw a warming period and then a second cooling 4 my B.P. in the late Pliocene. Recent climatic fluctuations saw much of northern Australia under arid conditions 15,000 years ago while 8,000 years ago, the arid vegetation was confined to an even smaller region than today. The last pluvial peak was probably 3,500 years ago and, overall, conditions have been getting steadily drier ever since.

Australia nowadays is a huge landmass astride the southern hemisphere's sub-tropical high pressure zone with a cool current running north along the west coast. Australia is not a windy country by world standards. A large high pressure system with an anticlockwise circulation of air moves across the continent about once a week bearing very little moisture. There are no large, steep mountain ranges producing orographic rains except in N. Queensland near Cairns, where the peaks rise to nearly 1,500 metres. However, the circulating winds can pick up a fair bit of moisture from the warm currents off the east coast and deliver this moisture as S.E. trade winds all along the east coast.

Here the comparatively low mountains of the Great Divide encourage precipitation and produce the relatively wet eastern coastal belt (1,000-1,500 mm mostly). (Figure 1).




In summer, the high pressure systems move further south allowing moist tropical air to cover the northern parts of Queensland, Western Australia and the Northern Territory. This part of the country (to about 20 °S latitude) has a distinct monsoonal climate with wet summers and dry, frost-free winters. In southern Australia, the reverse (northward) movement of the high pressure cells in winter allows the prevailing westerly winds over the Southern Ocean to regularly move rain bearing cold fronts across Tasmania, Victoria and southern inland Australia. These fronts can extend as far north as 25°S and occasionally bring good rain to Western Australia and South Australia south of about 32 °S. This results in the classical mediterranean climate of mild, wet winters and hot dry summers in these southern areas (Figure 3). The island nature of Tasmania limits such seasonal extremes and it has a climate akin to New Zealand or Eire. Inland Australia tends to have a special continental climate which differs from other arid and semi-arid regions in the southern hemisphere, even though early climatic classifications would indicate close similarities.

The net effect of these rain-bearing influences is shown on the map as median annual rainfall (Figure 1), but this hides the large variability, both seasonally, annually and spatially, which can occur. Rainfall reliability is greatest in the strongly monsoonal and mediterranean climates and along the east coast. Where rainfall is seasonal there is only one rainy season, but this may be up to 5 months long.

Except for the coastal strip east of the Great Dividing Range, Australia between 25 and 30° S has no defined rainy season and radiation frosts are very common on fine winter mornings (Figure 3). Cyclones are very common in the tropics and subtropics as far as 25°S, usually originating in the Coral or Timor Sea, N.E. and N.W. of Australia, respectively. These can bring huge falls of rain in a short time and penetrate deep into the continent as rain depressions (up to 800 km). Good falls of winter rain can also come to central Australia from April to June from high-level jet stream moisture which moves across northern Australia in a N.W-S.E. direction from the Timor Sea. However, low level moisture is also required to trigger the fall of rain. Convection storms with severe winds, dust and lightning are common in summer but tornadoes are rare.

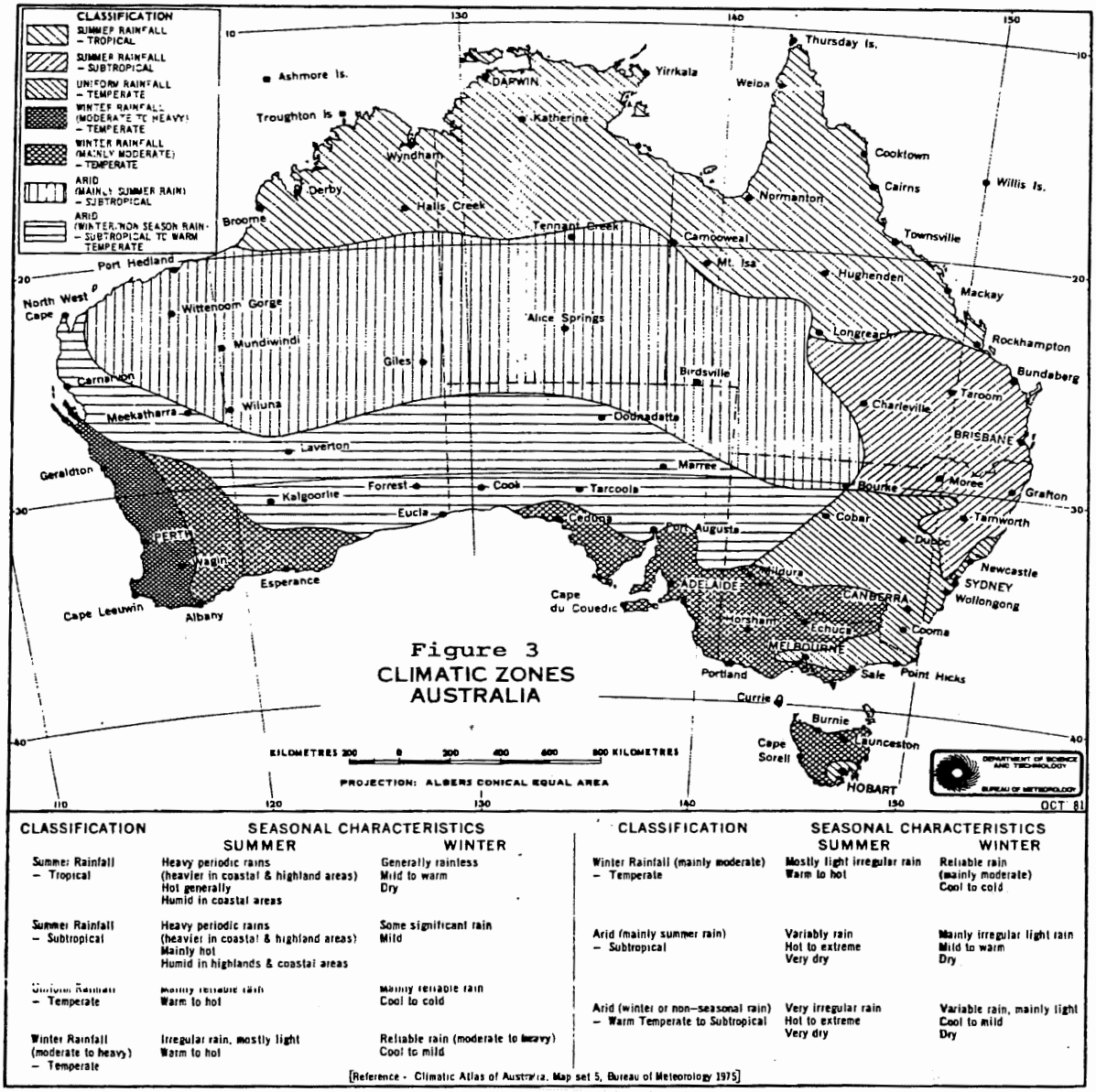



Figure 3
CLIMATIC ZONES
AUSTRALIA

| CLASSIFICATION | SEASONAL CHARACTERISTICS SUMMER | WINTER |
|---|---|---|
| Summer Rainfall – Tropical | Heavy periodic rains (heavier in coastal & highland areas) Hot generally Humid in coastal areas | Generally rainless Mild to warm Dry |
| Summer Rainfall – Subtropical | Heavy periodic rains (heavier in coastal & highland areas) Mainly hot Humid in highlands & coastal areas | Some significant rain Mild |
| Uniform Rainfall – Temperate | Mainly reliable rain Warm to hot | Mainly reliable rain Cool to cold |
| Winter Rainfall (moderate to heavy) – Temperate | Irregular rain, mostly light Warm to hot | Reliable rain (moderate to heavy) Cool to mild |

| CLASSIFICATION | SEASONAL CHARACTERISTICS SUMMER | WINTER |
|---|---|---|
| Winter Rainfall (mainly moderate) – Temperate | Mostly light irregular rain Warm to hot | Reliable rain (mainly moderate) Cool to cold |
| Arid (mainly summer rain) – Subtropical | Variably rain Hot to extreme Very dry | Mainly irregular light rain Mild to warm Dry |
| Arid (winter or non–seasonal rain) – Warm Temperate to Subtropical | Very irregular rain Hot to extreme Very dry | Variable rain, mainly light Cool to mild Dry |

[Reference - Climatic Atlas of Australia, Map set 5, Bureau of Meteorology 1975]

Elsewhere it tends to be "feast or famine". For example, Charleville in the non-seasonal rainfall belt has had twice as many years with below average annual rainfall as compared to above average in the last 100 years. In winter (April-September), over 50 mm of rain has been recorded in any particular week and in summer (October-March) up to 100 mm has been received at least once in any nominated week over the past 100 years. Humidity over most of Australia tends to be relatively low, particularly away from the coastal strip, and dews and fog are limited to a few days per year in inland areas. Radiation levels are high by world standards and cloud cover conversely low.

Over the last 15 years, considerable research has been done to find causal linkages between sea surface temperatures, the Southern Oscillation Index (SOI) and regional rainfall in Australia. The SOI is the mean atmospheric pressure difference between Tahiti and Darwin. There is a good correlation between the SOI and the occurrence of El Nino (dry) and La Nina (wet) seasonal conditions around the Pacific Ocean. However, the usefulness of such probability-based predictions is still of limited use to most individual farmers. The 40-day wave or Walker effect seems to have better predictive value for rain but it has only a time scale of about a week ahead.

Mean temperatures are relatively warm by world standards due to the lack of a large cold continental mass to the south of us and the low altitudes of most places. There are no perennially snow-capped mountains. Morning frosts are common in inland Australia due to the cloudless, still nights of winter,

and the minimum air temperature in southern inland regions may be 2-5°C below zero for many consecutive mornings. In summer, maximum day temperatures often exceed 38°C in all places except Tasmania. The hottest area of Australia is around Wittenoom Gorge in N.W. Western Australia. Australia has neither very long summer days nor very short winter days compared to many parts of the world. Thus, strong short- or long- day requirements for flowering are not a feature of the Australian vegetation. Nonetheless distinct flowering seasons under daylength control do occur in some species.

## SOILS

By world standards, Australia's soils are generally mature, low in available phosphorus and generally lack a water table. We have no true chernozem soils, nor tundra soils, and peats are very limited. Like many other countries we used the Great Soils Group terminology at first to classify our soils (Stephens, 1966) but nowadays we have our own system. Our first endemic system was based on soil profile development (Northcote, 1971) but recently Isbell has developed a modified version of the FAO-Unesco system which uses terms allied to the US 7$^{th}$ Approximation. This does not imply that our system is better universally than any other, just that it suits our environment and our range of soil types. Our soils have been included in the F.A.0. - UNESCO world classification (Sheet X) and a very serious attempt was made to apply the U.S. Soil Taxonomy. However, the high level at which soil temperature is introduced has little relevance to the mild Australian climatic conditions near the coast and too large a proportion of the inland country automatically falls into the Aridosols based on length of growing season. Soil horizons form the basis of Northcote's classification as in many other world systems. A compilation of information on our major soil types, plus a 1 : 5,000,000 map, can be found in Northcote *et al.* (1975). Northcote uses the term duplex soils very widely and this means a relatively light textured soil (sandy to loamy), shallow A horizon (10-30cm) which abruptly changes into a dense clay B horizon and subsoil. The colour and structure of both horizons is variable. Fertility varies from fair to very poor. Duplex soils can occur under brigalow scrub, poplar box woodlands or cypress pine forests

In general, soils are not closely allied with the prevailing climate but tend to reflect past climates or parent rock material. Organic matter and fertility of most soils is low except for recent alluvia, red rainforest soils derived from basalts and the dark, cracking clay soils of inland Queensland and N.S.W. Soil erosion is a very serious problem throughout Australia due, not mainly to steep slopes or inherently fragile fabric, but rather to excessive exposure of bare soil to the wind, strong sun and high intensity rainfall.

## VEGETATION

Since the early Tertiary, Australia has been relatively isolated from the other continents. Thus its modern flora has evolved in relative isolation for 50 million years. In the warm, humid climate of the early Tertiary, the whole continent was probably clothed in a relatively homogeneous, mesic flora although xeromorphy was already prevalent in response to the low fertility soils (Beadle 1981). However the current arid zone flora is thought to have evolved fairly recently as the continent drifted north and rotated 90° in a clockwise direction. The last arid climatic peak occurred about 10,000 years B.P. At that time much of Northern Australia experienced arid conditions.

### The present Australian flora

Scleromorphy is regarded as the hallmark of Australian plants, i.e. relatively short, stiff leaves, short internodes and small size generally (Barlow 1981). Whether this is due to the relative aridity of the climate or the relatively low phosphorus and calcium status of our soils is a matter for debate. There are, however, a number of other features of our vegetation which are obvious. Firstly, the complete absence of the Cactaceae and Bromeliaceae; secondly the endemic nature of the huge (700 species) genus *Eucalyptus* & allies; thirdly the large number of *Acacia* spp. (835) and the existence of its unique phyllodineous section Phyllodinae; fourthly the very small number of native conifers in the temperate regions; and fifthly the very small number of deciduous trees and shrubs. We have all the

grass tribes except Maydeae and all the Asteraceae (daisies) bar two tribes. The tropical forest family Dipterocarpaceae does not occur in Australia. Some of the other large Australian genera are endemic, e.g., *Hakea, Eremophila, Boronia, Daviesia* and *Prostanthera* (Beadle 1981).

Within the eucalypts, the farming community recognises five main types, based mostly on bark characteristics –

(i) gums - smooth bark on trunk and branches.
(ii) boxes - rough scaly bark on the trunk and major branches but smooth on small limbs.
(iii) stringybarks - fibrous, easily stripped bark on trunk and most branches.
(iv) ironbarks - dark, hard, deeply furrowed bark on trunk and branches.
(v) mallees - multi-stemmed, short-statured shrubby trees with a large underground lignotuber (a huge, swollen perennial woody structure below the stems).

Scientists now subdivide traditional eucalypts into several subgroups, based on flower bud, capsule and seedling features. The main genera are now *Eucalyptus* and *Corymbia*. Eucalypts extend from the snowline (snow gum *E. niphophila*) through the numerous other environments right out to the desert heart of Australia where the white-stemmed ghost gums (C. *papuana*) grow. Most Acacias are called wattles in coastal areas but inland they tend to have special aboriginal names such as mulga, gidgee, brigalow, mineritchee and boree.

In far northern Australia, the vegetation is rich in species from the Indonesian-Malaysian region, e.g. Euphorbiaceae & Ericaceae, while in the cool alpine areas of S.E. Australia and Tasmania the vegetation has affinities with the Antarctic region, e.g. myrtle beech (*Nothofagus* spp.). The flora of the arid and semi-arid regions differs from many similar climatic regions of the world by the absence of large succulents and the high incidence of evergreen shrubs and small trees. Forests are restricted to the eastern fringe, S.W. Western Australia, S.E. South Australia and Tasmania, and occur mostly in hilly country. The forests are exclusively eucalypt dominant except for small areas of rainforest in the tropical east coast (where *Araucaria* spp. are prominent) and the Tasmanian beech forests. An altitude-induced tree line only occurs in very isolated areas of Tasmania (>1500 m) and Mt. Koscuisko (above about 1900 m) where snow and strong winds restrict growth for much of the year. The largest flowering plant in the world, *Eucalyptus regnans* (Mountain Ash) which grows to 100 metres tall is found in wet sclerophyll forests of Tasmania. S.W. Western Australia is a special biogeographical region with thousands of endemic species, many being extreme forms of common endemic genera eg. kangaroo paws (*Anigosanthos* spp.) and huge-flowered eucalypts (*E. macrocarpa*).

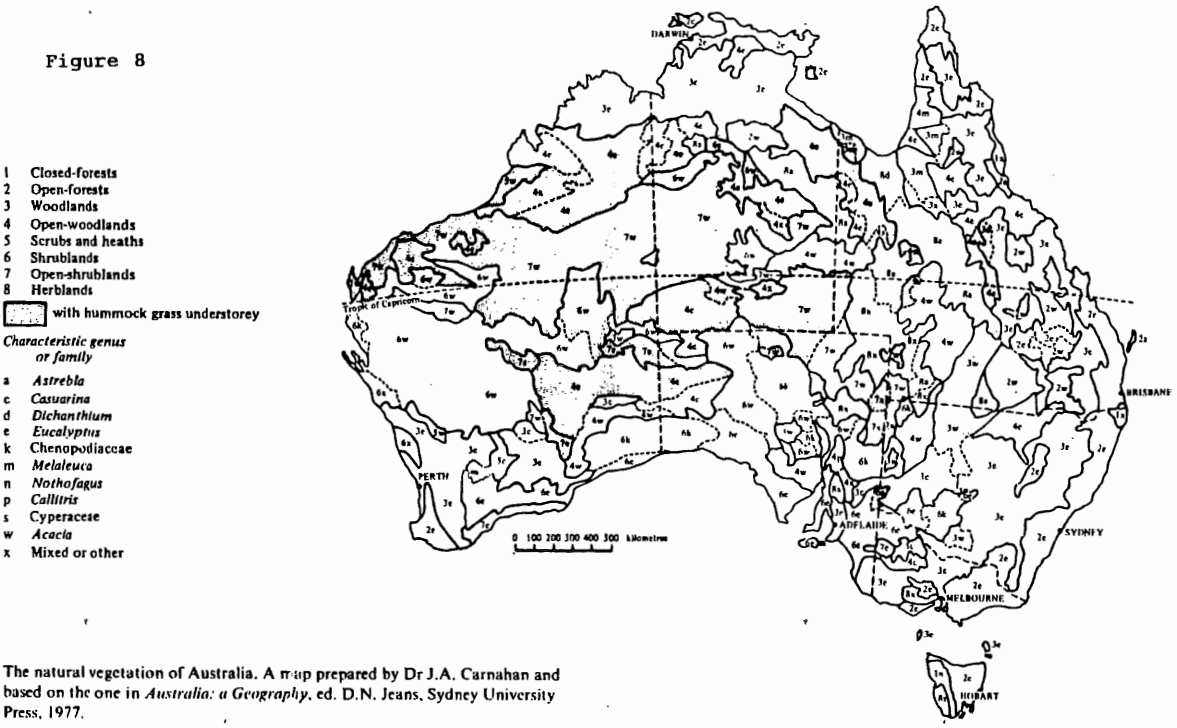
As the vegetation map (Figure 8) shows, Australian vegetation varies from forests through woodlands, shrublands and heaths to grasslands. The forests occur in the wetter coastal and mountainous regions, the shrublands in the semi-arid to arid areas while the other vegetation forms occur in a variety of areas. Heaths can occur from wet, swampy coastal areas to sub-humid areas with poor sub-soil drainage. *Banksia* spp. and *Melaleuca* spp. (tea trees) are common in the coastal heaths. The forests and woodlands are nearly all dominated by *Eucalyptus* spp. with a wide range of shrub understoreys. *Melaleuca* spp. dominate in some swampy areas of N. Queensland while parts of inland Australia have conifer woodlands of Cypress pine (*Callitris* spp.) or the conifer-like she-oaks (*Allocasuarina* spp.) on poor sandy soils. However, in southern arid Australia low chenopod shrublands (*Atriplex* and *Maireana* spp.) cover vast areas on loam to clay soils.

There are in southern Australia, nowadays, some areas of induced annual grassland where a previous cover of trees has been removed and exotic, annual grasses (*Lolium, Bromus, Vulpia* and *Critesion*) have taken over. Kangaroo grass (*Themeda triandra* formerly *T. australis*) was once very widespread in many natural communities and has a wide range of ploidy levels and growth habits to cope with the many climates involved. *Heteropogon contortus* (Black speargrass) is another common grass found in our tropical areas which also occurs naturally in S. Africa and America.

All over northern and central Australia there has been a serious increase in the density of unpalatable shrubs, particularly wattles, eucalypts, cypress pine, Cassias (*Senna* spp.), *Dodonaea* spp. (hopbushes) and *Eremophila* spp. (turpentines). Wild fires in 1975 did kill out significant areas of these woody

weeds in inland regions. Tree and shrub density varies dramatically from paddock to paddock, reflecting past and recent management. In southern Australia the near opposite applies; trees and shrubs are difficult to re-establish once woodlands have been cleared and then cultivated and/or grazed with sheep.

Figure 8




The natural vegetation of Australia. A map prepared by Dr J.A. Carnahan and based on the one in *Australia: a Geography*, ed. D.N. Jeans, Sydney University Press, 1977.

Cypress pine is restricted to acid, sandy, well-drained landscapes. The presence of dense mulga indicates lack of sheep grazing during a favourable regeneration cycle in the past. Gidyea scrub (*Acacia cambagei*) grows on alkaline clay loams and becomes more common north from Bourke, reaching its greatest development in central western Queensland around Blackall. When cleared, gidyea soils grow excellent buffel grass (*Cenchrus ciliaris*) pastures. In their natural state, gidyea scrubs offer only limited grazing from the sparse understorey of saltweeds and burrs (*Sclerolaena* spp.). Bastard sandalwood (*E. mitchellii*) is a common problem woody weed in cleared gidyea areas but can be easily controlled by fire in the early years after clearing. The alluvial floodplains of the inland rivers support either coolibah (*Eucalyptus microtheca* or *E. coolabah*) open woodland, gidyea scrub or open mitchell grass (*Astrebla* spp.) tussock grassland. Cooper clover (*Trigonella suavissima*) can grow prolifically on these plains after winter flooding.

The major grasslands of Australia are either the *Astrebla* (Mitchell grass) tussock grasslands on heavy clay soils in the tropics or the hummock *Triodia/Plectrachne* spp. (spinifex) grasslands on red sandy soils. There are four species of the endemic genus *Astrebla*, the commonest one in eastern Australia being curly (*A. lappacea*). The Astreblas are strongly perennial, highly drought tolerant grasses which are fairly palatable and provide stability to this land type, both for animal production and soil binding. The mitchell grasses are highly regarded pasture species in dryland Australia but unfortunately they only grow on heavy cracking clay soils. The vast, undulating, inland grasslands on clay soil can be dominated in a run of good summers by Queensland bluegrass (*Dichanthium sericeum*) plus various *Iseilema*, *Panicum*, *Digitaria*, *Eriochloa* and *Aristida* spp. Herbaceous legumes such as *Rhynchosia minima*, *Desmodium campylocaulon* and *Crotalaria dissitiflora* are also common.

There are some 45 species of the closely related endemic grass genera *Triodia* and *Plectrachne* and their hummock grasslands occupy about one third of arid Australia. All are of low palatability and nutritive value, many have sharp, rigid leaves but they are very well adapted to the environment's low, aseasonal rainfall, acid infertile soils and periodic fires. In Central Australia, the large (1-2 m)

hummocks of these sharp-leaved grasses act like low palatability shrubs, with animals foraging mainly between them and using them as shelter. On this land type, stocking rates are very low (1 beast/40-80 ha) as the animals live on the small amount of browse and ephemeral growth which can exist in competition with the spinifex. Most hummock grasslands have a sparse to mid-dense cover of shrubby *Acacia* and/or eucalypt plants. Burning is used by some managers to stimulate soft regrowth, which stock will eat fairly readily.

Though mulga occurs throughout inland Australia right across to the west Australian coast, it reaches its greatest size and density around Charleville. There trees may grow to 12 metres in height and the density of mature trees can be over 500 per hectare, effectively creating a forest with little understorey vegetation. Mulga is a highly regarded, palatable, thornless, evergreen drought fodder which regenerates freely from seed but does not coppice. It is restricted to acid, red soils of low fertility and young stands can contain over 5,000 plants 2-3 m tall per hectare. When not too dense, there is a valuable pasture understorey of grasses such as mulga mitchell (*Thyridolepis mitchelliana*), mulga oats (*Monachather paradoxus*), *Digitaria* spp. and many herbaceous dicotyledons.

Small areas of ephemeral swamp exist in semiarid Australia and in them lignum (*Muehlenbeckia florulenta* - Polygonaceae) is a common shrub. Lignum can grow 2m high, is almost leafless, and is only grazed slightly. Therefore it can form dense thickets which become very difficult to muster. They harbour wild pigs and feral cattle and seriously hinder disease control programmes, especially on more extensively managed properties.

Brigalow (*Acacia harpophylla*) scrubs in Queensland often have belah (*Casuarina cristata*) or Dawson gum (*E. cambageana*) trees through them plus a scattered shrub layer of wilga (*Geijera parviflora*) & sandalwood. A range of chenopods (*Atriplex, Sclerolaena* spp.) and grasses, particularly brigalow grass (*Paspalidium caespitosum*) make up the sparse ground layer. When cleared of timber, the brigalow soils make excellent farming soils except where gilgai development is strong. Brigalow trees sucker profusely when damaged and though chemicals will control regrowth, best control comes from ploughing. Despite being an Acacia, brigalow sets no hard seed and seeds germinates on the first rain. Also it will not store for more than a few months in the laboratory. If the suckers are controlled and a naturalised pasture develops, the grasses are largely tussock species from a wide range of genera including *Austrostipa, Paspalidium, Chloris, Panicum, Aristida, Dichanthium* and *Digitaria.* Legumes are virtually absent, possibly due to the high salinity levels of the subsoil. Exotic ones such as Siratro (*Macroptilium atropurpureum*) will not persist either. *Desmanthus virgatus* from America is showing more promise for this role but is unproven yet. By comparison the exotic grasses, Rhodes grass (*Chloris gayana*), green panic (*Panicum maximum* var. *trichoglume*) and buffel grass persist very well on these soils.

The brigalow scrubs were infested with an introduced cactus, known locally as prickly pear (*Opuntia inermis*), until the South American moth *Cactoblastis cactorum* was introduced to control it in the mid-1920's. Within 5 years the pear was almost eliminated. Tree pear (*O. tomentosa*) is still common but this exotic pest is nowadays being contained by the Mexican cochineal insect (*Dactylopius coccus*). Bottle trees (*B. rupestre*) occur naturally in brigalow scrubs.

In the limited areas with deep black, basaltic soils, much of the native vegetation has been removed to allow intensive cropping of the very fertile soils. Originally they carried an open eucalypt woodland of poplar box or mountain coolibah (*E. orgadophila*) with some coolibah (in wetter areas), Queensland blue gum (*E. tereticornis*) (on hills) and carbeen (*C. tessellaris*) on sandy areas. The grassy understorey was predominantly Queensland bluegrass, other Andropogoneae, Paniceae and some *Danthonia* spp. In places the woodlands gave way to open tussock grasslands dominated by Queensland blue grass and kangaroo grass. As in many other heavily grazed areas of Australia, kangaroo grass quickly became a minor component of these pastures under continual grazing.

Many poplar box woodlands have a shrub understorey of sandalwood (*E. mitchellii*) and a range of tussock grasses such as *T. triandra, Bothriochloa decipiens* (pitted bluegrass), curly windmill grass (*Enteropogon acicularis*) and slender chloris (*Chloris divaricata*). In southern Qld, Cypress pine

forests (including State Forests), occupy large areas on the sandier, shallow solodic soils. These forests provide a valuable supply of termite-resistant timber which can be used for a wide range of purposes. The cypress forests have an understorey of coarse grasses, predominantly *Aristida* spp., and grade into heaths on soils with perched watertables, into silver-leafed ironbark (*Eucalyptus melanophloia*) woodlands on some soils and narrow-leafed ironbark (*E. crebra*)/bull-oak (*Allocasuarina luehmannii*) forests on poorly drained lowlands. These ironbark communities are also very common on hills and ranges.

On higher rainfall mountains, layered open forests grow on a wide range of soils. The dominant trees in eastern Australia are Sydney bluegum (*E. saligna*) and stringybarks (*E. eugenioides* and *E. andrewsii*) with a wattle understorey (mostly *Acacia falcata* and *A. pustula*) and, in places, black she-oak (*Allocasuarina littoralis*). The species vary with latitude along the eastern Australian coastline but the basic structure is the same and very different from that found 100 km inland behind the Great Dividing Range. On the West Australian coast, lack of a moist onshore airflow and ranges (except near Perth) means that the coastal vegetation is not greatly different from that hundreds of kilometres inland, as the maps show. Patches of these forests still remain, often invaded by introduced lantana (*Lantana camara*). On the eastern coastal ranges, small remnants of sub-tropical rainforest remain on deep red earths derived from basalts. The rainforests contain a wide variety of trees including yellow wood (*Flindersia xanthoxyla*), blackbean (*Castanospermum australe*), brush box (*Lophostemon confertus*), red cedar (*Toona ciliata*) and Bunya pine (*Araucaria bidwillii*). Many of these make excellent timber and have been extensively logged. Various lianas, vines and epiphytes, plus *Cordyline* species and shade tolerant palms (*Archontophoenix* sp.), grow in profusion near drainage lines within the forest. Most rainforests are now reserved as National Parks.

The sandstone, granite and schist hills in the subcoastal lowlands are covered in open eucalypt forests with a range of understorey shrubs such as *Macrozamia* palms (Zamiaceae), wattles and grass trees (*Xanthorrhoea* spp.). Grasses are abundant, particularly kangaroo grass. A wide range of other (mostly palatable) grasses grow such as *Bothriochloa bladhii* (forest bluegrass), *B. decipiens* (pitted bluegrass), blackspear (*H. contortus*), *Dichelachne micrantha*, barbwire grass (*Cymbopogon refractus*), blady grass (*Imperata cylindrica*) and a range of twining legumes, e.g. *Glycine tabacina*. The timber has largely been cleared nowadays but the pastures remain relatively unchanged except that black spear has increased as a result of regular spring burning. In isolated areas, introduced pasture species are now grown with the aid of fertilizers. Beside railway lines there is often a prolific growth of kangaroo grass due to regular burning and lack of grazing animals. This grass in its many forms and ploidy levels was the dominant grass over much of humid and sub-humid Australia before European settlement. However, like *T. triandra* in S. Africa, it is vulnerable to heavy grazing.

Large state conifer forests (*Pinus radiata, P. patula*) have been planted in some places, particularly on heath soils. On the tidal sea edges and along big rivers, mangrove species eg. *Bruguiera gymnorhiza* take over and on the seashores pandanus palms (*Pandanus tectorius*) may be seen. The flora around Eastern Qld is truly tropical except in isolated valleys where frosts occur in winter. Ornamental trees such as the Brazilian jacaranda (*Jacaranda mimosifolia*) and the African poinciana (*Poinciana regi*) line many city streets and parks.

## CURRENT LAND USE

Land use in Australia outside National Parks and State Forests is generally determined by three main factors:

(1) Rainfall - primarily as it effects length of growing season
(2) Soil Type
(3) Frost Incidence

Naturally, mean temperatures determine the basic suite of crops and pastures which can be grown, with southern Australia and Tasmania having the potential to grow barley and *Lolium/Medicago*

pastures while northern Australia can grow maize, sugarcane and paragrass (*Brachiaria mutica*). Rainfall is most important because below about 300 mm M.A.R. in southern Australia cropping is very unreliable while in Northern Australia about 800 mm is needed for dryland cropping. For improved pasture species to be sown successfully, about 250 mm and 600 mm respectively are needed for the species available. Thus, only about 9% of Australia is climatically suited for arable land and, if unsuitable landscapes are removed, this figure reduces to 7.5% or 57 million hectares (Davidson, 1981). Currently about 20 million hectares are actually cultivated, mostly in the south-east.

Only 30% of Australia is climatically suited to improved pastures or forestry and if the 7.5% of arable areas are excluded, the majority of this area lies in northern Australia, particularly Queensland. About 15% of Central Australia is so dry and poorly supplied with underground water that it will probably never be used for any permanent pastoral enterprise. Thus, if the 1.5% occupied by National Parks is also deducted, about 53% of Australia will always remain natural pastures grazed by domestic stock. Hence, the philosophies of range management will need to play an important role in the long term conservation and utilization of our land.

The relatively dry climate has also minimized soil-forming processes so that the surface parent rock largely determines the soil type in pastoral regions. The result can be very rapid changes in fertility and vegetation as you cross a boundary between geological strata, e.g. from mulga country to mitchell grass country. Suitable irrigation water is so scarce that its availability only controls land use over a relatively small area (0.2%) of Australia (1.5M hectares) of which 70% is in Victoria and southern N.S.W. At present there is a lot of hard talking being done to rationalise the harvesting of river and overland flows to satisfy agricultural, industrial and environmental needs, especially by the Murray-Darling Basin Commission.

Most of the forestry areas are natural hardwood forests and almost all of the planted forests are pine forests, mostly *P. radiata.* Native rainforest reserves occupy les than 1 million hectares, while gazetted Cypress pine forests occupy only 4.4 million hectares. Forest use and the allocation of timber to mills is another major social and political issue at present. This topic is also mixed in with general tree clearing guidelines that are being legislated in all States. They in turn relate to the global issues of greenhouse gases and carbon credits.

In the drier pastoral regions, sheep are the major stock in the southern half of the country while northern regions are used almost exclusively to run cattle. In dryland areas, sheep are almost exclusively Merino (21-25 micron wool). The distribution of Merino sheep is largely determined by the position of the dingo barrier fences and the frequency of sharp-seeded grasses in the pastures. Barrier fences currently exist in the states of Queensland, N.S.W., S. Australia and W. Australia. Goat numbers are presently increasing with numerous breeds and regions involved. Cattle breeds are determined by the prevalence of the introduced cattle tick (*Boophilus microplus*).

## LAND USE AND TENURE IN AUSTRALIA

### Pre-European Settlement

Though Australia was first settled by the Australian Aborigines about 40,000 years ago, by 1788 when the first European settlement was established near Sydney there were probably only 300,000 aborigines. They had about 550 tribal groups speaking about 300 distinct languages. Though tribal territory was clearly defined and strict social codes and laws existed, no permanent villages existed, even around isolated permanent water holes or along the coast. Most lived in the wetter coastal areas but inland tribes spread out along the major river courses. They hunted and fished for their food and foraged widely for plant foods of all kinds, moving as seasons demanded to where the food supply was (both plant and animal). They did not sow crops but did use fire strategically to burn off small areas of old dry pasture to encourage fleshy-rooted plants to shoot and to flush out reptiles. The resulting green pick also attracted kangaroos which could be hunted for meat.

Thus the utilization of land was opportunistic by both man, beast and plant. Lightning-induced fires occurred sporadically over wide areas in dry seasons, especially on the grassy plains after good seasons. However, some shrub communities grew so vigorously that they inhibited grass growth in almost all years and fires were very rare, e.g. the chenopod shrublands and some *Acacia* shrublands. Some of these species are sensitive to fire, e.g. mulga, gidyea and bluebush whereas most Australian rangeland trees and shrubs are not killed by fire. There were concentrations of animals, birds and Aborigines around permanent waterholes during droughts and this caused local damage to the landscape. Permanent scalds or claypans developed near many inland waterways if the soil type was susceptible to sheet erosion (e.g., duplex solodics), long before domestic livestock were introduced.

**Post European settlement**

By 1850 the inevitable skirmishes and bloodshed with the Aboriginals who resisted the occupation of their land had subsided because their population had been seriously depleted by these conflicts and introduced diseases such as measles, particularly in the south east. Meanwhile the European population had risen to 405,000. However, overstocking and a drought over much of Australia led to a huge drop in stock numbers at the start of the 1900s. In N.S.W., a Royal Commission found that a 4 year drought plus overstocking plus rabbits had led to serious erosion and a decline in landscape stability and vegetation cover. Its report resulted in a special Western Lands Commission being set up to administer tenure of their western lands. Most extensive grazing lands have long term leasehold tenure controlled by State governments but the tenure details vary greatly between States. Native title over land is being redefined for aborigines in some areas at present.

In western N.S.W. carrying capacity today is still only half that which prevailed in the 1890s. Prior to 1901 there had been a devastating drought in S. Australia in 1865 which led to the delineation of Goyder's Line, beyond which rainfall is too low to allow profitable cereal growing, even today. Other large areas in S. Australia and southern W. Australia have had to be completely destocked since 1900 because persistent overstocking of small, unprofitable holdings led to serious denudation and soil erosion. With a general awareness of the problems of soil erosion and dryland salinity from over-clearing now abroad in Australia, far more effort is nowadays going into soil conservation measures in all states. In some cases this involves the declaration by State Governments of erosion hazard areas. In such areas owners or lessees can be compelled to comply with orders from soil conservation officers regarding earthworks, etc. Artesian bores cannot be sunk without having approval from relevant water authorities.

The fertility of brigalow country was well known early this century but the introduced prickly pear was an impossible limitation to its development. All that changed with the release of the cactoblastus moth. This quickly removed the problem but not until after World War II was the heavy machinery available to allow large scale clearing of brigalow scrub. The Queensland Government then sub-divided the large holdings which originally existed in brigalow areas and ballotted the new blocks out amongst suitable applicants. Initially much of the newly cleared land was sown to pastures – rhodes grass, green panic and buffel grass mostly. Suitable pasture legumes were not found although lucerne grows for a few years if well managed and naturalised annual burr medics (*M. polymorpha* and *M. minima*) colonised the most southern areas where winter rains are more reliable. Today more and more of the brigalow lands are being sown to crops.

Certain State Forests are leased to graziers for rough grazing when deemed desirable but many National Parks are never used for grazing domestic stock and rarely for mineral exploration. At present management of feral animals in National Parks is minimal and does pose some disease risks, e.g., pigs and water buffalo can carry TB and foot-and-mouth disease. Aboriginal reserves have special legislation pertaining to them and entry is restricted to all non-residents. Mineral resources are owned by the Government, so leaseholders cannot supplement their rural income from them.