PART II

THE NATURAL ENVIRONMENT
VEGETATION

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Classification

For the purpose of this study, the classification of vegetative communities is based on the climax form, because other forms, being transitory, are not consistent indicators of site conditions. The vegetation which existed prior to settlement has been regarded as climax. The chief modifying agent of the vegetation prior to white settlement was fire. The incidence of lightning fires, and the extent to which they spread in present-day forests, indicates that occasional localised fires and very occasional extensive fires were probably typical. The use of fire by aboriginals must have added to the frequency of occurrence, but on the whole, the fire history prior to settlement was probably much less severe than it has been in the first 100 years or so of settlement. This must be taken into account when the present indigenous vegetation is studied in relation to the climax forms.

Large areas of timbered land have been cleared or severely thinned, to the extent that the original condition is no longer evident. Roadside vegetation, which is at times the only tree vegetation in the locality, has to be used as a guide to the original. It must be interpreted with caution however, as the narrow strip of vegetation may not be similar to the original fully-closed stand with competition on all sides. The writings of some of the early settlers have indicated that the present shrub-chocked condition of much of the forest country has developed since settlement (Andrews 1920).

The first step in classifying the vegetation of the catchment was to identify the different structural forms (or formations) which exist in the area. (The structural form of a vegetative community characterises the spatial relationships which exist between its members. This involves the form of the species which dominate the site, either because of size or number, their spatial arrangement in both the vertical and horizontal planes, and the presence or lack of subordinate strata).

The structural forms recognised in this survey are based on those proposed by Beadle and Costin (1952), except for the alpine shrub community defined by Carr and Turner (1959) and corresponding to the heath formation of Beadle and Costin. Within the structural forms, commonly occurring combinations of species were looked for. These were formed into floristic groups, each of which contains species with similar habitat requirements, and reflects a particular combination of environmental factors.

The floristic groups recognised in this survey are not based on a detailed study of the species relationships, which is beyond the scope of the survey. For convenience, they have been called alliances, although no attempt has been made to recognise associations and group them into alliances, sensu Beadle and Costin (op. cit.). The alliances however, are quite real and readily identifiable. They generally can be related to similar vegetation described by Morland (1958b, 1959a) from the New South Wales side of the Hume catchment, and by Costin (1957a) from the high mountains in southern Australia. Some of the vegetation in the southern part of the Hume catchment is similar to that described by Costin (1954) from the Monaro Region of New South Wales. These relationships are illustrated in Table 13.

Some of the structural forms are of small extent in the catchment, and contain relatively few dominant species. Generally, these are regarded as a single floristic group and are not studied beyond recognising the dominant species. Other structural forms occur over extensive areas and contain a large number of dominants. In this case, more attention has been paid to the species involved, as more information was needed for satisfactory classification.

Figure 18 illustrates the relationships between the alliances within the catchment.

Description of the Vegetative Units

(The definitions of the structural units in this section are adapted from those of Beadle and Costin (1952).)

(1) Feldmark: The feldmark is an open community of dwarf plants dominated by "cushion-forming" or prostrate plants only a few inches high. Bare ground separates the scattered members and is a notable feature of the unit. In this area *Ewartia nubigena* and *Helipterum incanum var. alpinum* are the dominant members.

This vegetation has a very limited occurrence in the catchment. It is confined to exposed peaks and ridges in the alpine tract, notably on the northern aspect of Mt. Loch and on Mts. Nels and Bogong. Costin (1957a) comments that this wind-exposed type of feldmark may have been formed as a result of accelerated erosion of these exposed areas. It is possible that its condition is the result of normal erosion of these exposed sites, and it seems that it is being maintained by erosion. Frost action is severe on the unprotected ground and wind sorting of the coarser particles, usually rock chips, is common (Plate 21). The resultant soil is a lithosol.

The feldmark community gives way to alpine herbfield under less-severe conditions.

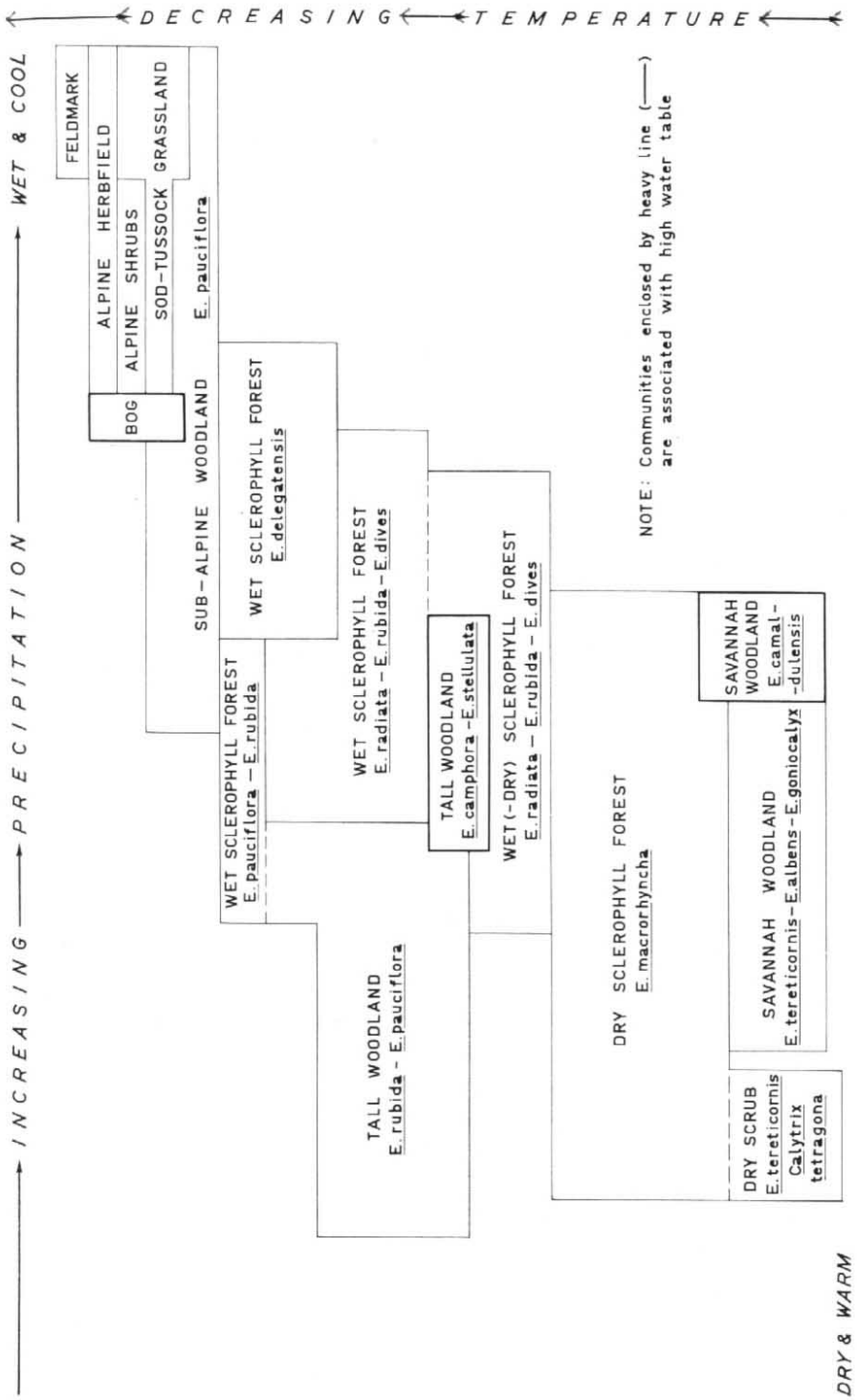

Fig. 18 – Relationships between vegetative communities

(2) *Alpine herbfield:* This is a community dominated by both grasses and forbs which form a continuous sward. The most abundant species are *Celmisia longifolia* and fine-leaved forms of *Poa australis.*

With the exception of the sites occupied by the feldmark vegetation, this community occupies the highest slopes of the alpine tract, and is largely confined to the south-western boundary of the catchment. There are isolated occurrences on Mt. Pinnibar, Mt. Gibbo and Mt. Cobberas (Costin 1957a). It occurs extensively over Mt. Bogong and on the Spion Kopje-Mt. Nels-Hollands Knob ridge, where elevations range from about 5,500 feet to over 6,500 feet. Within this elevational range, alpine herbfield occurs on the freely-drained sites where alpine humus soils are dominant.

Other vegetative communities associated with the alpine herbfield are the alpine shrub community**,** sod-tussock grassland and feldmark.

Because of the palatability of many of the herbs, this vegetation suffers from selective grazing by cattle in summer. Concentration of cattle on palatable vegetation also results in trampling damage. The co-dominant, *Poa australis*, is not generally palatable to cattle except for the young shoots and the seed heads. The herbs which are so obvious in the ungrazed early-summer sward become less obvious as the grazing season progresses. Over-grazing of this community in the past has lead to opening up of the sward, and frost action and wind erosion make re-establishment of complete cover difficult.

(3) Alpine shrub community: The shrubs generally form an open, or more-or-less closed community, which varies from about one to several feet high. Some of the shrubs have a prostrate habit and thick, gnarled trunks and limbs, indicating that they are relatively old. Older shrubs with this habit may be degenerating from the centre where P. australis or other members of the alpine herbfield may be becoming established. Species composition of this vegetation varies considerably. The more common species are *Oxylobium ellipticum*, *Hovea longifolia*, *Orites lancifolia*, *Grevillea australis*, *Prostanthera cuneata*, *Pleurandropsis trymalioides* and *Pimelia ligustrina*. Species of the alpine herbfield, notably *P. australis* and *C. longifolia*, are normally intimately associated with the shrub communities (Plate 14).

This community has a similar distribution to the alpine herbfield, but is normally confined to rocky areas, or to sites on which snow does not persist for as long as elsewhere. The soils range from alpine humus soils to lithosols.

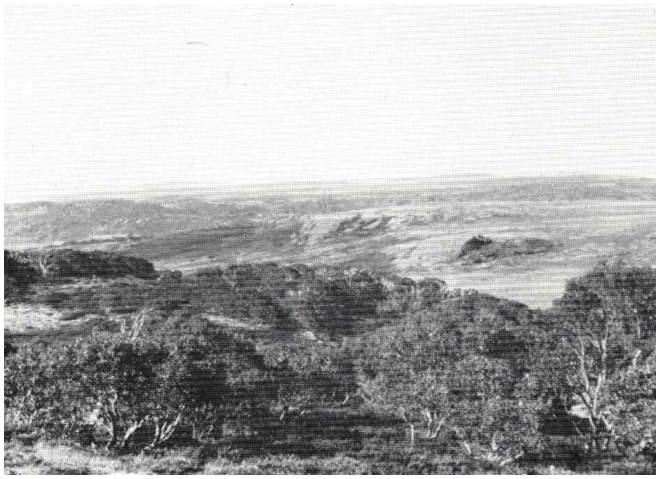

Plate 14. Alpine-sub-alpine vegetation at the head of Middle Creek.
The sub-alpine woodland has been damaged by fire had has been replaced by coppice regrowth. Shrubs occur under the regrowth and on the northerly slopes of Basalt Hill. Grassland and herbfield occur on the undulating low surface.

Table 13 – Relationships between Vegetative Communities of Victorian Hume Catchment and those from adjacent areas

Victorian Hume Catchment		**NSW Hume Catchment (Moreland 1958b, 1959a)**		**Monaro Region NSW (Costin 1954)**	
Formation	**Floristic Unit**	**Formation**	**Floristic Unit**	**Formation**	**Floristic Unit**
Fledmark	*Ewartis nubigena* alliance	..	..	Fjaeldmark	*Epacris petrophila-Veronica ensifolia* alliance
Alpine herbfield	*Celmisia longifolia-Poa australis* alliance	Alpine grassland	*Poa caespitosa-Celmisia longifolia* association	Tall alpine herbfield	*Celmisia longifolia-Poa Caespitosa* alliance
					Brachycome nivalis-Danthonia alicola alliance
Alpine shrub community	*Oxylobium ellipticum-Hovea longifolia-Orites lancifolia* alliance	High moor	*Prostanthera cuneata-Orites lancifolia-Phebalium ovatifolium-* etc. alliance	Heath	*Oxylobium ellipticum-Podocarpus alpinus* alliance
Sod-tussock grassland	*Poa australia* alliance	..	..	Sod-tussock grassland	*Poa caespitosa-Danthonia mudiflora* alliance
Bog	*Sphagnum cristatum* alliance	..	..	Raised bog	*Epacris paludosa-Sphagnum cymbifolium* alliance
				Valley bog	*Carex gaudichaudiana-Sphagnum cymbifolium* alliance
Fen	*Carex gaudichaudiana* alliance	..	..	Fen	*Carex gaudichaudiane* alliance
Sub-alpine Woodland	*Eucalyptus pauciflora* alliance	Alpine Woodland	*E. pauciflora* association	Sub-alpine Woodland	*E. niphophila* alliance
Wet sclerophyll forest	*E. rubida-E. pauciflora* alliance	Sub-alpine sclerophyll forest	*E. Dalrympleana-E. pauciflora* association	Wet sclerophyll forest	*E. delegatensis-E. Dalrympleana* alliance
	E. delegatensis alliance	Wet sclerophyll forest	*E. gigantea* association		
	E. radiata-E. rubida-E. dives alliance		*E. radiata* alliance		*E. fastigata-E. viminalis* alliance (in part only)
Dry sclerophyll forest	*E. macrorhyncha* alliance	Dry sclerophyll forest	*E. macrorhyncha* alliance	Dry sclerophyll	*E. macrorhyncha-E. Rossi* alliance (in part only)
			Callitris alacarata association	Dry scrub	*Acacia glauescens-Eriostemon trachyphyllus* alliance (in part only)
Tall woodland	*E. camphora-E. stellulata* alliance	Savannah woodland	*E. camphora* association	Savannah woodland	*E. pauciflora-E. stellulata*
			E. blakelyi-E. melliodora-E. stuartiana association		*E. melliodora-E. blakelyi* alliance (in part only)
Savannah woodland	*E. tereticornis-E. albens-E. goniocalyx* alliance	..	*E. albens* association	..	
	E. rubida-E. pauciflora alliance	..	..	Savannah woodland	*E. pauciflora-E. stellulata* alliance (in part only)
Wet-tussock grassland	*Poa australis* alliance	..	..	Wet-tussock grassland	*Poa caespitosa* alliance

Carr and Turner (1959) have suggested that the widespread, though scattered, occurrence of shrubs within the alpine herbfield and other alpine and sub-alpine vegetative communities, is the result of the more successful colonisation by shrubs of the inter-tussock spaces opened up by over-grazing. Costin (1957b) includes fire as an agency in opening up the sward. The gradual elimination of much of the invading shrub communities is predicted by Carr and Turner (op. cit.) and Carr (1962), provided that grazing damage is prevented.

(4) Sod-tussock grassland: This grassland community consists of discrete tussocks of *Poa australis,* the tops of which form a closed canopy of interlacing leaves. The spaces between the tussock bases may be colonised by shade-tolerant herbs. Fine-leaved forms of *P. australis* are predominant.

This vegetation generally occurs in the moister, but not water-logged situations where cold-air drainage is a feature of the micro-climate. It may occur from the uppermost elevations in the catchment to below the tree line in narrow valleys. The soils are usually alpine humus soils. On higher or better-drained sites, sod-tussock

grassland may be transitional to alpine herbfield or alpine shrub community, and at the lower end of its elevation range it gives way to sub-alpine woodland. The sub-alpine woodland may also replace it on upper-valley slopes. On more-poorly-drained sites, a wet form of the alpine shrub community may replace the grassland, or it is replaced by fen or bog communities where water-logged conditions occur.

In some respects this vegetation resembles the alpine herbfield. It is susceptible to opening up of the sward when over-grazing of the inter-tussock vegetation occurs, and this can lead to soil loss by wind erosion and the invasion of the grassland by shrubs (Carr 1962). However, it does not seem to be as easily damaged as the herbfield type of vegetation because it contains fewer species which are palatable to cattle.

The tussocks of *P. australis* in both the sod-tussock grassland and the alpine herbfield are susceptible to damage by high pressures such as caused by vehicular traffic or stock trampling, particularly early in the growing season. In the sod-tussock grassland more damage may be done by trampling of the tussocks than by the grazing. A single traverse by a vehicle, such as a Land Rover, during the susceptible period will result in a relatively permanent track which will still be obvious after several years. Severe trafficking results in the death of the vegetation in the tracks, and wind erosion causes the tracks to become entrenched.

(5) Bog: The bog community consists of hummock-forming mosses and other hygrophilous plants. Dy continuous, though slow, regeneration of the moss at the surface, quite deep deposits are developed in which the sub-surface material is largely dead moss and other plant remains. *Sphagnum cristatum is* the dominant member of this form of vegetation. *Carex gaudichaudiana, Richea continentis, Hypolaena laterifolia* and *Epacris paludosa* are other species which are commonly associated in bog communities.

Their occurrence is restricted to areas within the alpine and sub-alpine tracts which are permanently wet. Most of the drainage lines in these tracts have or had bog vegetation in them.

Because of the palatability of some species of the community, and the presence of water, they have been subjected to severe trampling by grazing cattle (Plate 15). The trampling and erosion have resulted in many extensive bogs drying out and shrinking, until all that remains are narrow banks of moss along the drainage channels.

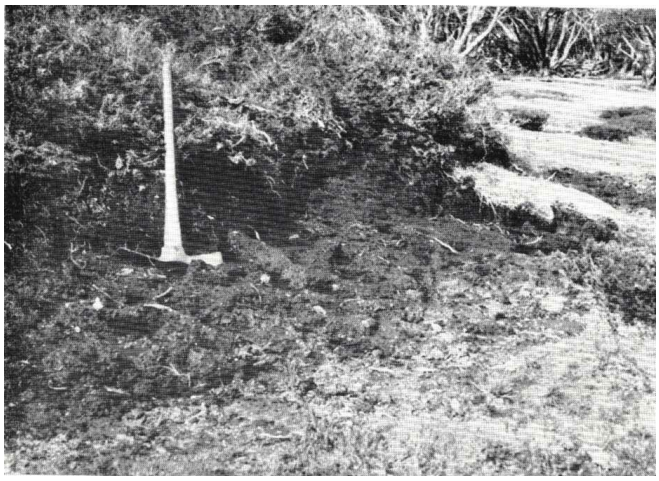

Plate 15. A raised bog which has been considerably damaged by the trampling of cattle. Camp Valley, Mt Bogong.

(6) Fen: The fen is a community of herbaceous plants which grows in saturated soil but which lacks hummock-forming mosses. The sedge, *Carex gaudichaudiana,* appears in most fen communities together with numerous other hygrophilous plants. The floristics have not been examined in detail in this study.

The most extensive occurrence of this vegetation is along the course of Morass Creek for several miles above its gorge tract, where *Eleocharis sphacelata* and *Juncus polyanthemos* are the more obvious species. There are only minor occurrences elsewhere, mainly in the alpine tract.

(7) Sub-alpine woodland: This vegetation is characterised by trees which form a more-or-less closed canopy, and in which the crown depth is greater than the length of the bole. A continuous ground flora of grasses and forbs is present. At the upper limits of its range this community may be reduced to a scrub or wet mallee formation and frequently it has an open woodland form. *Eucalyptus pauciflora* is the only tree species and a broad-leaved form of Poa australis is usually dominant in the ground flora. Herbs such as *Celmisia longifolia* and *Ranunculus sp*. may be present, and shrubs of *Oxylobium ellipticum* and *Bossiaea foliosa* often form a dense understory in communities which appear to have suffered fire damage.

The sub-alpine woodland vegetation has an extensive distribution within the catchment. It extends from about 4,000 feet up to about 6,000 feet elevation in favourable localities. The most extensive occurrence is over most of the country above about 4,000 feet from Mt. Pinnibar through Mt. Gibbo and Davies Plain ridge to Mt. Cobberas. It also occupies considerable areas below the alpine herbfield and sod-tussock grassland communities, from Mt. Bogong around to the Dividing Range south of Mt. Hotham At its lower limit it rapidly, and at times, abruptly gives way *E. delegatensis* or *E. rubida-E. pauciflora* wet sclerophyll forests.

Considerable areas of the sub-alpine woodland were burned in the extensive fires of 1939, and numerous coppice shoots now grow from the stumps of most of the dead trees (Plate 14). The replacement of the tall, large-crowned woodland trees by the short, shrubby coppice has an adverse effect on snow accumulation, and allows earlier snow-melt (Costin et. al. 1961).

(8) Wet sclerophyll forest: In this formation the dominant stratum consists of tall trees with interlacing crowns, and the sub-ordinate strata contain mesomorphic species. Three floristic units have been recognised within the formation.

(i) The community dominated by *E. rubida*[*] and *E. pauciflora* is not usually as tall or as luxuriant as the other communities in this formation. Its form is variable and may approach tall woodland, and at times is transitional to sub-alpine woodland. *E. dives* is sometimes also present. The ground flora is usually a continuous sward of a broad-leaved form of *Poa australis* and may contain scattered or numerous shrubs of *Daviesia latifolia* and *Platylobium formosum* on warmer sites, or *Bossiaea foliosa* and *Oxylobium ellipticum* on colder sites.

This community generally occurs between 2,500 feet and 4,500 feet elevation, and is restricted to areas where soil-moisture availability is lower than optimum for *E. delegatensis*. Thus, it often occurs within the *E. delegatensis* forest on dry, exposed ridges. Its most widespread occurrence is in the south-east of the catchment where a rain shadow reduces the rainfall, although elevations are about 2,500 feet to 3,500 feet. Soils are generally leptopodzols or cryptopodzols.

Where recurrent fires have not induced a dense low shrub stratum, the grassy floor of this unit provides good summer grazing.

(ii) *E. delegatensis* grows in virtually pure stands, although it does mix with species from adjoining communities at its boundaries. This vegetation has the typical wet sclerophyll forest form (Plate 16). The subordinate strata consist of small trees of *Acacia dealbata* and *A. falciformis*, and shrubs of *Daviesia latifolia*, *D. corymbosa var. laxiflora, Tieghemopanox sambucifiblius* and others. In some communities, the ground flora is a dense sward of a broad-leaved form of *Poa australis,* with only infrequent small shrubs. Wet-gully vegetation usually has a dense tall shrub stratum of *Bedfordia salicina, Pomaderris apeteala* and *Olearia argophylla,* with a ground flora of ferns and mosses.

[*] In this study E. *rubida is* taken to include *E. dalrympleana.*

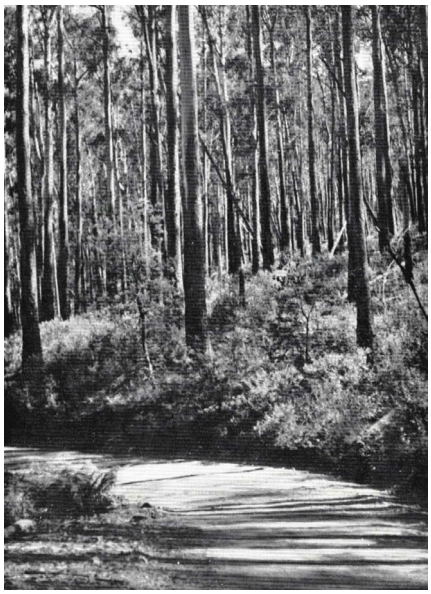

Plate 16. Wet sclerophyll forest of *E. delegatensis* beside the Omeo Highway near Mt Wills. The scrub is mainly *Daviesia latifolia*.

Some of the best *E. delegatensis* forests in the catchment occur on the dissected plateau country and the steep slopes from east of Mt. Benambra through to Mt. Pinnibar. Scattered occurrences are located from Mt. Pinnibar, south through the headwaters of most of the tributaries of the Upper Indi and Gibbo Rivers. To the west of the Mitta Mitta River, extensive areas of *E. delegatensis* forest occur on mostly steep country around Mt. Wills, and at elevations of from about 3,000 feet to about 4,500 feet on the south-western boundary of the catchment in the vicinity of Mt. Phipps. Scattered patches, mainly on southern aspects, occur in the upper valleys of Middle Creek and Bundarrah and Cobungra Rivers.

The lower limit of the community seems to be controlled by the distribution of winter snow, which plays a part in the regeneration of the dominant species (Grose 1961), and the upper limit is probably also temperature controlled. Thus the community grows at lower elevations on southerly aspects and at higher elevations on northerly aspects, provided soil moisture is not limiting.

Near its upper limits, the soils associated with this community are transitional alpine humus soils, but in general they are acid brown earths. They are deep and well-drained soils. This community does not occur on shallow or poorly-drained soils.

At the upper edge of its range, the community is rapidly replaced by sub-alpine woodland and on shallow soils, and particularly on dry or exposed ridges, it is replaced by *E. rubida-E. pauciflora* wet sclerophyll forest. At lower elevations it is replaced by the *E. radiata-E. rubida-E. dives* alliance.

The timber of *E. delegatensis is* of value for sawmilling, and extensive utilization of the species has been carried out in the Mt. Pinnibar-Mt. Benambra area and around Mt. Wills. Adequate seedling regeneration is essential for maintenance of the community and for planned forestry. To achieve this, extensive site disturbance is necessary to expose the mineral soil (Grose op. cit.).

The presence of an abundant shrub stratum in most of this vegetation is thought to indicate a fairly long history of light ground fires. Recurrent fires also appear to have caused considerable damage to the timber trees, many of them having fire scars in the butt through which fungal and insect infestations have entered.

(iii) The third floristic group of the wet sclerophyll forest formation contains a number of tree species of which *E. radiata, E. rubida* and *E. dives* are the most common. *E. viminalis* and *E. bicostata* often occur in locally moister situations and *E. maculosa* occasionally enters the community on dry ridges. In the upper part of its range, the undergrowth and ground flora are similar to those of the *E. delegatensis* forests. Over much of its range however, shrubs of *Cassinia aculeata, Daviesia latifolia, Pultenaea juniperina* and sometimes *D. ulicina* with *Platylobium*

formosum, Pteridium esculentum and *Coprosma hirtella* are common. Most, if not all, of the shrub species are encouraged by fire, and the dense nature of the undergrowth in most of this vegetation appears to indicate a history of repeated ground fires. Areas which appear to have escaped regular fires have a closed sward of a fine-leaved form of *Poa australis* with only scattered and weak shrubs of the above species (Plate 17).

The community ranges from the higher-rainfall areas around 3,000 feet elevation, where it adjoins *E. delegatensis* forest, to the drier areas around 1,500 feet elevation where it grades through a dry form into the *E. macrorhyncha* dry sclerophyll forest. It thus occupies a very large part of the catchment from the foothills in the north to the slopes of the Dividing Range in the south.

The soils are cryptopodzols on the typical montane slopes, and acid brown earths at the upper end of the elevation range of the community. On the plateau remnants and elsewhere, where the topography is undulating, amphipodzols are the dominant soils. At the lower end of its range, the soils may be leptopodzols. Lithosols also occur, but *E. dives is* usually the only dominant species of the community which grows on these.

To date, only limited use has been made of these mixed eucalypt forests for logging. The timber of the dominant species is rarely free of minor defects, such as gum veins and enclosed knots, and generally is only suitable for scantling-quality timber. *E. radiata, E. rubida* and *E. bicostata* are the more favoured because of fewer defects. Longer lengths of clear timber are obtainable from them.

Plate 17. *E. radiata-E. rubida-E. dives* wet sclerophyll forest on the Koetong plateau. The grassy forest floor with scattered small schrubs of *Platylobium formosum* indicates that the area has not been burned frequently.

(9) *Dry sclerophyll forest:* Trees of the dry sclerophyll forest have poorer form and are not as tall as those of the wet sclerophyll forest, and the ground flora is poorer in species and abundance. Vegetative ground cover is usually discontinuous and soil protection is largely dependent on forest litter.

This vegetation contains a number of eucalypt species of which *E. macrorhyncha* is the most generally present. Other species which may be co-dominant are *E. radiata, E. dives, E. rubida, E. maculosa, E. goniocalyx, E. polyanthemos,* and *E. melliodora.* The ground flora consists mainly of scattered tussocks of *Poa australis, Themeda australis* and *Danthonia spp.* with scattered small shrubs of species such as *Hibbertia sp., Platylobium formosum, Hardenbergia violaceae* and shrubby *lignotuberous* eucalypt regrowth.

Callitris endificheri, together with a shrubby form of *E. tereticornis* (probably var. *blakelyi),* and a dense shrub stratum of *Calytrix tetragona, Acacia sisculifbrmis, A. lanigera, Dodonaea cuneata* and others, form a xerophytic association within the community which is often more typically a dry scrub. This corresponds to the *Callitris calcarata* association of Morland (1959a).

The alliance occurs in the 25-inch to 35-inch rainfall belt in the north of the catchment on most of the well-drained country. It also occurs in the rain-shadow areas in the south, such as parts of the Mitta Mitta River valley and around Staleyville, where small shrubs, such as *Banksia sp., Brachyloma daphnoides* and *Dillwynia parvifolia* occur in the shrub stratum (Plate 18). The *Callitris endlicheri* association is restricted to red granite hills at Thologolong and Pine Mountain, in the Murray valley.

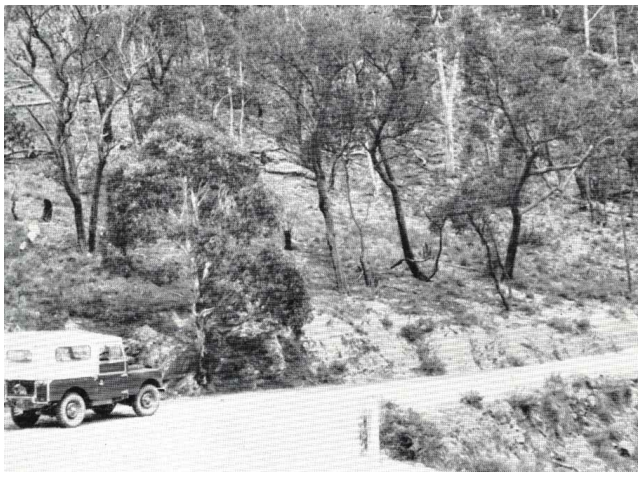

Plate 18. Dry sclerophyll forest of *E. macrorhyncha* alliance in the Staleyville land system. The sparse ground cover consists mainly of small scattered shrubs and forest litter.

In the north, the soils associated with the *E. macrorhyncha* alliance are mainly leptopodzols. The soils of the red granite area around Staleyville are more sandy but are still mainly leptopodzols frequently grading into regosols. The soils of the *Callitris endlicheri* association are similar.

Where soil-moisture availability is higher, the dry sclerophyll forest grades into wet sclerophyll forest of *E. radiata, E. rubida* and *E. dives.* In drier situations, such as at Pine Mountain, it grades into dry scrub. The terraces of the northern valleys support dry sclerophyll forest in their upper reaches, and as rainfall decreases it is replaced by savannah woodland of *E. tereticornis, E. albens* and *E. goniocalyx.* Occasionally it adjoins the *E. camaldulensis* savannah woodland of the lower stream flats in the north, although it never occurs on the flats itself.

The protection of the soil surface in this community is largely dependent on accumulated forest litter, the sparse ground flora merely providing anchorages for the litter. When the litter is burnt, re-establishment of cover is slow and sheet erosion can continue unchecked. Because of the proximity of much of this vegetation to cleared farmland it has often been burnt, though not so extensively in recent years. It is of little value for rough grazing, but the timbers are used locally for fencing materials and for short poles for telephone lines or shed construction. Fire protection is of great importance in this vegetation because of the nature of the ground cover and the steep country on which it grows.

(10) Tall Woodland: The tall woodland formation is composed of trees which have crown depths more-or-less equal to the length of the bole. The crowns of the trees are usually in contact. The ground flora is composed of grasses and forbs. The dominant species in the community with this formation are *E. camphora* and *E. stellulata,* with tussocks of *Poa australis* providing more-or-less complete ground cover. Hygrophilous herbs may also be present.

The most extensive occurrence of this community is on the flats of Morass Creek. Narrow strips of the community are also common along the banks of small perennial streams at elevations above about 1,000 feet. This vegetation favours cool, moist environments where the soil is saturated for part of the year. The soils are of alluvial origin and usually have gleyed subsoil. On the Morass Creek flats, the soils are prairie soils over clays in which small lime streaks occur.

The vegetation which occurs on the better-drained sites associated with the tall woodland community usually has the wet sclerophyll forest formation, with *E. radiata* and *E. bicostata* as the more common species. Savannah woodland of *E. rubida* and *E. pauciflora* often flanks the tall woodland in the Morass Creek area.

Clearing of the tall woodland community on the more extensive flats has occurred to a limited extent. The vegetation provides useful grazing but no commercial timber.

(11) Savannah Woodland: This woodland formation consists of trees which are separated by a distance equal to about the diameter of the crowns. The ground flora consists of grasses and forbs.

Three separate floristic groups have been recognised.

(i) In this floristic group, *E. tereticornis, E. albens* and *E. goniocalyx* are the most common species. Others are *E. bridgesiana, E. melliodora* and *E. polyanthemos.* The ground flora consists of grasses, mainly *Danthonia. spp.* and *Themeda australis.*

The main occurrences of this vegetation are on the upper terraces of the main valleys in the north of the catchment. Typical areas are around Tallangatta, Talgarno and the Cudgewa-Corryong plains. The topography is rolling and the soils are usually red podzolic soils or leptopodzols. Rainfall is generally about 30 inches per annum in these areas, and summers are hot and dry.

On steeper country, and as rainfall increases on the rolling topography, the community is replaced by dry sclerophyll forest. Drainage lines and the alluvial flats of the perennial streams within this community, support savannah woodland of *E. camaldulensis.*

The *E. tereticornis-E. albens--E. goniocalyx* alliance has been extensively thinned out or cleared completely for establishment of permanent pastures. These pastures frequently incorporate subterranean clover and Wimmera rye grass with native species. Some oat crops are also grown on this country.

(ii) *E. rubida* and *E. pauciflora* are the dominants in the second floristic group. *Themeda australis* provides a more-or-less continuous ground cover (Plate 19).

Plate 19. Savannah Woodland of *E. rubida-E. pauciflora* alliance near Benambra (Hinno Munjie land system).
This vegetation has been extensively modified or cleared over most of the alienated land.

This vegetation is widespread on the hilly country around Omeo and Benambra, at elevations of about 2,500 feet. It seems to be restricted to the most severe part of the rain shadow where rainfall is about 25 inches per annum. The soils are usually leptopodzols though there are some solodic soils.

Plate 20. Remnant of the *E. camaldulensis* savannah woodland on the Mitta Mitta flats at Noorongong (see also Plate 6).
This type of vegetation covered the lower terraces of the northern valleys but has been considerably modified since settlement.

A short dry sclerophyll forest form of this community may occur on exposed, rocky ridge tops. As rainfall increases, the vegetation changes to wet sclerophyll forest formation with *E. rubida* and *E. pauciflora* as dominants.

This vegetation has been extensively thinned or cleared in some places, and is used for grazing beef cattle and sheep, mainly on the native *Themeda* pastures. Over-grazing, particularly in drainage lines, possibly by stock looking for water, is a potential cause of deterioration of ground cover which results in erosion.

(iii) The third floristic group is dominated by *E. camaldulensis* and has a continuous ground flora of various hygrophilous grasses and forbs. This community is confined to the extensive alluvial flats of the lower reaches of the main rivers (Plate 20). Regular annual flooding or at least a high water-table during the winter and early spring, seems to be a requirement for the regeneration of the trees. Because of the water-table, the rainfall in the area is of little significance, although it is within the 25-inch to 35-inch rainfall area. Temperatures may be critical in limiting the distribution of the dominant species to the lower elevations. The soils are mainly alluvial brown earths, minimal podzolics or stream regosols.

At higher elevations, the stream flats are occupied by the tall woodland community of *E. camphora* and *E. stellulata.* Savannah woodland of *E. tereticornis, E. albens* and *E. goniocalyx,* or dry sclerophyll forest of the *E. macrorhyncha* alliance are usually found on the better-drained country surrounding the *E. camaldulensis* alliance.

Some of this vegetation has been thinned or cleared, but in many places, it is more-or-less in a virgin condition, particularly where lagoons and swampy country make access and improvement difficult. Possibly more use could be made of the areas occupied by this vegetation if drainage were more extensive. Grazing of beef and dairy cattle on native or improved pastures is the usual form of land use.

(12) Wet tussock grassland: Large tussocks of *Poa australis* form the major part of this vegetative community, but numerous other grasses and forbs which tolerate seasonally wet conditions are also present.

The most extensive occurrence of this community is on the Morass Creek flats and on the alluvium of Lake Omeo basin. Other small occurrences are on the limited areas of alluvium to be found along parts of many of the small perennial streams in the catchment. The soils are of alluvial origin and include minimal prairie and chernozemic soils as well as stream regosols.

In the Morass Creek area, this vegetation is associated with tall woodland of *E. camphora* and *E. stellulata.* It usually occupies the lower topographic situations, but not those remaining permanently saturated, which are occupied by the fen community. Other vegetative communities which may be adjacent to the wet tussock grassland are the wet sclerophyll forest or savannah woodland of *E. rubida* and *E. pauciflora* or the wet sclerophyll forest dominated by *E. radiata, E. rubida* and *E. dives.*

Where the wet tussock grassland is extensive enough, it is used for grazing, mainly of beef cattle. This has resulted in the naturally tall, tussocky vegetation being reduced to a somewhat irregularly short sward, except in inaccessible areas, where its natural condition is preserved.

Ecology of the Major Tree Species

The ecological relationships of the vegetative communities previously described are illustrated in Figure 18. This sub-section deals only with individual species.

Eucalyptus albens occurs in similar situations to *E. tereticornis,* in the lower Mitta Mitta valley as far east as Tallangatta East. This area has an annual rainfall of about 30 inches with hot, dry summers and cool, wet winters. Its occurrence is also closely related to coarse-textured soils derived from gneiss, however, this may be fortuitous.

Eucalyptus bridgesiana: This species also occurs in similar situations to *E. tereticornis,* but not usually on the steeper slopes. It also occurs at higher elevations than *E. tereticornis,* but not above about 2,000 feet. The rainfall range is up to about 35 inches per annum with a summer dry period. Temperatures are hot in summer and cool in winter. The soils usually have poor internal drainage.

Eucalyptus camaldulensis is confined to stream flats from about 600 feet to 1,000 feet elevation, which are periodically waterlogged and have a moderately high water-table, even in summer. Temperatures appear to be critical in limiting its distribution. At higher elevations it is replaced by *E. camphora.*

Eucalyptus camphora occurs on waterlogged soils or soils having a high water-table for much of the year. It occurs at elevations above about 1,000 feet to 1,500 feet where it appears that temperatures are too low for *E. camaldulensis.* It is frequently associated with *E. stellulata* which occurs on the better-drained sites.

Eucalyptus delegatensis is restricted to areas which receive light winter snow, usually at elevations of from about 3,500 feet to 4,500 feet. The seeds require low winter temperatures to break their dormancy (Grose 1961). Precipitations are in excess of 40 inches per annum, and soils remain moist throughout the year. Summers are mild and winters are cold. Soils are deeply weathered and freely drained. *E. dives* and *E. rubida occupy* dry ridge tops within the *E. delegatensis* range. It gives way to *E. pauciflora* above about 4,500 feet and to *E. radiata* with *E. rubida* below about 3,500 feet.

Eucalyptus dives has a broader ecological range than its near relative, *E. radiata.* It grows on shallow, well-drained soils within the *E. radiata* range, and also on dry aspects and shallow soils in the warmer areas which receive rainfall of less than 35 inches per annum. It may be associated with *E. rubida* on dry ridges at elevations below 4,500 feet.

Eucalyptus goniocalyx occurs generally on soils subject to excessive winter wetness and summer dryness, where annual rainfalls are up to about 40 inches. It is generally limited to elevations below about 2,000 feet. Other species with which it occurs are *E. tereticornis* and sometimes *E. dives* and *E. macrorhyncha.* Its range appears to overlap into the *E. tereticornis* and *E. macrorhyncha* ranges.

Eucalyptus macrorhyncha is generally confined to freely-drained soils where annual rainfalls are from 30 inches to 40 inches. It may occur in higher-rainfall areas if soil moisture-holding capacity is low, but low temperatures probably help to restrict this species to below about 2,500 feet elevation. It gives way to *E. dives, E. rubida* and *E. radiata* as rainfall increases and temperatures become lower. Other species which may be associated with *E. macrorhyncha* at the warmer and drier end of its range are *E. dives, E. rubida, E. polyanthemos* and *E. goniocalyx.*

Eucalyptus pauciflora occurs mainly above the *E. delegatensis* forests, that is, above about 4,500 feet elevation and up to about 5,500 feet. At the higher elevations, it is confined to rocky sites where protection from frost heave, or from mechanical damage to the seedlings by snow, is probably a survival factor. It also occurs with *E. rubida* in rain-shadow areas, where annual rainfall is as low as 25 inches, and elevations are about 2,500 feet. It sometimes occurs as an isolated specimen at elevations down to about 800 feet in the drier parts of the catchment. The range *of E. pauciflora* seems to be little influenced by rainfall or soils but apparently its tolerance to low temperatures is important.

Eucalyptus polyanthemos sometimes occurs with *E. tereticornis* on gently-sloping country, but it is more generally found on steep dry slopes or ridge tops. It is more common on soils which are dry in summer and does not generally occur on sites which are excessively wet in winter. Its elevation range is up to about 2,000 feet, and its annual rainfall range is up to about 35 inches. Other species often associated with *E. polyanthemos* are *E. macrorhyncha, E. dives* and *E. albens.*

Eucalyptus radiata requires moderately high soil-moisture status. It occurs mainly in areas receiving rainfall of more than 40 inches per annum, on deep, well-drained soils, but also in lower-rainfall areas where soils are more water holding, but not waterlogged. Its elevation range is from about 1,000 feet to about 3,500 feet. In cool, moist sites it is frequently mixed with *E. bicostata* and elsewhere it occurs with *E. rubida* and *E. dives* and sometimes *E. macrorhyncha.*

Eucalyptus rubida has a similar range to *E. dives* and occurs as a co-dominant with *E. radiata on* the drier sites within the range of the latter. It occurs with *E. pauciflora* in drier areas at elevations of about 2,000 feet to 3,000 feet. Although it most commonly occurs on moister and cooler sites, it is able to compete effectively over a range of environments from the dry, warm sites in the north, to the cool, relatively high-rainfall sites in the central part of the catchment.

Eucalyptus stellulata occurs usually with or near *E. camphora,* but occurs on somewhat better-drained sites adjacent to streams. Low temperatures and a moderate rainfall seem to be necessary for its occurrence.

Eucalyptus tereticornis occurs typically on hillocks or terraces where a perched water-table may be expected during winter, and where soils dry out in summer, and at elevations up to about 2,000 feet. In this catchment it is typically dominant on granitic or gneissic parent materials. Annual rainfall is about 30 inches and summers are hot and winters cool. On cooler sites it may be replaced by *E. rubida* and *E. pauciflora. As* rainfall increases and temperatures become lower, (generally associated with steeper and more-freely-draining topography), it is progressively replaced by *E. macrorhyncha, E. rubida, E. dives* and *E. radiata.* It is often associated with *E. bridgesiana, E. albens, E. goniocalyx* and *E. polvanthemos.*

A small form, presumably var. *blakelyi, occurs* on steep, dry slopes, where soils are shallow.

Vegetation in Relation to Land-use

The major land-use activities in the catchment are the collection of water for irrigation, harvesting of forests for sawn timber, and agriculture.

The growing awareness of the shortage of water in Australia has led to a re-assessment of the value of high water-yielding catchments such as the catchment to Hume reservoir. Their efficient functioning as water source areas is now more generally considered to be of the utmost importance. The naturally occurring vegetation, and particularly the ground flora, plays a highly significant part in the hydrologic cycle.

Grass and herbs play a multiple role in preventing excessive surface flow of rain water. They slow the movement of the surface water, thus allowing it more time to infiltrate, and prevent raindrop splash from dispersing the surface soil and sealing the soil pores. Also, the fibrous roots loosen the surface soil, and dead roots provide channels into the soil. The fine vegetative parts are readily humified when they die, and assist in making the surface soil more permeable. A dense litter layer can perform several of these functions, but the herb and grass cover is superior in assisting the complete infiltration of precipitation. In general, the taller shrubs and trees contribute little to this aspect of the hydrology.

For relatively shallow-rooted plants, such as the herbs and grasses generally, the concentration of plant nutrients in the surface soil is important. Depletion of these reserves may lead to deterioration in the vigour of the herbaceous ground flora. Much of the dry sclerophyll forest, particularly on the steeper slopes, has little or no herbaceous ground cover. This suggests that periodic burning and subsequent sheet erosion may have so depleted the nutrient reserves of the surface soil, that the herbs and grasses can no longer survive. Whilst the accumulation of litter may slow the movement of surface water, it is inferior to herbaceous ground cover in creating suitable soil conditions for rapid infiltration. As pointed out previously, over half the total water yield from the catchment is from areas between 1,500 feet and 3,500 feet elevation, much of which is dry sclerophyll forest with a dominance of litter ground cover.

The same arguments apply to all land in the catchment, however the soils above about 3,500 feet have more-stable structure and their infiltration capacity is probably not affected to the same extent as the soils from lower elevations.
The alpine grasslands and herbfields contain an abundance of fine-leafed Poa australis which, except for the fresh green shoots and the flower heads, is not palatable to cattle. Grazing of these vegetative communities is thus selective, the herbs being preferred. The heavy grazing pressure on the herbs reduces their vigour and may even lead to their elimination, and because of the low survival rate of shallow-tooted seedlings at these elevations, re-establishment of' grass or herbs from seed is slow. The result is that much bare soil is exposed and sheet erosion by wind and water follows. Although the loss of the soil is serious in itself, it is the effect of the bare soil on run-off which is most critical. On sloping land the inter-connected network of bare inter-tussock spaces allows surface flow to occur and results in an increase in the rate of delivery of precipitation and snow-melt water to streams. This is undesirable.

Shrubs are the most efficient colonisers of the bare spaces in the alpine herbfields and grasslands (Carr 1962). Shrubs, however, appear to have an undesirable effect in hastening snow-melt. (A. S. Rundle, pers. comm.). Fencing experiments (Carr and Turner 1959; Carr 1962) indicate that in the natural state, the vegetation of these areas consisted of a greater proportion of alpine herbfield and much less of the shrub community than at present. If this is so, the hydrologic condition of the snow country is below optimum.

The moss beds have suffered considerable deterioration as a result of grazing and burning (Costin 1957b). They have been reduced in area and depth as a result of lowering of the water-table following stream entrenchment which can be attributed to trampling by stock. In many places the moss beds have practically ceased to exist. The deep moss beds are capable of absorption of large quantities of water and are probably responsible for a substantial smoothing out of stream-flows. The deterioration of the bogs is a serious consequence of poor land-use.

The sub-alpine woodland of *E. pauciflora* has suffered considerable damage by fire. The mature woodland formation has, in most areas, been replaced by a wet mallee or wet scrub form of *E. pauciflora* regrowth. Costin et al. (1961) has demonstrated the value of the mature woodland form in encouraging the development of deep snow drifts in the gaps, and in delaying snow-melt. Re-establishment of the open woodland will be slow if natural selection is relied upon. A programme of judicious thinning may have to be carried out to speed the process.

In general, past land-use practices in the forested and snow areas of the catchment have caused changes in the vegetation which have been detrimental to its efficient functioning as a water-supply area. Fire has probably been the most damaging factor and considerable effort is being made, and must continue, to prevent the spread of fire in the catchment. Excessive grazing pressure on parts of the snow country has also had detrimental effects and there are indications that catchment efficiency and grazing of much of the snow country are incompatible.

The utilization of the forest trees for mill-logs is an important industry in the catchment. The *E. delegatensis* forests are particularly sought after by sawmillers because they yield large volumes of high-quality timber per unit area and are thus a much more economic proposition than the mixed-species forests, where both volumes per unit area and timber quality are lower. Increased demands for timber in Australia have been predicted (Turnbull 1959) so that more extensive utilization of the *E. radiata, E. rubida* and *E. dives* forests may be expected in the future.

Regeneration of the harvested crop is an essential part of forestry practice. In the *E. delegatensis* forests, the most satisfactory regeneration is achieved by burning the logged areas (Grose 1961). Unless a policy of single use (water supply only) is to be practised in this catchment, it is essential that after logging of an area, it should be regenerated as rapidly as possible. Although frequent burning or uncontrolled fire is considered detrimental to catchment efficiency, a controlled fire at intervals of 60 years or more, used as an aid to satisfactory regeneration, will probably not be detrimental.

To the early settlers, grass was the most sought after vegetation, and so those areas providing a maximum of grass with a minimum of clearing were the first to be claimed. Later, extensive areas of forest and woodland were cleared to improve the grazing. It was learned that burning the forest floor induced a fresh growth of grass, which was more palatable to stock than the unburned grass, and so the forests were burned periodically. The repeated burning however also encouraged shrub species with mechanisms such as propagation from hard seeds, which enabled them to survive the fires and regenerate promptly. These shrubs are now so abundant, that vast areas of previously good forest grazing country are practically useless for that purpose. The fires also caused much

damage to the trees. Those that were not killed suffered fire scars, which provided ready access for wood-destroying fungi and insects.

Prior to their being cleared, most of the existing farmed areas carried savannah woodland or dry sclerophyll forest. The woodland areas were the earliest settled, and when these were all occupied the adjacent dry sclerophyll forest was cleared, probably simply because it was adjacent to the already settled land. Ring-barking was the usual method of killing the trees, and these were later burnt.

In some areas, attempts were made to clear and farm land occupied by the wet sclerophyll forest in which *E. radiata is* dominant. In general, however, these attempts to farm the land have not been successful. An important factor was probably the isolation of these areas from the more closely settled areas.