THE ENVIRONMENT AND PLANT ECOLOGY OF THE HUME RANGE, CENTRAL VICTORIA

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The Hume Range is a small granitic plateau on the Great Dividing Range at the western end of the eastern highlands. It intercepts a relatively high and seasonally well distributed rainfall. The krasnozemic and podzolic soils are related to both climate and the topography. The old Mesozoic land surface of the plateau is deeply weathered and krasnozemic soils are developed on granodiorite, hornfels and mudstone. On the erosionally active slopes above about 500 m soils are brown and friable, below this altitude they are yellow podzolic and relatively poorly structured. Nutrient content of soils has been invariably concentrated by the litter cycle in the topsoils and in most cases the krasnozemic soils are better endowed than the podzolic soils.

Vegetation is also zoned altitudinally from aspect-delineated dry sclerophyll and grassy forests or woodlands in the foothills to increasingly tall forests, which culminate in wet sclerophyll forests of *E. regnans* above about altitudes of about 500 m. The *E. regnans* forests have shown a wide response to fire regimes over the last century which have produced a mosaic of old and young even-aged and multi-aged forests as well as scrub, and bracken and frost hollow grasslands. Some logging and local clearing by paling splitters took place last century and extensive reforestation has been carried out in this century.

Overstorey species often show different ecological amplitudes than understorey species, hence one eucalypt species may be associated with several understorey types or the same understorey may occur under several different eucalypts in different parts of the Hume Range. The gradients between different forests are dictated by the gradients of the environment, thus boundaries are often sharp on the south fall and diffuse on the northern extension of the plateau.

The understoreys of *E. regnans* have responded to the frequency regimes of surface and crown fires in relation to both the longevity and fire resistance of the species as well as the longevity of the seed stored in the topsoil. There has been a tendency for the mesomorphic wet sclerophyll understoreys to retreat under the onslaught of severe fire regimes from 1851–1926. Today, 70 years since the last fire, there is strong evidence of a recovery and spread of the wet sclerophyll elements in *E. regnans* forests on the plateau as well as a considerable advance into wet *E. obliqua*–*E. cypellocarpa* forests on the south and east slopes. Damp and wet sclerophyll forests of *E. regnans* in the northern half of the plateau have regenerated following the fires of 1982. The bryophytic and lichen communities on granitic rocks reflect the microclimate of the various forested and non-forested sites. Fires and exposure have caused a regression of these microcommunities to those of more xeric habitats.

Changes in the central core of mature forest 100 years after the last fires include the increase in abundance of more shade bearing species, which may lead to a form of *Atherosperma* rainforest in the continued absence of fire in the centuries to come—somewhat similar to that on the Errinundra Plateau in east Victoria. However, the chances that the Hume Range area will remain free of fire for this length of time is remote. *E. regnans* forest is therefore likely to remain a fire-disturbance climax.

Key words: plant ecology, environment, climate, soils, communities.

THE Hume Plateau is interesting, both biogeographically and historically because it represents an 'island' of wetter country on the Great Dividing Range at the western end of the eastern highlands and, being close to Melbourne, was used as a convenient supply of timber and water from the middle of last century. Perhaps today, it is most renowned for the large area of almost intact mature forest of *Eucalyptus regnans* Ferdinand von Mueller* which occurs astride the south-eastern

*Nomenclature of vascular plants has been standardised on the *Flora of Victoria* (Walsh & Entwistle 1994–99); that of the mosses follows Scott & Stone (1976).

edge of the plateau. This paper aims to describe the general ecology of the range—its environment, history, soils and vegetation and in particular the dynamic changes that have taken place over the last 51 years of study. To some extent it hopes to add some cohesion and perspective to earlier work (Ashton 1958, 1975a, 1975b, 1975c, 1975d, 1976a, 1976b, 1979, 1981a, 1981b, 1984, 1986, 2000; Ashton & Attiwill 1994; Ashton & Bassett 1997; Ashton & Chinner 1999; Ashton & Martin 1996a, 1996b; Ashton & Turner 1979; Ashton & Webb 1977; Ashton & Willis 1982; Brookes & Turner 1963; Gill & Ashton 1971).

ENVIRONMENT

Physiography

The major study area is situated in the eastern half of the Hume Range. The southern edge of the range forms part of the Great Divide, which, in this region, trends WNW to ESE. From the south the range appears as a broad massif that gradually rises from 366 m at the Kilmore Gap to 802 m at Mt Disappointment. The range then falls gradually to 700 m at Yorktown Hill before curving sharply down to the undulating Kinglake Plateau (490–595 m) (Fig. 1).

The Great Divide itself is broad and in many places ill defined, rising only slightly above the surrounding country. The southern slopes are steep and similar to those forming the Kinglake escarpment to the east. The steep stream gradients on the south fall indicate active erosion which has caused the Divide to migrate 6 km northward at Mt Sugarloaf in the Kinglake area (Hills 1975) and 2 km north westward near Mt Disappointment.

North of the Divide, a broad undulating plateau at 600–750 m (the Hume Plateau) extends for about 15 km before merging into the system of well defined NW–SE trending strike ridges at elevations down to 350 m (Fig. 2). The Hume Plateau is regarded as a relic of the peneplained Cretaceous terrain, now 150–180 m higher than the Kinglake Plateau from which it has been erosionally differentiated by a second phase of peneplanation, presumably in the early Tertiary period (Hills 1975).

Fig. 1. The southern scarp of the Hume Range from Whittlesea.

The metamorphic aureole of hornfels has been differentiated physiographically on the east as steep arcuate ridge at altitudes of 600–700 m wherever the drainage systems run parallel to it. However, the aureole is not differentiated in the northern area of the Hume Plateau where drainage systems are less well developed. In the south, the hornfels has been breached by more active erosion of the Plenty River system leaving conical hills at 400–500 m (eg. One Tree Hill; Fig. 3).

The Plenty River and tributaries have cut deep V-shaped valleys into the granodiorite, where they show a strong tendency to follow the major jointing system that runs NNW and NE (Fig. 3). The granitic stream pattern is also well developed in the headwaters of the Wallaby, Sunday and Silver creeks, where the streams follow a rectilinear course and the tributaries frequently unite with the main stream at angles that approach right angles. The profile of the Plenty River shows four main divisions. The headwaters are of the plateau type which, after 1–2 km, is abruptly replaced by a steeper gradient and the development of a deep valley (Fig. 4). Further downstream, below the

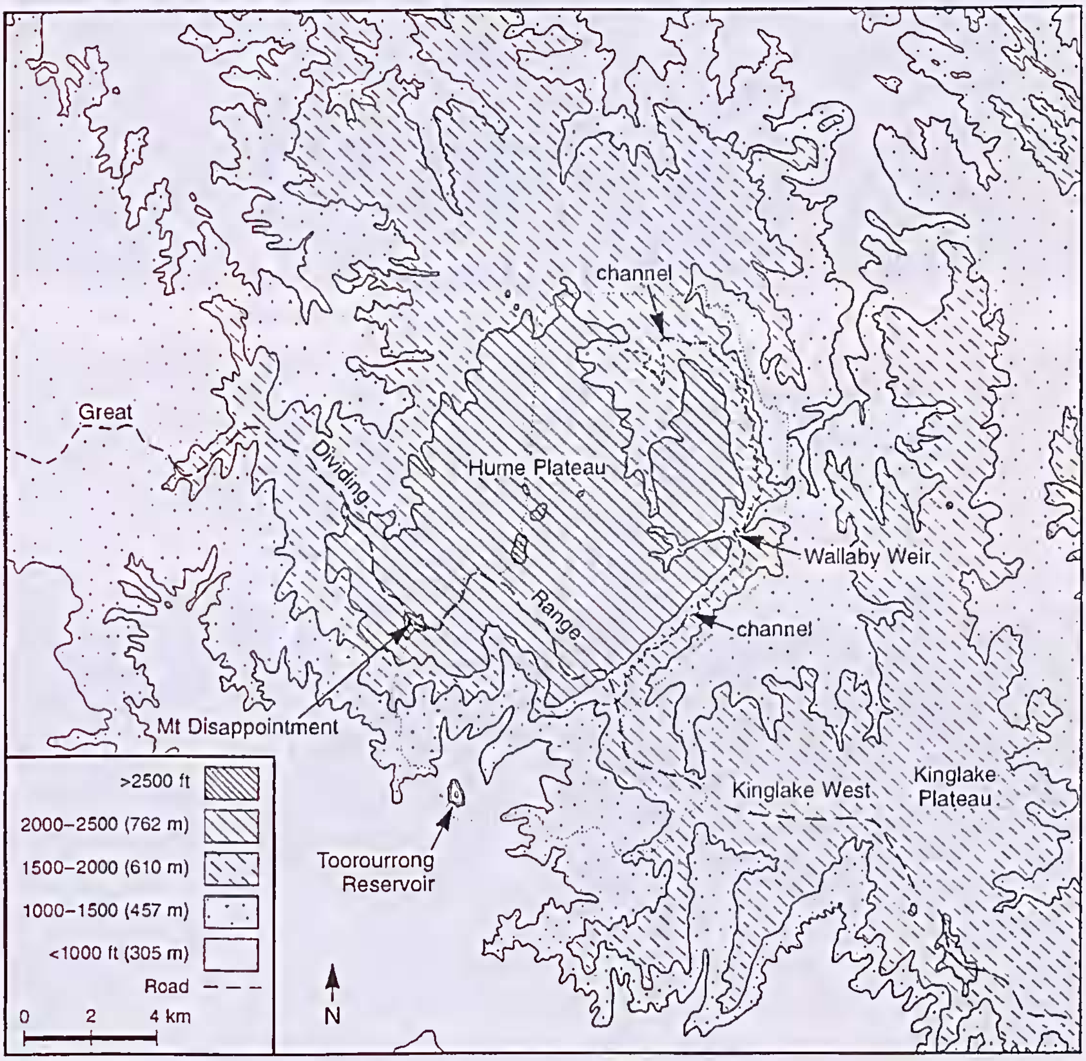


Fig. 2. Map of the topography of the Hume Range.

junction of the Big Ash Creek, the gradient becomes steeper with the development of a series of waterfalls and rapids. The final phase occurs when the Plenty River suddenly passes out of its mountain tract into an open valley at 275 m.

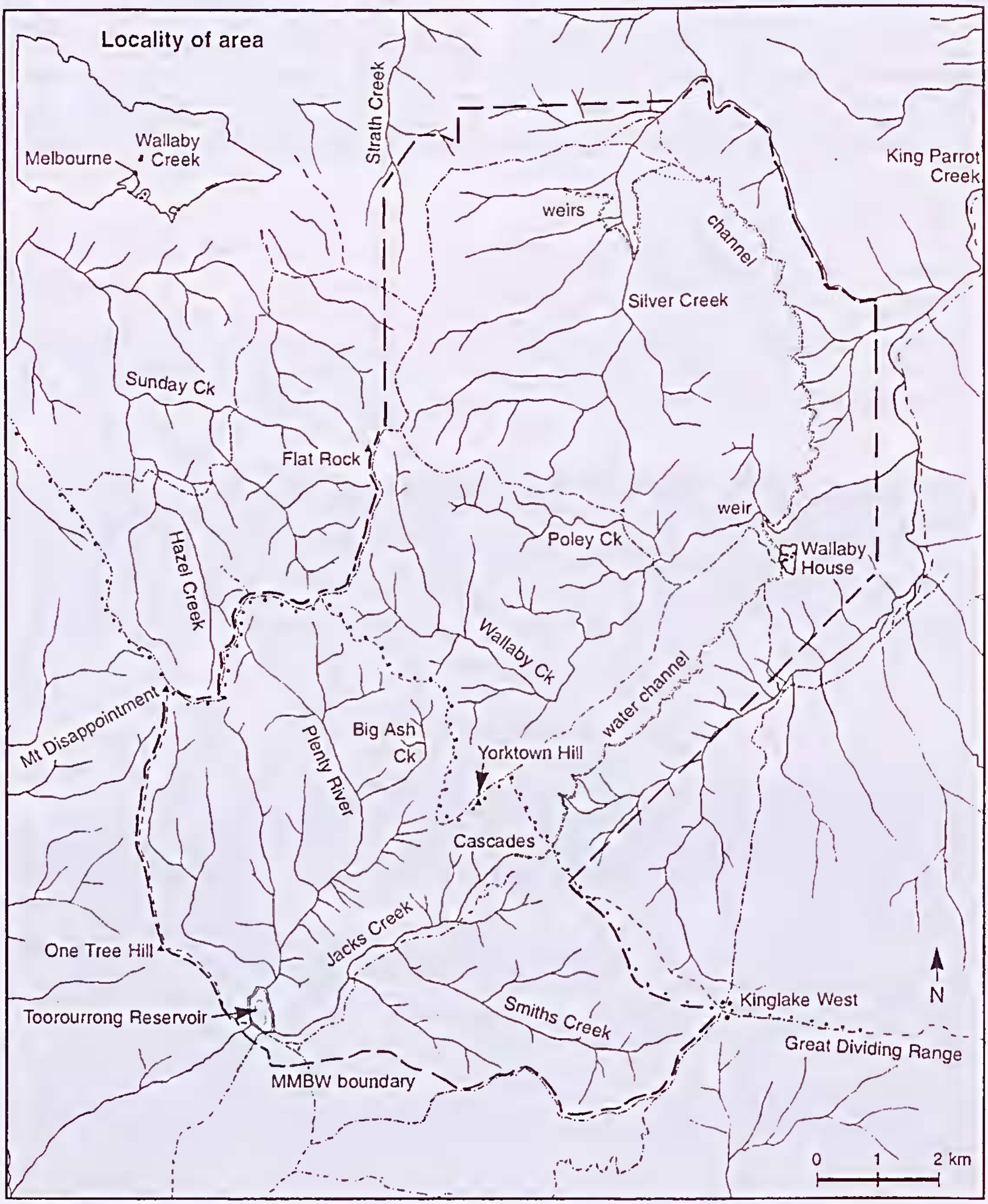


Fig. 3. Map of the geography of the Hume Range, Wallaby Creek.

Fig. 4. Steep south fall of the Plenty Valley.

Fig. 5. Gentle plateau terrain, Poley Creek area.

In the Wallaby Creek watershed the mature topography of the plateau is well developed (Fig. 5). The streams are inset into the undulating country in moderate to shallow gullies, and often flow through alluvial swamps up to 500 m long and 100 m wide. These flats are generally terminated on the downstream by harder or more massively jointed granodiorite whieh has resulted in small waterfalls and rapids and produeed a base level of erosion upstream.

The region around Flat Roek (762 m) is a foeal point on the Hume Plateau, for it is from here that many of the tributaries of the main streams radiate (Fig. 3). The gentle gradient of the Wallaby Creek is abruptly terminated by the development of the Nimmo Falls, a series of eataraets just north of Wallaby House where the Wallaby Creek has cut a gorge through the hornfels ridge. Below the Wallaby Weir a further series of eataraets oeeur before the alluvial flats of the King Parrot Creek are reaehed. Similar gorges oeeur where the Sunday and Silver creeks flow aeross the hornfels aureole. The lower seetion of the Silver Creek, eontrary to the Strath and Reedy ereeks that also drain the northern slopes, shows a spectaeular ehange of direction from N–NE to S–SE in a gorge cut through the resistant hornfels (Fig. 3).

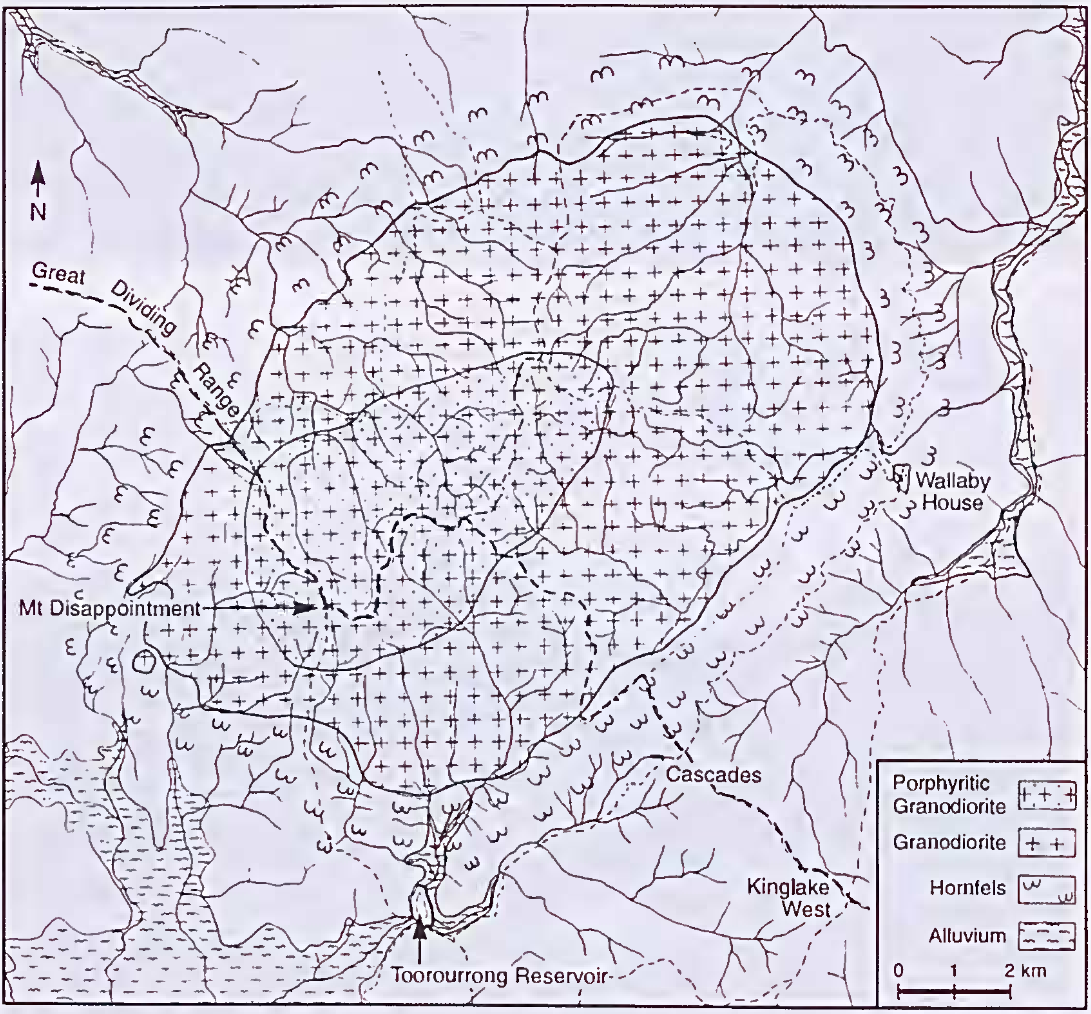


Fig. 6. Map of the geology of the Hume Range.

The physiography of this region was utilised in the construction of water channels and diversionary weirs. A water channel was built in 1883–85, approximately along the contour northwards from the lowest and most convenient part of the Divide above Jack's Creek. This channel taps the headwaters of the Wallaby and Silver creeks at altitudes of 518 m and 533 m respectively, and diverts their flow into Jack's Creek on the south fall at the Cascades. This augmented supply has increased the natural stream erosion, and in many places undercutting of the banks has occurred to a considerable extent. In 1884 the Plenty River was dammed back below its junction with Jack's Creek to form the Toorourrong Reservoir which serves as a settling basin for the greater part of the Yan Yean water supply. Over the 120 years since damming, the incoming creeks have developed small vegetated deltas which extend up to 220 m into the reservoir.

Geology

The Hume plateau consists largely of an elliptical granitic batholith striking NE–SW (Fig. 6). It is roughly 24 km long and 16 km wide and is surrounded by a metamorphic rim of hornfels about 1 km wide. The plutonic rock consists of an outer zone 1.5–3 km wide of normal grey granodiorite enclosing a central area the composition of which approaches an adamellite studded with with large euhedral orthoclase phenocrysts or poikilitic masses of feldspar in a medium to fine groundmass consisting of quartz, orthoclase, plagioclase and biotite. The age of this rock is probably Upper Devonian in conformance with other central Victorian granitic intrusions (Williams 1964).

The hornfels is a dark, finely crystallised and well jointed rock. It is tough and resistant to weathering and erosion. Its texture varies from saccharoidal near the granitic contact to very fine and mottled 1–2 km away. The mineral assemblage in these rocks is mainly biotite, sericite, quartz and cordierite.

The bedrock of the area consists chiefly of gently folded siltstones and sandstones of Lower Devonian age although in the north of the area the strikes and dips are more pronounced. Outcrops of older sandstones and mudstones (Upper Silurian) occur in as meridional anticlinal structures at Mt Disappointment and Kinglake Central (Williams 1964).

Fire history and land use

This area was first described by Hovell & Hume (1831) and in an account of their memoirs in 'The Journey of Discovery to Port Phillip 1824–25, New South Wales'. Their party followed the King Parrot Creek upstream to just south of the Flowerdale district before striking south-westerly over the ranges. From their description they crossed the Silver Creek gorge before ascending the high hornfels ridge between Wallaby House and the Silver Weir. From here they travelled 8 miles in two days before being forced to abandon their efforts to discover a way across the ranges. They had followed a general south-westerly direction through impenetrable scrub before returning east to their base on the King Parrot Creek. On their second attempt they travelled some distance up the King Parrot Creek and ascended the range. From here they made their way past the Yorktown Hill region on to the highest point of the range (863 m a.s.l.), and being still unable to discover a route called it Mt Disappointment. They were now 22 km from their base on the King Parrot, and, after recrossing the tracks they had cut for their cattle the day before, penetrated the western and southern slopes for a few miles. Here they

Fig. 7. A charred paling-splitter stump in young forest (1926 regeneration), Wallaby Creek valley.

described fine timber and impenetrable scrub and swordgrass. On the mountain they describe a black-butted timber species (Mountain Ash) of extraordinary height and dimensions, some of which was 'fit for ship's spars'. Beneath this tall forest, thick scrub, turpentine (musk?), sassafras and

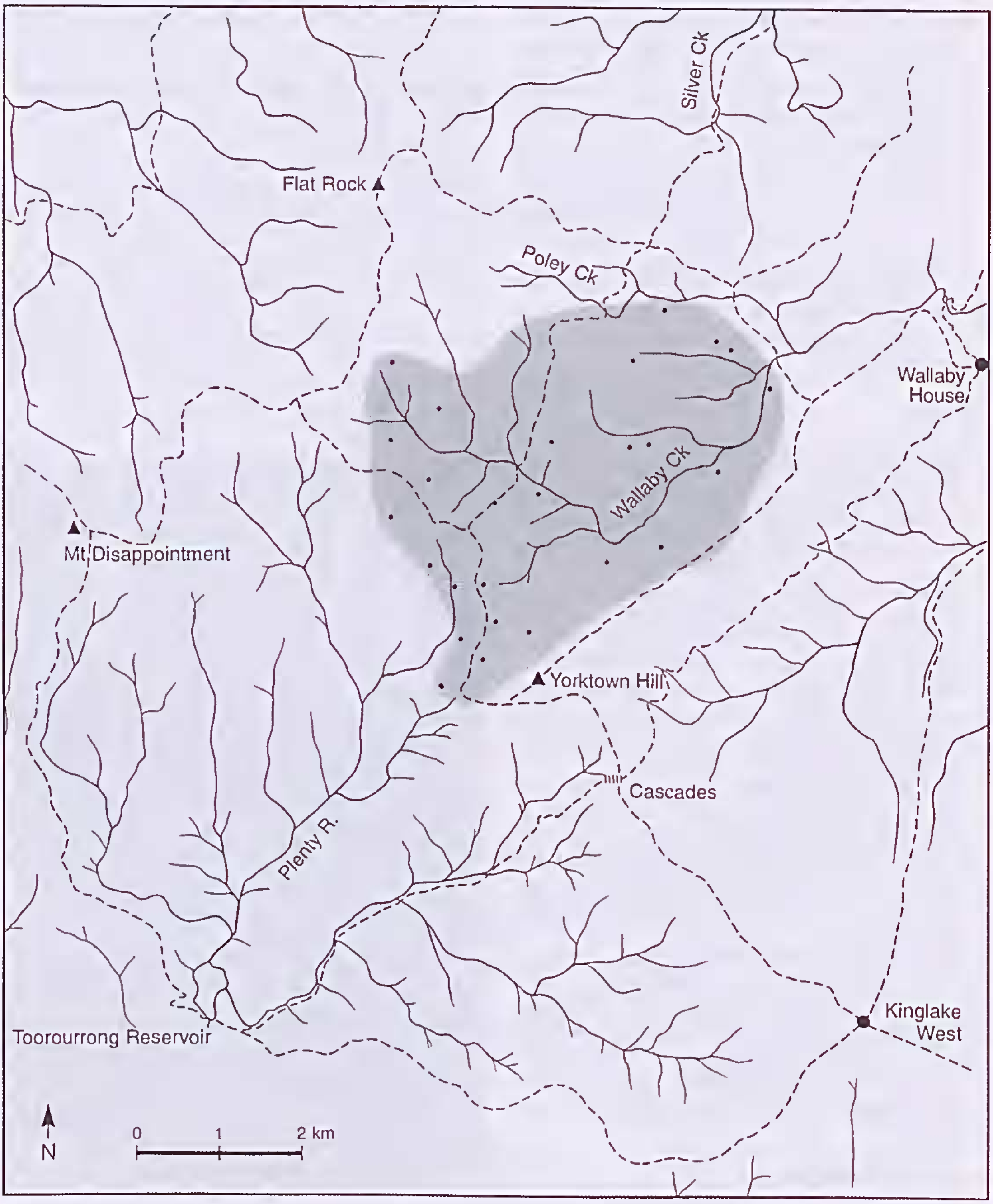


Fig. 8. Distribution of paling-splitter stumps identifiable on the plateau in 1950–52.

fern occurred, and pheasants (lyrebirds), ticks and leeches were common. They comment on the greater dimensions of the trees on the granite areas compared to the areas where the soil was strewn with fine hard rock (hornfels). The rocky ridges were described as being grassless, waterless, and carrying scrub in which the visibility was at times reduced to ten yards. Progress was also hampered by the prevalence of much dead timber and logs. After their return to the King Parrot Creek they travelled downstream until forced to evade a fire that was blowing directly into their path. They also mention recently burnt Stringybark country, and fires lit by the natives. Whether these fires represented the normal activity of the aboriginals, or whether they were deliberately lit to deter the explorers is not known. Stone axes have been found in the Mountain Ash area on the Hume Plateau and around Wallaby House, indicating that these people at least made excursions into the wetter country from the adjacent tribal areas of the Goulburn and Yarra valleys.

The area is partly surrounded by open forest–grassland from the NE to the SW, hence the possibility that fires burnt into this country, either accidentally or deliberately, with NE to NW winds is a real one, and one which would have considerable ecological significance. It is well known that scrub growth is always densest following a fire, and that after a period of 30–40 years considerable thinning out occurs. It is possible that the extremely dense scrub encountered by Hume and Hovell over much of the Hume Range could have been the result of a fire 10–20 years before. The present day 'Big Ash' forest on the southern edge of the plateau would have been then about 124 years old.

The whole range is reported to have been swept by the fire of Black Thursday (13 January 1851). This was mentioned in a Royal Commission Report (1876), and the Melbourne *Argus* on the 14 and 15 February 1851, describes the desolation wrought to settlers by the fire along the Plenty Valley. This fire was the culmination of a long, dry summer, and spread with tremendous rapidity following the sudden development of a fierce, hot northerly wind. Before the 1851 fire the Hume Range was heavily timbered with tall forest, and scrub had evidently thinned out so that it was possible to 'ride a horse beneath it'. Following this fire there was a rapid

Fig. 9. Aqueduct from Wallaby Creek to the Great Divide at altitude of 510 m.

and dense growth of trees and scrub. However severe this fire may have been, it is certain that fairly large tracts in the Wallaby Creek catchment either escaped the fire or were burnt through only by a surface fire.

The history of Melbourne's water catchment policy was born of the controversy surrounding land use and water purity of Melbourne's first piped water supply from the Hume Range catchment in the latter half of the 19th Century. In particular, it was concerned with farmyard and township activities of the Whittlesea area and the commencement of paling splitter activities on the south slopes (Seeger 1948–49).

The Royal Commission Report of 1876 gave details of the land use in the Melbourne Water Supply Catchment. In 1853 three mills were set up in the north of the Plenty (Hume) Ranges, where 12 000 sq. ft of first-class Mountain Ash and Blue Gum* (Grey Gum?) were extracted per week. It is not clear whether these mills were operating in the present water reserve area. In 1860 the paling splitting industry was established, and in 1863 the first palings were sent to Melbourne. At one time the population reached 400, including about 100 splitters, and the settlements of Yorktown, Germantown, McGuiness Weir and Colonial Camp were developed within the present water supply reserve area. The Inspector General, Mr William Davidson, in a Report to the Commissioner of Public Works 1881, wrote: '... since that year [1874] I have frequently visited the mountains [the Hume Range] and have observed the gradual destruction of what I formerly knew as magnificent forests of Mountain Ash ... Although the average number of splitters in the mountain is only 30–40, yet I can safely state that some thousands of acres of country which I knew seven years ago to be almost primeval forest are now nearly devoid of live timber. This is not the actual result of the felling operations of the trifling number of splitters —it is rather the result of the numerous bushfires which annually sweep the mountain, and which I am convinced are attributable to the presence of the splitters' (MMBW 1987). The splitters, who ranged over a considerable area of the plateau, left a scattering of characteristic flat-topped stumps 1–2.5 m high (Fig. 7) which are quite distinct from the highly irregular and jagged natural stumps. In 1950–52 recognisable paling splitter stumps were mapped during general reconnaissance. They occurred chiefly in the relatively flat Wallaby Creek catchment—including the scrub as well as young and Big Ash areas. Fig. 8 represents the area where stumps have escaped the worst of the subsequent fires, and, therefore, only indicates the minimum area over which splitters must have operated. As yet, no stumps have been found on the south fall, where extraction on steep slopes would have been more difficult. Splitters tested likely trees by examining the fissility of a test chip from the butt, and although the splitting qualities of this part of the tree are generally poor they were taken as an indication of the value of the tree as a whole. The remains of these axe marks are still preserved on lightly charred, brown-rotted stumps as well as in butt scars on living trees in the Big Ash forest. Discarded segments of logs have also been preserved where they have been colonised by brown rot fungi. Only a small percentage of stumps show board marks because the spring board technique which developed in America did not replace the scaffolding method until about 1872. Studies of stump densities in the Big Ash forest at Wallaby Creek indicate that between 2.4 and 7.4 trees ha^{-1} were taken by paling splitters, which, on the average, is equivalent to a removal of <7.4% of the timber. Evidence in the Royal Commission Report is somewhat exaggerated in regard to growth rate of trees, and the number of trees extracted.

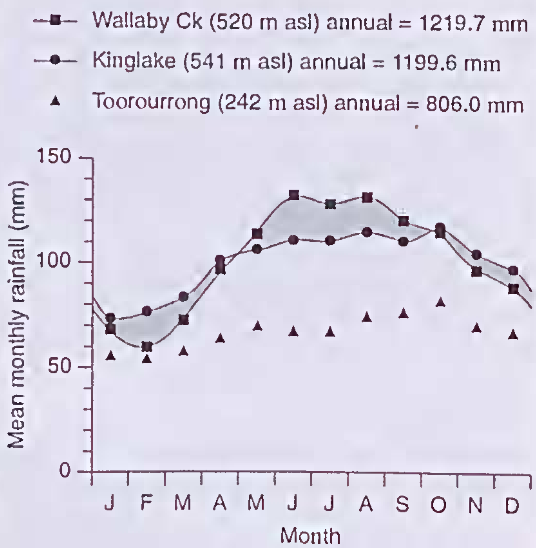


Fig. 10. Mean monthly rainfalls for Wallaby House, Toorourrong Reservoir and Kinglake Central, illustrating the seasonal differences north and south of the Divide.

*Blue Gum is not indigenous to this area, probably planted *c.* 1882.

Fig. 11. Cold front cloud on the top of the southern scarp of the range in spring.

Fig. 12. Layered mist on a late winter evening, *Poa ensiformis* frost hollow, Wallaby Creek, 1951.

It was stated that one tree was left per 58 m^2 (= 170 trees per ha^{-1}), and that the trees removed were 150–160 ft (45–50 m) high, with a diameter of 8 ft (2.5 m) breast height. Cut logs and sections of logs found beside the cut stump supports the claim that splitters often only used part (20–25%) of the timber which they felled. Regrowth of timber and scrub is reported to have followed this thinning of the forest, and the clear cutting of ten acres on the ridge near Yorktown. It does not mention, however, whether fire was used in these clearing and partial felling operations. Long parallel furrows, which appear to be the remains of the old access tracks for bullock carts of this period, are still discernible along parts of the Toorourrong and Yorktown ridges.

In 1871 a timber reserve was proclaimed on the south side of the range to reduce the pollution of the water supply and the muddiness caused in the streams and reservoirs by logging and hauling operations. In 1873 the timber reserve was extended two miles on the north side of the range, taking in part of the Wallaby Creek catchment. Paling splitting was prohibited in this part of the Hume Range from this date, although a certain amount of illicit logging went on at Yorktown and Mt Disappointment until 1881. The industry, however, continued in the Sunday Creek catchment and other parts of the range until about 1920. The water channel to the Wallaby Creek was built in 1883 (Fig. 9), and extended 3 years later to the Silver Creek, thus augmenting the Plenty River supply that had served Melbourne since the completion of Yan Yean system in 1854–57.

For the next 30 years little detailed information is available about this region although a certain amount of bullock grazing in the Wallaby Creek catchment was carried out by timber cutters from further west. This area is well remembered by Mr J. Lorenz of Whittlesea (pers. comm.), who described it as being occupied by magnificent big mountain ash forest, under which there were large areas of hazel, wire grass, mountain oats and fern. Grazing was confined to the mountain oat and wire grass areas. This forest existed, where today there are large tracts of bracken and scrub.

Reports from the Wallaby House Visitor's Book by Mr W. Davidson in 1870–90 (anon.) described a fine forest of mountain ash along the channel between Wallaby House and the Cascades, where dense honeysuckle (*Correa lawrenciana*?) and hazel scrub, tree ferns, wattle and sassafras were to be found. Today, this area is largely occupied by scrub, bracken, exotic conifer plantations and stands of mountain ash and messmate regeneration. Sassafras is absent or extremely rare in the gullies in the area referred to. Other reports by Mr Davidson refer to the big bushfire in 1898. On the 14 January 1898 he writes: 'We visited the works, unfortunately just three days too late. Have witnessed the desolation arising from the most extensive bushfire within our experience.'

This fire was also remembered by Mr J. Lorenz (pers. comm.), who describes it as one of the largest and hottest fires that he had ever seen. It was fanned by a fierce NW wind and burnt through the entire range, and swept as far as Steele's Creek near Yarra Glen. That year, like 1851, was a bad fire year, and many areas throughout the State, including most of Gippsland (Red Tuesday), were burnt out. This fire either missed, or burnt as a ground fire, through several areas, including the Big Ash and patches of tall Ash that grew along the channel in 1903. Evidence from ring counts and tree form suggests that a large part of the Intermediate Class Spar Ash forest of the Plenty River headwaters arose as an even aged regeneration following this fire.

Information from Mr J. Giddens of South Morang, substantiated by several other early employees of the Melbourne & Metropolitan Board of Works (MMBW—now called Melbourne Water), indicate that there were two subsequent fires, one in 1905 and the other in 1908. The former is mentioned in the Wallaby House Visitor's Book.

Fig. 13. Estimated monthly air temperatures on the plateau and in the mature forest, in comparison with those of Melbourne.

These fires bore down on Wallaby House from the Silver Creek area to the N and NW, and burnt into the Wallaby Creek headwaters and down past the Cascades. The 1908 fire originated at Wallan and burnt to Mt Disappointment before travelling to the Silver Creek area. It finally burnt out pine plantations at Toorourrong and travelled as far east as Howat's Lookout south of Kinglake, where it was put out by a severe thunderstorm. These fires were apparently not as severe as that which occurred in 1898.

At this time a flourishing area of wild oats (*Dryopoa dives*), known locally as 'the wild oats country', occurred from the Wallaby Bridge area to Flat Rock and the Sunday Creek, and within the Water Reserve a good deal of illegal bullock and sheep grazing was carried out. This area was repeatedly burnt, mostly by small fires, to stimulate the growth of the grass, which tends to die out after 3–4 years. Many of these fires burnt out of control accidentally, or deliberately, and some swept into the Wallaby Creek area and down the Mt

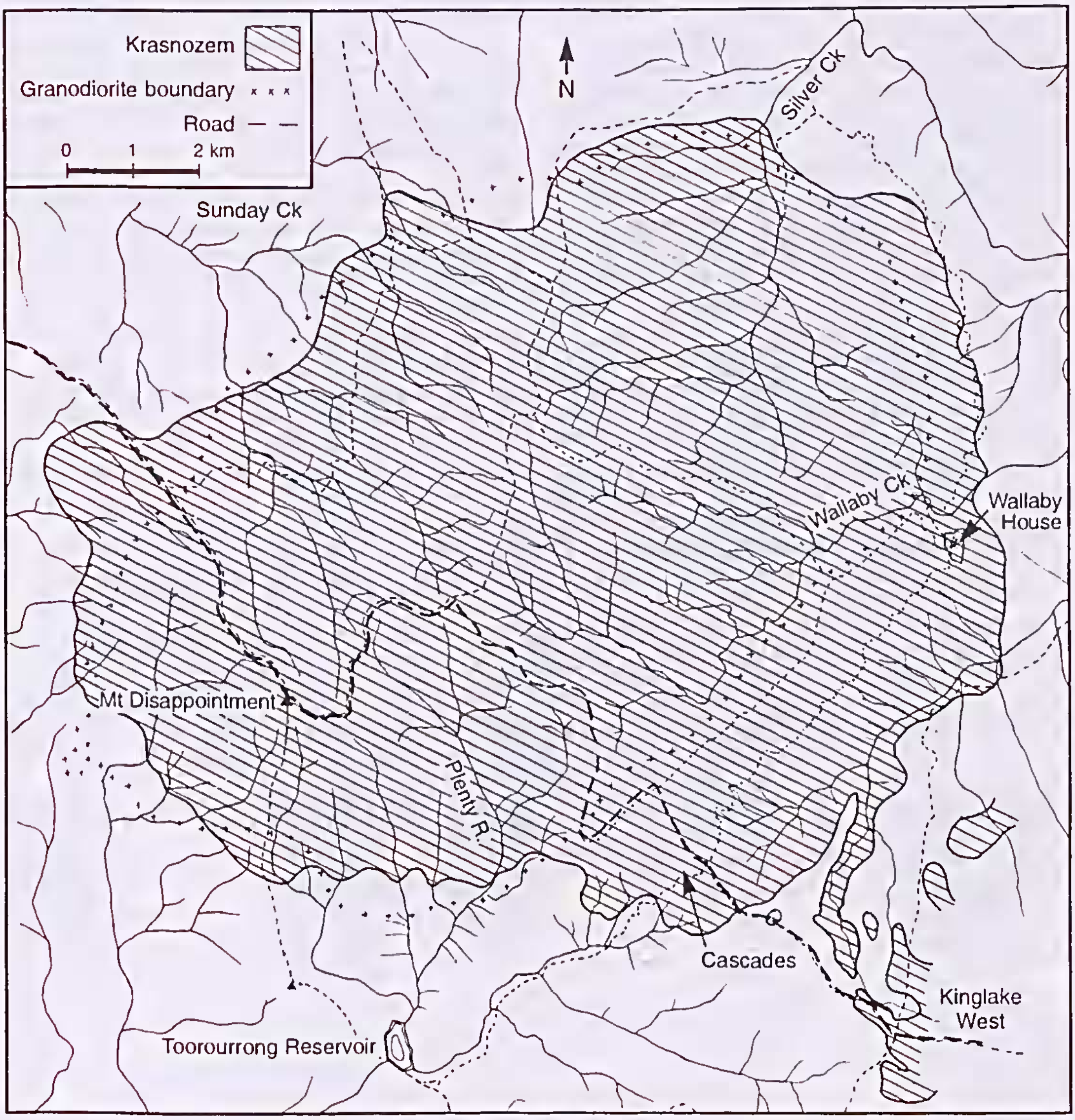


Fig. 14. Map of krasnozem distribution on the Hume Range.

Disappointment–Flat Rock ridge to Bruce's Creek and Upper Plenty. One old resident (anon.) remembers fattening a team of bullocks on the Wallaby Creek area in 1915 on a luxuriant growth of 'oats' (*Dryopoa dives*) that had followed a fire the year before. A fire in 1914 was also reported from Wallaby House and Kinglake West.

A further fire occurred in the south-west of the area in 1919 at and below Mt Disappointment, where it burnt in from the Wallan district and crossed the MMBW firebreak between One Tree Hill and Mt Disappointment and penetrated a short distance (A. Blair, pers. comm.). The bracken areas on the south face of Mt Disappointment are said to have originated after this fire, when young Ash regeneration following the 1908 fire was destroyed. It is probable that the large areas of scrub and bracken in the Wallaby Creek Catchment are due to the succession of fires which occurred around the turn of the century.

A major fire occurred in February 1926, at the end of a very dry season. This fire started in the Flowerdale district, and burnt in on a strong NE wind, the two arms of the fire converging on the Wallaby Creek Catchment. It then burnt past the Cascades to Toorourrong and the Whittlesea Road, before a cool south wind change arrived and blew the fire into the Big Ash country where it was put out by rain. It is certain that one arm of the fire burnt on towards the Mt Disappointment area and into the Sunday Creek Catchment before this change occurred. The limit of the ground fire in 1926 was mapped in the mature Ash forest where about 600 ha of *Pomaderris* understorey remained unburnt (Ashton 2000a). Thus every fire in the last 100 years has either bypassed or burnt as a surface fire through the central area of mature Mountain Ash, although it is probable that its overall area was reduced with each successive fire. A great many of the fires have travelled down the flank of the ridge between the Wallaby Creek and the Cascades. It is possible that with the initial devastation of early fires bracken and drier types of scrub, such as *Cassinia*, developed which could carry and, to a certain extent, direct the subsequent fires. Without doubt the plethora of fires in the early decades and this century were responsible for considerable deforestation on the plateau, although some areas in the Wallaby–Poley Creek divide and south of Yorktown Hill at the top of the Toorourrong spur, may have been due to clearing for settlements and associated fires (W. Ferguson 1882, in Seeger 1948–49).

The fire in December 1938 like many of the previous fires, began in the Wallan–Wandong area and burnt along the south side of the range. It burnt with great speed and cut a swathe through the forest 0.8–1.2 km wide over One Tree Hill, jumped the Plenty Valley and burnt on to the Cascades. The following day the fire spread out

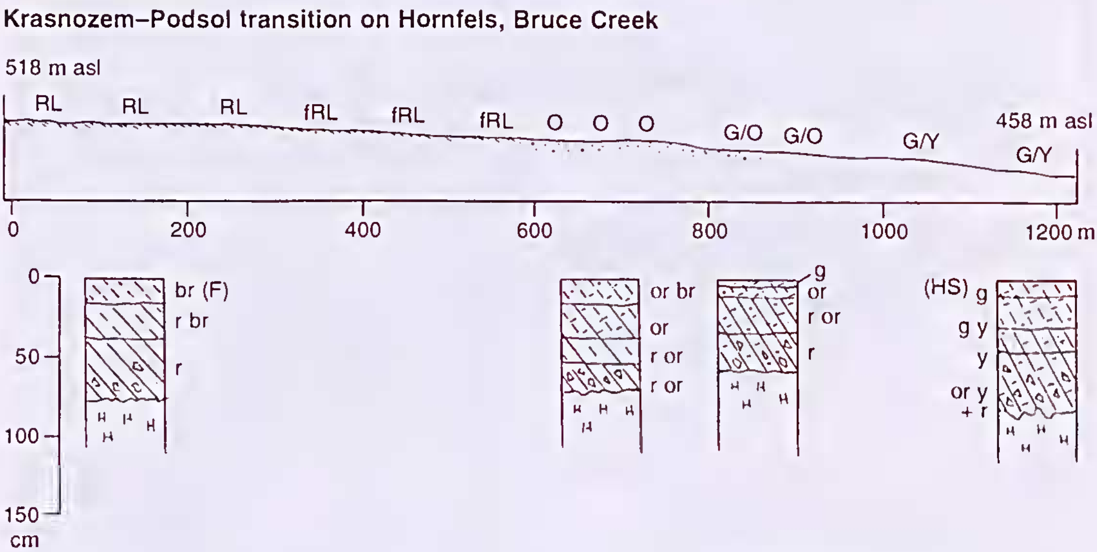


Fig. 15. Soil profile changes from krasnozem to podzol through a zone of micropodzol on hornfels parent material SW of Mt Disappointment. RL = red loam; f = fine structured; O = orange; Y = yellow; G = grey.

in the bracken and scrub areas above the Cascades and below the Big Ash, and was finally put out along the channel 1.6 km north-east of the Cascades. It burnt in small tongues up to the top of the ridge, and into the foot track entrance in the bracken and scrub areas, but died out wherever it penetrated young or mature Ash stands. All reports are unanimous in stating that the fire never crossed the fire break at the top of the ridge. Butt scars are present in some stands of 1926 regeneration, which are probably the result of very low intensity creeping fires in 1938.

A severe fire in November 1982 burnt from Wallan ESE to Mt Disappointment then was swept to the NE by a gale-force cool change. It crown-fired on the ridges at night and killed much young forest of *E. regnans* on the western edge of the Wallaby Creek catchment and killed or damaged extensive stands in the Silver Creek Catchment. It was controlled and extinguished one day later at Flowerdale and Kinglake North.

The recent fire and land use history of this region is, therefore, complex. Recurrent bushfires of various and varying intensities have occurred in many parts of the reserve from 1851 to 1982, which have burnt some areas repeatedly and severely, and left other parts practically untouched. This complex of burning and logging, together with the regeneration of the inter-fire periods, has resulted in the development of a complex patchwork of vegetation types in the Mountain Ash area and multi-aged forests in lower slopes and foothills.

Climate

The regional climate of central southern Victoria is cool and temperate, and approximately fits the mesothermal subhumid type of Thornthwaite (1931). On the ranges, however, a great many different microclimates exist due to both diverse topography and vegetation. With the exception of rainfall, the measured components of the climate are few in this region, hence data from Melbourne and other localities have, with certain reservations, been used.

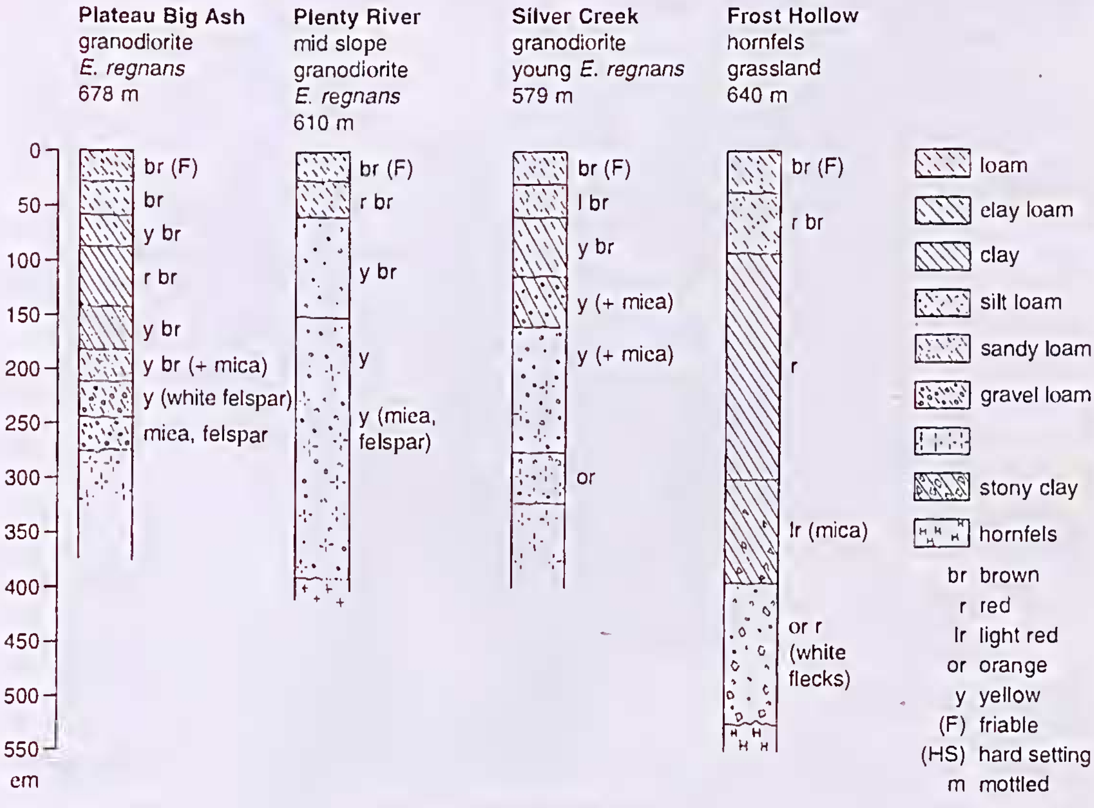


Fig. 16. Variation of krasnozemic profiles across the Hume Range.

Rainfall. Rainfall on the Hume Plateau was recorded by Brookes (1950) during 1949–50 and subsequent records have been taken on the plateau and in the forests. Rainfall figures are obtainable from Wallaby House at 518 m and Pheasant Creek (Kinglake) at 527 m, for more than 60 years, and show average rainfalls of 1209 mm and 1230 mm, respectively. Both these stations are located in messmate areas where mountain ash, if present, is strictly riparian. The average monthly rainfalls of these stations show important differences. Wallaby Creek 8 km north of the Great Divide shows a decided June maximum and is typical of stations in central Victoria north of the divide, western Victoria, Bass Strait and Tasmania. At Kinglake on the Great Divide the rainfall is evenly distributed throughout the year and exceeds that of Wallaby Creek in the late spring, summer and early autumn (Fig. 10). The relatively even distribution of rainfall and the spring–autumn maxima type are found south of the divide in central Victoria and eastwards to the Tasman Sea (RAAF 1944). On the Hume Plateau, the rainfall data from 1949 to 1957 showed an even distribution with a slight winter maximum. On the ranges and to the south of them much rain comes from the SW–W quarters due to Southern Ocean depressions and westerly cyclones. These winds which bring winter rains with frequent showers of light to moderate falls in southern Victoria tend to produce little rain more than 15–25 km north of the divide in this region. Considerable rain also comes from the N and NW during the winter due to northward migration of the low pressure systems and the arcuate course of the rain bearing winds from the Southern Ocean. This rain largely falls on and north of the divide. Hence, considerable areas in southern Victoria are in a relative rain shadow during the period that these winds are dominant. Rain has been observed falling at Wallaby House and clearing immediately south of the divide at Kinglake in July during a prolonged spell of cold north wind weather. Monsoonal troughs can be responsible for very heavy rain or periods of steady light rain

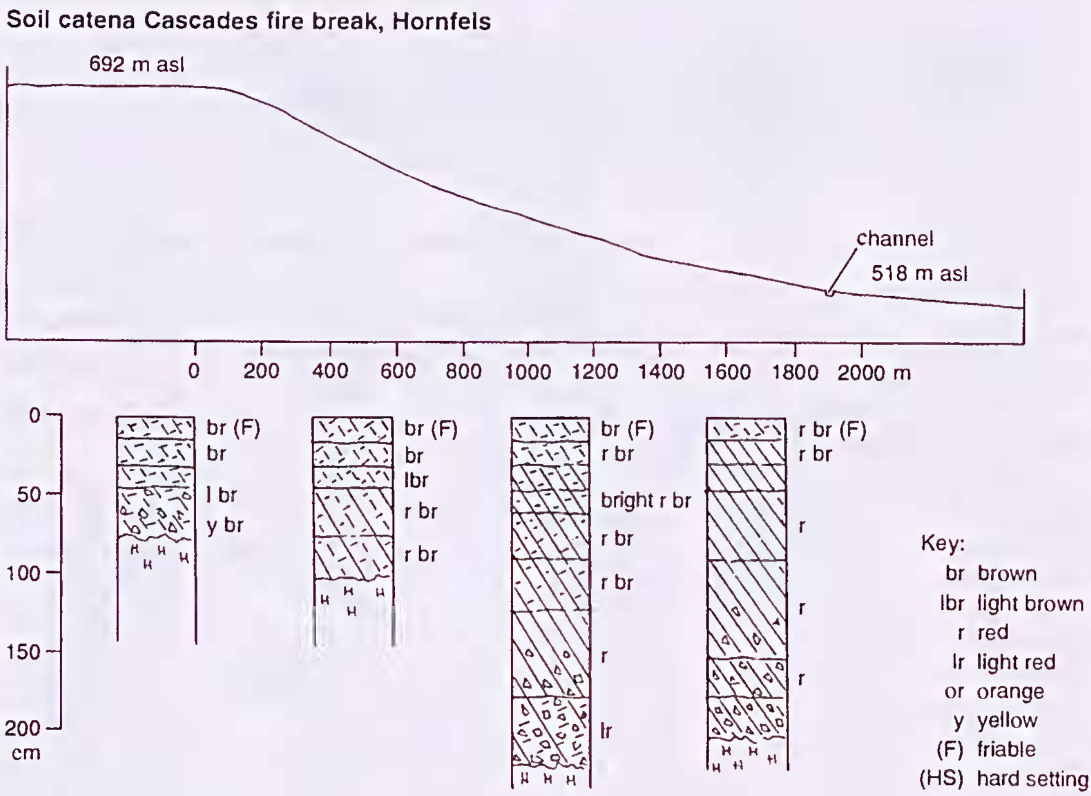


Fig. 17. Catenal variation of krasnozem profiles down the Great Divide from Yorktown Hill to the Cascades, Hume Range.

with E to SE winds. These troughs may occur at any time during the year but are most conspicuous in late summer. Periods of drought causing stress of vegetation may occur in the summer months from January to March.

The coefficient of variation of annual rainfall is 22.2% for Wallaby Creek and 20.8% for Kinglake. At higher elevations, the variability of the rainfall during the summer months is likely to be less due to orographic rains and the low cloud. In the severe droughts of 1938–40, 1967–68, 1982–83 and 1996–97 when rainfall was 50% of average, many trees and shrubs died on areas of shallow rocky soil, such as at Nimmo Falls. The most damaging conditions followed years when deficient winter rainfall deprived deeper subsoil of moisture replenishment.

The mean annual rainfall as well as seasonality of it is likely to vary across the Hume Plateau. Rainfall measured in a small bracken area at the entrance of the Big Ash from 1949–57 suggested that the mean for this site on the southern edge of the plateau at 670 m would be 1295 mm, if the Wallaby House records for this period are compared with the long term average. The relationship between altitude and long term mean annual rainfall differs with direction from the Hume Range. Thus on the basis of regression lines, the increase in rainfall for the western stations is 108 mm/100 m and for the eastern stations is 158 mm/100 m. On this basis the Hume Plateau (610-716 m) could have a mean annual rainfall between 1371 mm and 1524 mm. Personal observations suggest that the quality as well as the quantity of rain varies over

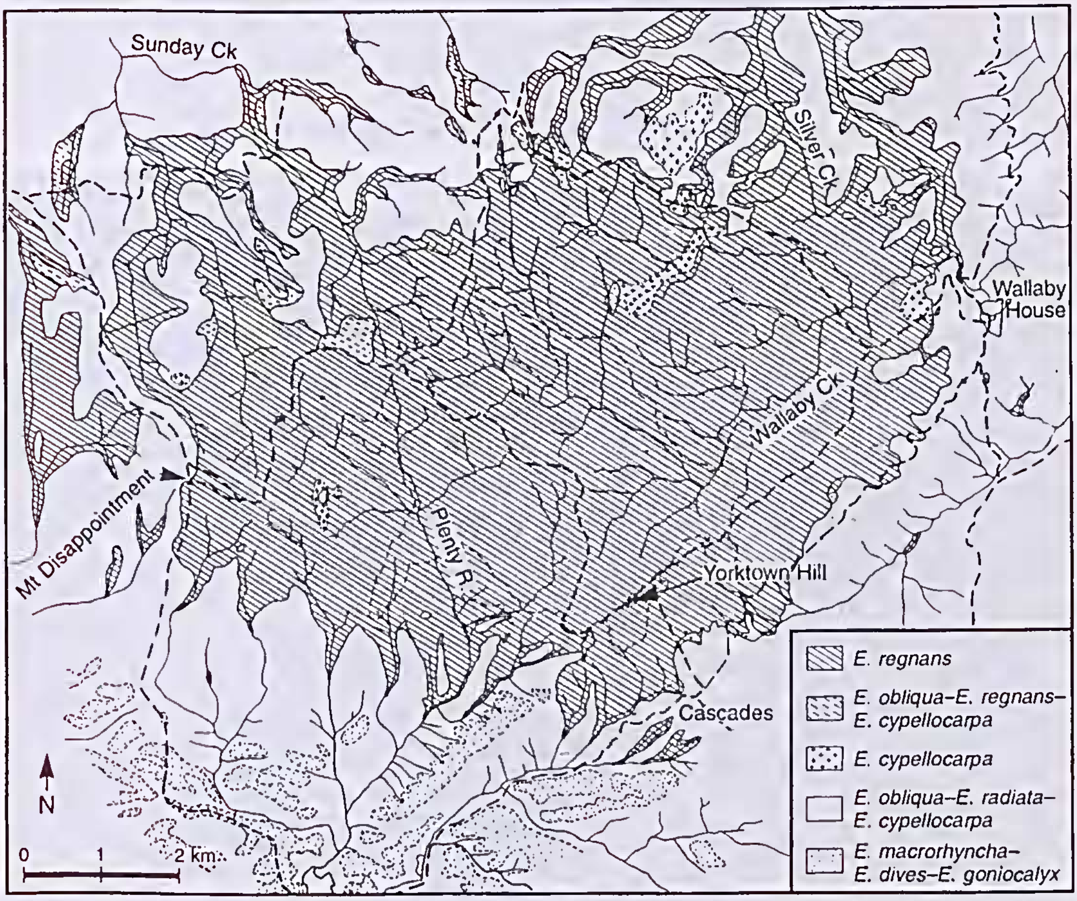


Fig. 18. Map of the distribution of *E. regnans* on the Hume Range.

the Hume Range. Rain occurs more frequently and showers persist longer on the Great Divide which constitutes the southern edge of the plateau. The relatively high winter rainfall of the Hume Plateau result from its elevation and its geographic relationship to the rain-bearing north-westerly winds as well as the south-westerly winds not intercepted by the Otway Ranges.

Fog, mist and cloud. In southern Victoria cloud cover is a maximum in winter and a minimum in summer. Fog from low temperature inversions may develop on flat or low lying terrain on the Hume and Kinglake plateaux on cold evenings, however the commonest source of fog on the Hume Range is due to the interception of low cloud by the mountains. Cloud bases of cold frontal systems commonly condense between 460 and 520 m in south central Victoria (RAAF, 1944). The Dividing Range is frequently fog-bound under these conditions in winter for 4–5 days per month. The cloud base impinging on the Hume Range often does so at an angle of 5–10°, thus fog may be intense in the Big Ash forest on the Divide whilst the northern part of the plateau at the same altitude is clear of it (Fig 11).

Since most of the mountain ash area lies above the 520–550 m contour it is often subjected to foggy conditions. Brookes (1950) stressed the importance of fog drip as a source of moisture in the Wallaby Creek catchment, and estimated that condensation of the fog on the vertically disposed leaves of the mature *E. regnans* canopy forest amounted to an additional 178–228 mm per year. When no rain follows cool changes in summer such fog drip may ameliorate the environment inside the forest. On 10 March 1950, the entire litter layer in the Big Ash forest was saturated by 24 h of fog drip. The percentage water of litter rose from 20% to 200% (ODW), whereas that of the topsoil (0–10 cm) only increased from 25% to 30% (ODW). It has been estimated that the litter layer in this forest would require 5 mm of rain for such saturation.

Snow. Almost every year some snow occurs on the Hume Ranges. Generally a few light falls, to depths of 50–75 mm, occur every few years at Wallaby House. Over three years in this area, the following falls were noted: 1949, 2 falls (1 heavy, 1 light fall); 1950, nil; 1951, 3 falls (1 very heavy, 1 moderate, 1 light). Snow can occur in all months

Fig. 19. Dry sclerophyll forest (*E. dives*, *E. goniocalyx* and *E. macrorhyncha* with *Xanthorrhoea australis*) on the Toorourrong ridge.

Fig. 20. Dry sclerophyll forest of *E. macrorhyncha* with a sparse understorey on a steep, stony NW slope.

Fig. 21. Grassy sclerophyll forest (*E. melliodora*, *E. goniocalyx* and *E. dives*), on deeper podzolic soil in the foothills near Toorourrong.

Fig. 22. Dry sclerophyll forest of *E. obliqua–E. radiata* with bracken and *Goodenia ovata* on podzolic soil in the foothills at the base of of the south fall, 1980.

Fig. 23. Damp sclerophyll forest of multi-aged *E. obliqua*, *E. cypellocarpa* and *E. radiata* on krasnozem soil near the Cascades.

from April to December. Conditions conducive to falls of snow are those caused by deep inverted V depressions moving up rapidly from the Southern Ocean when cold N–NW winds are followed by squally S–SW winds. On 19 July 1951 and 9 August 1951 such conditions prevailed and heavy snow fell on the ranges and light snow in Melbourne. Snow accumulated to depths of 300–450 mm on the Hume Plateau and 150–175 mm at Wallaby House and resulted in heavy damage to the forests. Snowfalls at Kinglake similar to those of July 1951 occurred in 1912 and 1931.

Hail storms can occur during the autumn, winter and spring and are caused either by freezing updrafts in massive thundery cumulus clouds or by cold front condition similar to but not as severe as those producing snow.

Frost. Depending on the local topography and type of vegetation, radiation frost can occur on the Great Dividing Range in Central Victoria from March to December. The main areas of frost in this district are the Kinglake and Hume plateaux and the Whittlesea and Yan Yean flats. Foley (1945) divided Victoria into zones depending on the length of the frost-free period. This zone tends to follow the ranges and hills and the two-month, frost-free period area extends along the divide to Mt Disappointment and reoccurs in the western highlands. Temperature data were collected from studies of microclimate in the catchment area in 1950–85. Maximum–minimum thermometers were placed horizontally 5 cm above short herbaceous growth in grassy hollows and on bracken covered ridge tops, and in various types of forest. These records indicated that ground frosts occur in the grassland areas in every month of the year, although those occurring in the summer were light and sporadic. Very severe frosts occur during the winter in the grassy frost pockets where temperatures of −10 to −15°C were registered and bare soil commonly froze to depths of 1–4 cm. During successions of frosty nights and fine days needle ice 5–7 cm high may remain for many days in shaded and protected areas on the plateau. On the margins of frost hollows the foliage of *E. regnans* trees may be powdered with light frost to a height of about 15 m.

Minimum temperatures on the ridges were almost always 3–4°C higher than in the hollows. Only rarely did temperatures descend to freezing point under forest canopy and on those occasions were associated with a blanketing of heavy snow. Observations in the grassy hollows indicate that a layered mist of cold dense air can occur on frosty nights to a depth of 4–6 m over the grass swards in frost pockets and frost-plains on this plateau (Fig. 12). Although spring and autumn frosts are not usually as severe as those in mid winter, damage to vegetation may be greater due to the unhardened condition of foliage.

Air temperature. The air temperatures have been recorded from 1950–57 by maximum–minimum thermometers placed in wooden boxes open to the south. These were placed 1.2 m above the ground in the grassland frost hole, bracken ridges and in the young and mature mountain ash forest. They were read every 1–3 weeks. The absolute maximum and minimum for each month could, however, be obtained and compared with similar figures from Melbourne. Assuming that the ratio of the average monthly temperatures from the average of the absolute maximum and absolute minimum for each month in 1951–53 is approximately the same at Melbourne and the Hume Plateau, a correction can be applied to the Wallaby Creek data to give the average annual temperature (Fig. 13). For the frost

Fig. 24. Wet sclerophyll forest of *E. obliqua* with *Bedfordia arborescens*, upper Toorourrong ridge, south-east aspect.

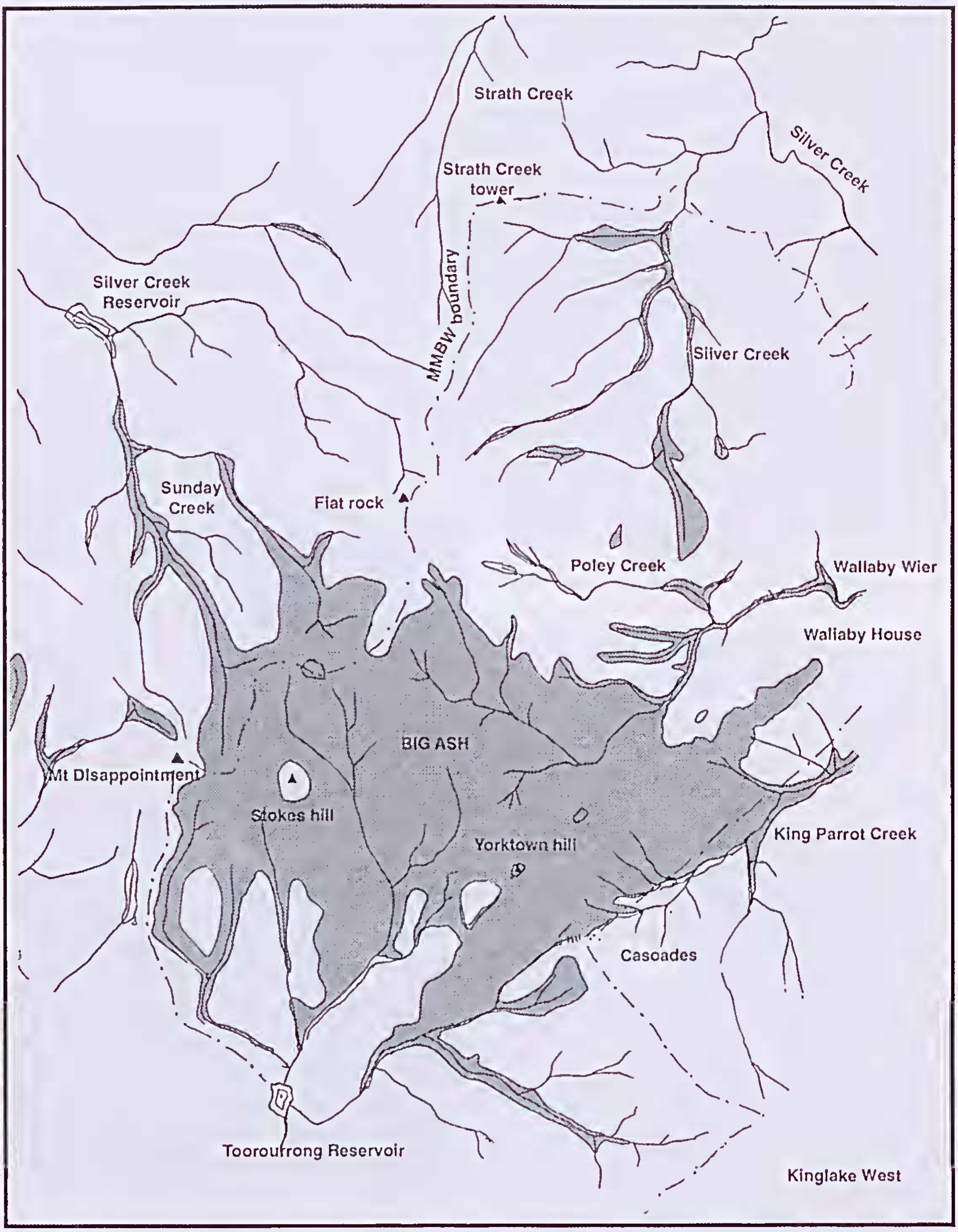


Fig. 25. Distribution of wet sclerophyll understorey on the Hume Range, 1980.

pocket this was estimated to be 10°C and for the mature mountain ash forest, 9.4°C. The amplitude of maximum and minimum temperatures was very much less in the mature forest than in exposed bracken or grassland sites. The mean annual temperature of numerous Victorian stations was plotted against the altitude and a regression line indicated that the temperature of this area would

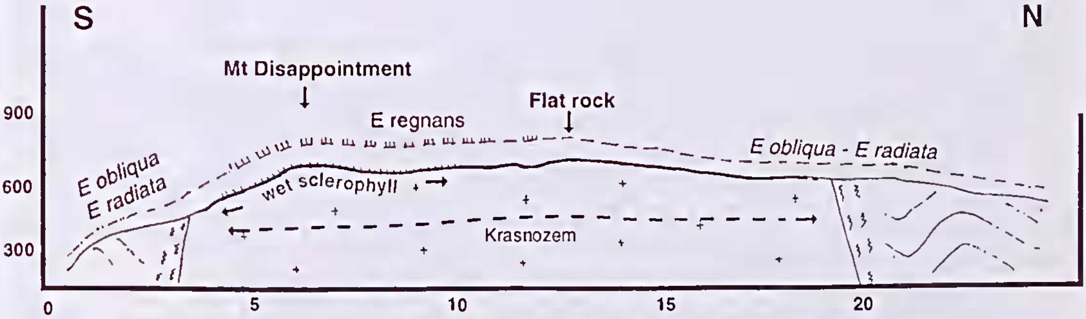


Fig. 26. Landform profile N–S across the Hume Range, showing limits of dominant tree species.

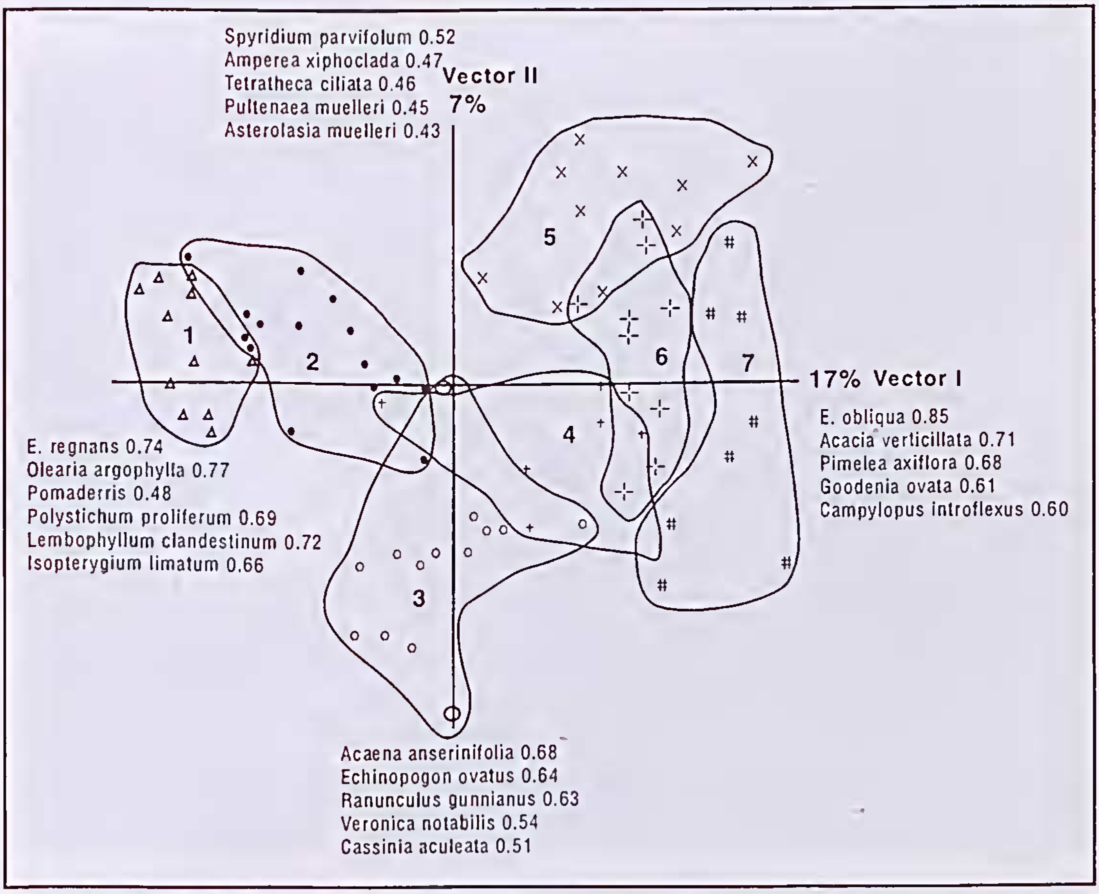


Fig. 27. Ordination of seven quadrat groups from five transects, north–south and east–west across the Hume Range.

be 11.4°C. The discrepancy of the frost hole temperature could well be due to the fact that the temperature was recorded from a site which was colder than normal for the area and indicates a fall of 1°C per 120–196 m increase in altitude. The maximum temperatures during the summer on the Hume Plateau vary from 4–6°C below those of Melbourne. The temperatures near the ground within the mature mountain ash forest were consistently lower than those of Melbourne and varied from 10–16°C lower in the summer to 7–8°C lower in the winter. On 24 January 1952 when the maximum air temperature in Melbourne was 43.7°C, it was 38°C on the frost hollow grassland (625 m a.s.l.) and only 33°C beneath the *Pomaderris* understorey of the Big Ash forest (686 m a.s.l). At Melbourne and the Wallaby Creek catchment, January and February are the hottest months and July and August the coldest months.

Wind. The winds in southern Victoria are largely controlled by the annual north–south migration of the high pressure belt from about 30°S to 40°S latitude. This results in the predominance of southerly winds in the summer and northerly winds in the winter. The seasonal winds of the districts south of the divide are reinforced in the summer by afternoon sea breezes and in the winter by katabatic nocturnal winds from the highlands. The stronger winds tend to be regional and less likely to be affected by local topography than the local winds. For the region September is usually the windiest month and May the calmest. Wallaby House is situated on a spur that is frequently protected from N, NW and W winds. A calm can be registered in this area whilst strong NW winds are blowing through the timber on the plateau. In the Big Ash the effect of vegetation on wind velocity is extremely marked. A gale in the crowns at heights of 75 m may be felt only as a gentle breeze at ground level which, in canopy gaps, may blow in a direction opposite to that in the canopy.

Fig. 28. Aerial mosaic of the Hume Range (1939), showing the central Big Ash area, the surrounding pattern of younger stands and the crescentic region of scrub, bracken and grassland—mainly on the plateau. Much of the non-forested area is now covered with young eucalypt plantations.

Fig. 29. The Big Ash stand 290 years old, with tall, 30-year-old wet sclerophyll understorey of *Olearia argophylla*, *O. lirata* and *Bedfordia arborecens.*

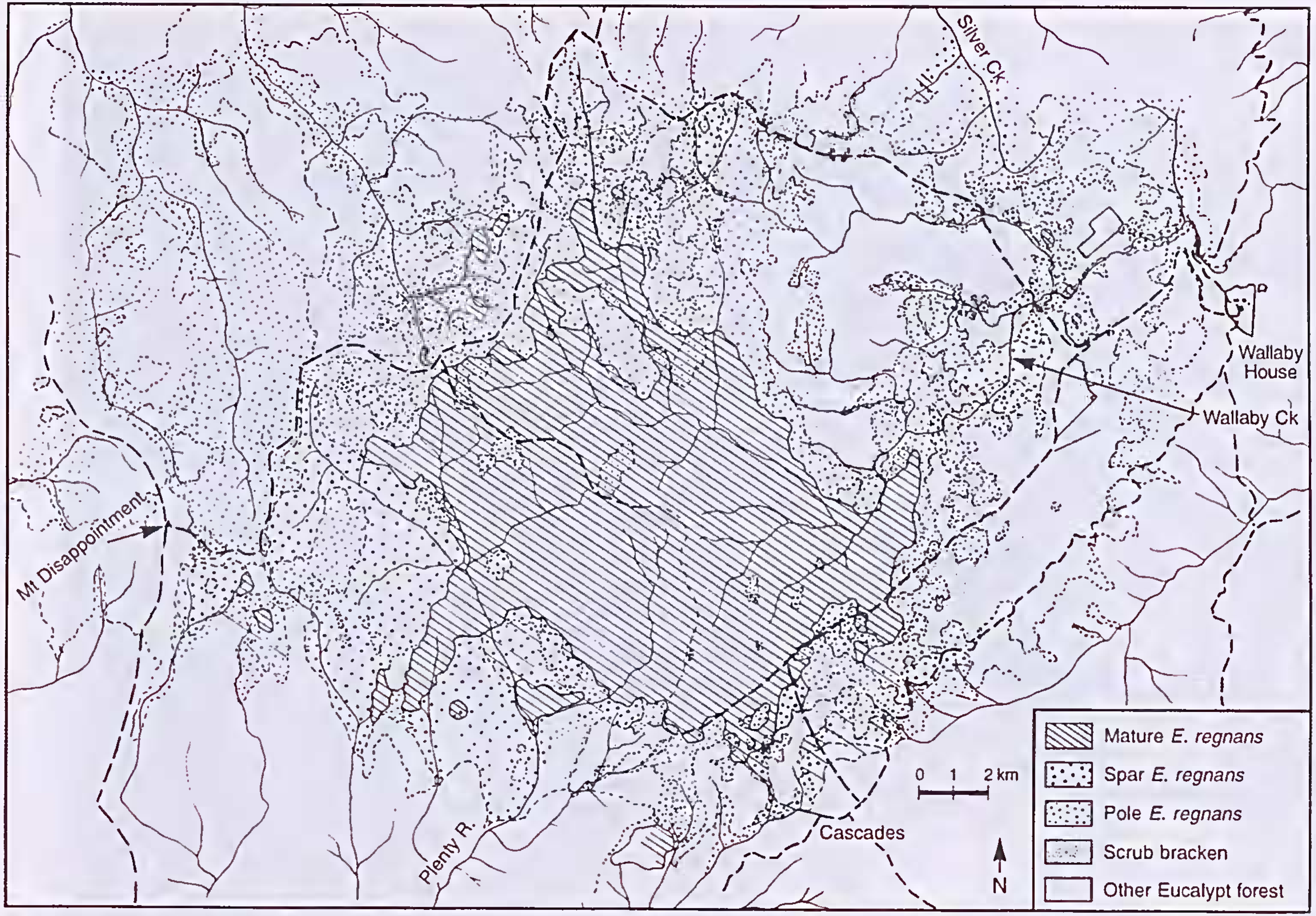


Fig. 30. Map of the distribution of the mature, intermediate and pole stage stands of *E. regnans* and non-forest areas. Unless otherwise obvious, the cohorts of forest are mapped according to the predominant age class.

SOILS

Soil types

Soil types are primarily controlled by climate and topography and have been influenced by past environments and the age of the land surfaces. They are however, only modified texturally by the parent material. One of the striking features of the area is the change from poorly structured grey-yellow podsolised soils of the foothills to the strongly structured krasnozemic loams of the Kinglake and Hume plateaux (Fig. 14). The transition takes place in *E. obliqua–E. radiata* forests at an altitude of 400–500 m where the annual rainfall is about 1143 mm. The distribution is thus similar to that in the Dandenong Ranges (Clifford 1953). The transition may be abrupt over 20 m in the south or diffuse over a distance of up to 300–400 m in the north where the exact boundary is somewhat arbitrary. The change to podzol is first indicated in the topsoil by a loss of coarse crumb structure and a fading of color from red to orange and finally grey. The subsoil usually remains red well into the podzol zone but eventually changes through orange to yellow at lower altitudes. In some transitions south-west of Mt Disappointment (Fig. 15), the uppermost few centimetres are grey over a bright red to orange topsoil and subsoil, suggesting that 'micropodsolisation' of the red soils is taking place. On the Kinglake Plateau the transition zone is a mosaic of red and grey soils, some of the latter conspicuously occurring in depressions exhibiting poor drainage and supporting dense swards of *Lomandra longifolia* (Gill & Ashton 1971).

Krasnozemic soils. These are friable, red brown gradational soils (Northcote 1979) with high organic matter contents (15–20%) in the upper 20–30 cm. Typically, both clay content and color intensity increase with depth to at least 1–2 m. Below this depth, soil may grade into decomposed rock either through an increasing amount of rock fragments or through a zone of loamy gravel consisting of quartz, weathered feldspar and biotite on granodiorite or fine micaceous sand on hornfels.

Fig. 31. Pole stage *E. regnans* (1926 regeneration) with a wet sclerophyll understorey, dominated by *Olearia argophylla* and *Pomaderris aspera*.

In these sites decomposed rock, which retains the fabric of the original parent material, may extend downwards for some metres. The depth of soil profiles vary from 0.3–0.4 m on the tops of rocky hills or ridges to 3.5–5.5 m on the flat, stable terrain of the plateau. Granitic parent material is indicated by the quantity of quartz gravel and coarse sand fractions in the topsoil and in the coarseness of the mica component at the base of the profile (Table 1).

E. regnans is confined to the krasnozem soil, however at higher altitudes the topsoil is brown and grades with depth to a red-brown or yellow-brown subsoil. On the steep slopes of the upper Plenty Valley organic-rich loams 40–50 cm deep occur over yellow gravels and decomposed rock fabric (Fig. 16). The impression obtained is that large blocks of granodiorite have decayed relatively quickly without the typical development of red clays in the subsoil. At lower altitudes in the *E. obliqua* forest zone the krasnozem is brighter red throughout, with somewhat lower organic matter contents.

The outstanding physical features of this soil include the high rate of water infiltration and its good aeration and water retention. On an oven dry weight basis the topsoil (0–15 cm) has a permanent wilting point of topsoil between 11% and 23%, a water holding capacity of 80–90% and a percentage disaggregation (using the wet sieve method) of 22–25%. Organic matter contents are relatively high (10–20%), although at the butts of old trees this may be as high as 56% (Ashton & Willis 1982).

The catenal variation in profile development downslope is indicated by a decrease in rock fragment and an increase in soil depth (Fig. 17).

A description of soil profiles on flat terrain under mature *E. regnans* on the Hume Plateau on granodiorite and mixed age *E. obliqua–E. cypellocarpa–E. radiata* on the Kinglake Plateau siltstones at the Cascades is given below:

Mature *E. regnans* on granodiorite, 685 m

0– 30 cm—dark brown coarsely friable loam
30– 60 cm—brown loam to light clay loam more finely structured
60– 90 cm—yellow-brown clay loam with patches of red-brown clay
90–145 cm—red-brown light clay, cloddy but well fractured
145–183 cm—pale yellow-brown gritty micaceous clay
183–213 cm—loose yellowish sandy loam with patches of reddish-brown sand loam and whitish crumbly rock fabric
213–244 cm—loose yellowish sandy loam with brown biotite and milky decomposed feldspars
244–274 cm—loamy gravel with mica and decomposed feldspar and quartz, some patches of both decomposed and firmly coherent granodiorite.

Mixed age *E. obliqua, E. cypellocarpa, E. radiata* on siltstones, 515 m a.s.l.

0– 15 cm—red-brown finely friable clay loam
15– 30 cm—red-brown clay loam with weaker structure

Depth (cm)	Parent material: Granodiorite					Hornfels				
	Organic matter (%)	CS	FS	S	Cl	Organic matter (%)	CS	FS	S	Cl
0–15	10.9	11.3	22.9	33.6	38.6	10.8	7.5	29.9	28.5	33.1
15–22.5	7.4	10.9	24.9	34.7	36.2	5.9	3.4	37.3	38.4	25.3
22.5–45	5.2	10.3	22.6	31.1	43.7	5.2	4.2	36.9	32.7	31.3
45–68	2.9	11.1	20.4	20.1	54.4	4.4	3.7	36.4	26.2	32.9
68–90	1.7	11.2	20.3	19.8	58.0	2.9	5.7	40.6	23.1	28.9
			Granodiorite Tors							
0–2.5	56.8	24.4	21.4	22.2	31.8					
			Fern Gully							
0–15	16.2	47.6	18.0	13.8	20.5					

Table 1. Particle size analysis of krasnozem profiles from granodiorite and hornfels areas on the Hume Range (% oven dry weights).

30– 45 cm—red-brown light clay, weak blocky structure
45– 91 cm—red clay, weak blocky structure
91–152 cm—red clay with patches of yellow-brown silty clay and weathered siltstone
152–198 cm—red to yellow-brown clay to silty clay with increasing abundance of siltstone.

Chemical analysis. Soils were collected in triplicate from four depths to 67.5 cm from 13 vegetation types on granodiorite and hornfels across the Hume Plateau and analysed by Soil Testing Laboratories, Dalgety and New Zealand Loan Ltd (1967) for pH, organic matter, $P_{(conc)}$ HCl extractable and 'available' extracted by 0.05 N H_2SO_4, N as NH_3 (Truog's method), and exchangeable cations (Ca, Mg, K) after treatment with ammonium acetate. Trace elements were extracted by ammonium acetate (Mn), 0.05 N H_2SO_4 (Fe, Zn) and EDTA (Cu) (Appendix 1).

The results indicated a highly significant decrease in nutrient concentration and organic matter content with increasing depth, except for Fe which tended to increase at the lowest levels in most profiles. The increase in nutrients in the topsoil is undoubtedly due to nutrient cycling (Attiwill & Leeper 1987). Ratios of nutrient concentrations of topsoil (0–7.6 cm) to subsoil (61–68.6 cm)

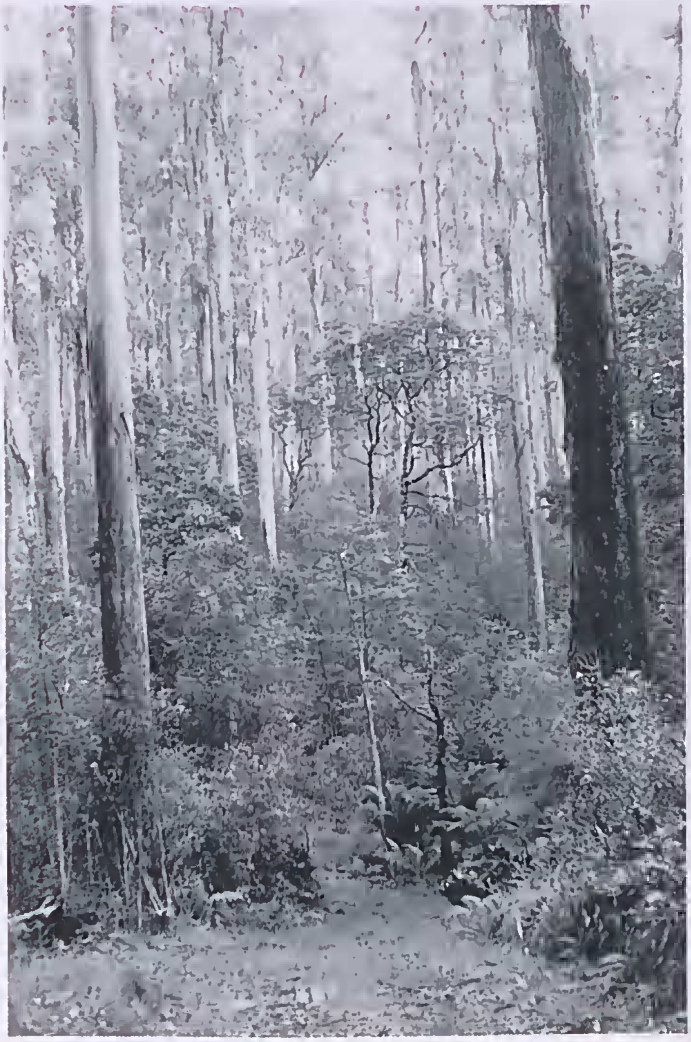


Fig. 32. Spar stage *E. regnans* on a steep, east aspect (Yorktown Hill area), a wet sclerophyll understorey of *Bedfordia arborescens* and *Olearia argophylla*.

could be called an 'index of accumulation'. This index ranges from 13.7 (Ca) to 9.7 (Mn), 7.5 (Mg), 7.3 (Zn), 5.0 (N, Cu), 3.5 (C), 3.0 (K), 1.5 (P HCl extract) and 0.7 (Fe). As was indicated in earlier work (Ashton 1975b), the concentration of Ca in the surface soils under *Pomaderris aspera* is marked in both scrub and young *E. regnans* forest on hornfels but is much less marked on granodiorite sites. Over all profiles there is little consistent difference between the nutrient status of soils on granodiorite and hornfels.

In general the nutrient status of soil in the mature forest is better than that of the dense young stands and fern gully rainforest on the same parent material. Organic matter concentrations in the topsoils of the fern gullies vary from near-peats on swampy flats to almost pure gravels on stream banks. The nutrient status (especially Ca) of grassland soil is in general, less than that of bracken soils derived from the same parent material, although both the values of N and P are similar. There was no significant correlation between HCl extractable and 'available' P in profiles from all sites ($r^2 = 0.12$). More sophisticated analyses designed to investigate availability of these two limiting elements was not done hence any interpretation must await appropriate correlations with growth responses of the major indigenous species.

Podsolised grey-brown soils in the foothills. These soils vary from silty loams formed on mudstones, sandstones or hornfels to coarse sandy or gravelly loams on granodiorite. They are characterised by their bleached topsoil and relatively poor structure. The parent material is reflected chiefly in the texture of the topsoil—especially in the amount of quartz gravel from granitic rock. There is frequently a sharp boundary to a yellow clayey subsoil which may lead to the development of buckshot gravel

Fig. 33. Spar stage *E. regnans* with a wet sclerophyll understorey of *Pomaderris aspera*, *Acacia melanoxylon* and *A. dealbata* on the south fall.

Fig. 34. Young shrub stratum of *Olearia argophylla* in 1980, under pole-stage *E. regnans* after the demise of *Cassinia aculeata* in the 1960s.

Fig. 35. Establishment of *Olearia argophylla* seedling (arrow) in the bracken understorey of a pole-stage *E. regnans* forest in a ridge top site.

as a result of intermittent waterlogging. Such water-logging occurs chiefly on gentler slopes at lower altitude and therefore in lower rainfall sites. Many of these soils can be termed duplex (Northcote 1979). These soils have relatively low organic matter contents and are liable to erode following disturbance. Hydrophobic soil conditions after fires may lead to sheet erosion or mud flows (Leitch et al. 1983).

Podolised soils occur as a complex of types which are best developed in the foothill country. On the hornfels and mudstones the silty loam podsol soil is similar to the Hallam Loam described by Holmes et al. (1940) in the Berwick district. On steep slopes, this soil type can be very stony and fits the embryonic soil division proposed by Nikivoroff (1948). Where granodiorite is present outside the Red Loam area, a grey gravelly to sandy loam soil occurs over a heavier subsoil which is similar to the Harkaway Sands south of the Dandenong Ranges (Clifford 1953). The podsol soils carry dry sclerophyll or grassy forests which vary greatly in floristic composition and are dominated by *E. obliqua–E. radiata* in more mesic sites and *E. melliodora*, *E. goniocalyx*, *E. dives* and *E. macrorhyncha* in more xeric sites. The presence of *E. cephalocarpa* on some lower slopes suggests seasonally waterlogged subsoils (Clifford 1953).

Fig. 36. Profile of a 50-year-old spar-stage stand of *E. regnans*, with moribund *Cassinia aculeata* invaded by *Pomaderris aspera*.

A typical profile in the foothills on siltstones is as follows:

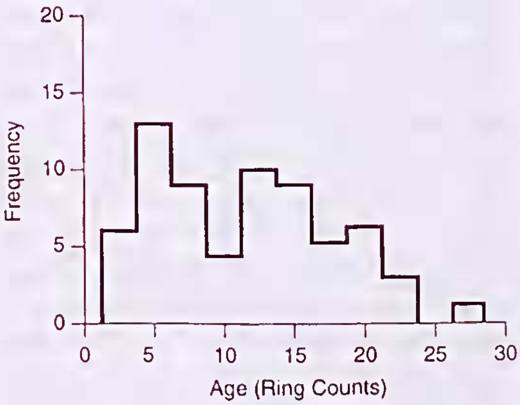


Fig. 37. Frequency distribution of ring counts of *Pomaderris aspera* invading senescent *Cassinia aculeata* understoreys of *E. regnans* forest.

0–10 cm—dark grey silty loam with weak crumb structure
10–30 cm—pale grey-brown silty loam with occasional buckshot gravel
30–60 cm—mottled yellow-brown silty clay with angular blocky structure
60–90 cm—mottled yellow-brown-red silty clay to decomposed siltstone.

Riparian soils of the Fern Gully and stream flats. The soils in the fern gullies vary from a colluvial red to brown loam in rocky gullies to a rather variable, organic sandy loam on gully flats. Generally the latter soils are moist throughout the year and during the winter the watertable may be at or close to the surface. Surface soil may therefore be peaty and subsoil gleyed with grey and orange mottled clays or gravelly loams. The burrows and casts of earthworms and the mud towers of land crabs (*Engaeus* sp.) are often conspicuous. The vegetation in these areas consists of tall scrub of *Leptospermum grandifolium* stands in swampy sites, and rainforest of Sassafras–Blackwood on somewhat better drained sites.

Fig. 38. Understorey succession in pole stage *E. regnans* forest near Yorktown Hill. The understorey of *Cassinia aculeata* and *Poa ensiformis* present in 1950 has given way to one of dense *Olearia argophylla–Lepidosperma elatius* in 1998.

A typical soil profile in the *Leptospermum* area is as follows:

0–30 cm—dark brown organic matter rich loam or sandy loam
30–45 cm—yellow-brown sandy clay loam
>45 cm—passes gradually into a yellow clay with sand in which mottling of grey and yellow can occur.

The watertable occurs at about this last level in summer but is at or very close to the soil surface in winter. The depth to the watertable can increase with distance from the stream, though local areas of standing water in old stream meanders may be found some distance away. Occasionally *E. regnans* trees can be found on restricted areas 0.5–1.5 m above the summer water table level.

The mechanical analysis of the topsoil 0–15 cm shows an extremely high coarse sand fraction (49.0%), and an organic matter content of 27%. The large amount of coarse sand in the profile is due to the complexity of stream deposition. These areas are subjected to local flooding following exceptionally heavy rains and sand and gravel can be deposited and concentrated with the removal of much of the finer material. This was observed in February 1950 along the upper Plenty River when a fall of 150 mm of rain over 3 days caused flooding and the deposition of 2.5–7.5 cm of sand over the original soil surface and moss mats. As a result of such periodic deposition near the stream course in this gully, the highest organic matter content may occur at depths between 5 and 15 cm. Increased runoff following the denudation of the slopes by repeated fires is likely to have increased accumulation in these gullies and augmented the normal processes of soil creep.

Downstream, at lower altitudes along the valley bottoms, alluvial flats have developed immature loamy to sandy loam topsoils. Wet sclerophyll forest occurs as a riparian strip and the flats may support grassy or bracken understoreys beneath *E. viminalis*.

Fig. 39. Understorey of bracken–*Poa ensiformis* understorey under pole-stage *E. regnans* adjacent to a frost hollow, Wallaby Creek. Occasional open grown trees of the original stand present. In the 1950s this understorey was almost entirely tussock grass.

Prehistory of a plateau swamp. In the swamp on the Poley Creek studied by Pittock (1989), alternating layers and lenses of coarse sand, clay and peat sediments occur from 0.55–2.0 m on the surface of weathered granodiorite. From C^{14} dates, a large lens of sand between 1.05 and 1.55 m, was deposited between 12 450 and 14 500 yr BP. Peat and sandy peat occupies the upper 55 cm of the deposit. Much of the early history of this deposit involved conditions of rapid erosion and accumulation and stream migration. The present peat conditions appear to be relatively recent and associated with a marked increase in the pollen from myrtaceous shrubs.

Pittock (1989) considers that before 14 450 yr BP, high inputs of grass, Restionaceae, Epacridaceae pollen and spores of *Lycopodium* in conjunction with low inputs of eucalypt pollen and fern spores, indicates the existence of 'alpine' conditions—possibly similar to present day snow gum environments. *Lycopodium* does not now occur on the Hume Range. The frost hollow site at Poley Creek is thought by Pittock to represent the lowest 'alpine' environment recorded in Victoria for the end of the last glaciation. The increase in eucalypt and *Tasmannia* suggests after this period an amelioration of climate, possibly similar to present day *E. delegatensis* forests. Wet sclerophyll forest taxa, indicated by the pollen of *Pomaderris* and spores of numerous fern species (especially *Dicksonia*), have increased since about 10 000 yr, whereas *Tasmannia* pollen has decreased markedly. Today, the latter species is rare in the wet forests on the Hume Range but common in montane wet forests at 1000 m altitude on Mt Macedon and Mt Donna Buang, 55 km to the west and south-east, respectivly. Grass pollen inputs have remained relatively low until the recent deforestation of nearby catchments 100–150 years ago. Thus the distribution of pollen taxa in this deposit suggest big changes of surrounding vegetation on the Hume Plateau during the Holocene period, implying considerable migrations of species.

Relationship of E. regnans *seedling growth to the quality of topsoils.* The growth of *E. regnans* seedlings on krasnozem and yellow-grey podzolic soil.—The growth of seedlings was studied under glasshouse conditions in Melbourne in 1952 using top soils (0–15 cm) from a range of plant communities on the Hume Range. These included krasnozem soils from granitic and hornfels and mudstone areas as well as podzolic soil from mudstone near the Cascades.

The dry weight of seedlings grown for 4 months in 12.5 cm diameter pots after 4 months (Table 2) indicated that krasnozem soil under *E. regnans* forests from granodiorite and hornfels was significantly better than krasnozem on mudstone areas from either *E. regnans* or *E. obliqua* forests. Growth on podzolic soil from *E. obliqua–E. radiata* forest however, was very much poorer than all other soils sampled, except subsoil (60–80 cm) from krasnozem on mudstones. The lower growth rates on krasnozem from *Poa ensiformis* grassland soil has been substantiated by later work (Ashton & Kelliher 1996).

Comparison of growth of *E. regnans* and *E. obliqua* seedlings on krasnozem and podzolic soils from mudstone areas.—In 1953 topsoils were collected from krasnozem in *E. regnans* forest and from both krasnozem and podzolic soil in *E. obliqua* forest. The soil structure on one-half of the podzolic soil collection was improved

Fig. 40. Damp sclerophyll understorey of *Coprosma quadrifida* in pole-stage *E. regnans* (1926 regeneration) in Silver Creek Catchment, 1990. The post-fire understorey components of *Cassinia aculeata*, *Acacia verticillata* and *Goodia lotifolia* died out in the 1960s.

by the application of krillium some days before sowing. The percentage disaggregation of krasnozem in *E. regnans* and *E. obliqua* forest was 48.0% and 51.5%, respectively. The value of 80.9% in podzolic soil was reduced to 49.1% by the addition of krillium. Plants were harvested after 3 months growth in the glasshouse.

The results confirmed those of the previous experiment since no significant difference occurred in dry weight of *E. regnans* occurred on krasnozem from *E. regnans* and *E. obliqua* forests. However, the growth of *E. obliqua* seedlings was markedly better ($p < 0.001$) in krasnozem soil from *E. regnans* forest than from *E. obliqua* forest (Table 3). Although the growth of *E. regnans* on the podsolised soil was significantly poorer than on the krasnozem soil, that of *E. obliqua* was not significantly different on these two soil types. The improvement of structure in podsolised soil had no significant effect on the growth of either *E. regnans* or *E. obliqua* seedlings. This difference in behaviour of the two species suggests that *E. obliqua* may be better able to utilise nutrient sources present in the podzol, whereas *E. regnans*

Soil type	Parent material	Vegetation	Seedling dry weight	Statistical significance
Krasnozem	Hornfels	*E. regnans* and *Pomaderris*	4.31	a
Krasnozem	Hornfels	*E. regnans*	5.39	a
Krasnozem	Granodiorite	*E. regnans*	5.21	a
Krasnozem	Mudstone	*E. regnans*	3.00	a b
Krasnozem (subsoil 1 m)	Mudstone	*E. regnans*	1.20	d
Krasnozem	Mudstone	*E. obliqua*	2.63	b e
Podzol	Mudstone	*E. obliqua*	0.89	f d

Table 2. Mean dry weight (g) of *E. regnans* seedlings in topsoils (0–15 cm) from a variety of communities on the Hume Range (12.5 cm diameter pots in glasshouse 10.xii.52–9.iv.53; n = 5). Those with same letters are not significantly different at $p \leq 0.05$.

Fig. 41. Dense pole-stage, 29-year-old *E. regnans* in the Wallaby Creek valley with an almost bare floor, 1955.

may be more nutrient demanding. The exclusion of *E. regnans* from the podzolic soils in the field in this region is likely to be due to the drier associated climate, however the lower nutrient status of podsolised soils may reduce the ability of *E. regnans* to compete successfully with *E. obliqua* and other eucalypts on those sites. Questions concerning factors controlling the boundary of *E. regnans* and *E. obliqua* have been discussed by Ashton (1981).

Growth on waterlogged krasnozem soil.—*E. regnans* avoids waterlogged soils and is only found in swamps where local areas rise slightly above the watertable. The reaction of seedlings at the 10-leaf stage to waterlogging to within 1–2 cm of the surface in porous pots 20 cm in diameter was studied for 45 weeks in a glasshouse in 1952. The mean height growth in waterlogged soil (21.2 cm) was less than half that in free-drained soil (46.6 cm). The experiment confirmed general field observations on the deleterious effects of waterlogging on *E. regnans* although the factors involved are likely to be numerous and complex especially those involving the stability of tall trees.

Seedlings	Forest	Soil type	Dry weight	Statistical significance
E. regnans	*E. regnans*	Krasnozem	3.04	a
E. regnans	*E. obliqua*	Krasnozem	2.46	a
E. regnans	*E. obliqua*	Podzol	0.77	b
E. regnans	*E. obliqua*	Podzol + krillium	0.97	b
E. obliqua	*E. regnans*	Krasnozem	3.60	a
E. obliqua	*E. obliqua*	Krasnozem	1.99	b
E. obliqua	*E. obliqua*	Podzol	2.28	d
E. obliqua	*E. obliqua*	Podzol + krillium	1.72	e

Table 3. Mean dry weight (g) of *E. regnans* and *E. obliqua* seedlings in soils (0–15 cm) from forests on mudstone, on the Hume Range (12.5 cm diameter pots in glasshouse 10.i.54–10.iv.54; n = 7–10). Krillium added to podzol soils to enhance soil structure to equal that of krasnozem. Same letters indicate no statistical difference at $p \leq 0.05$.

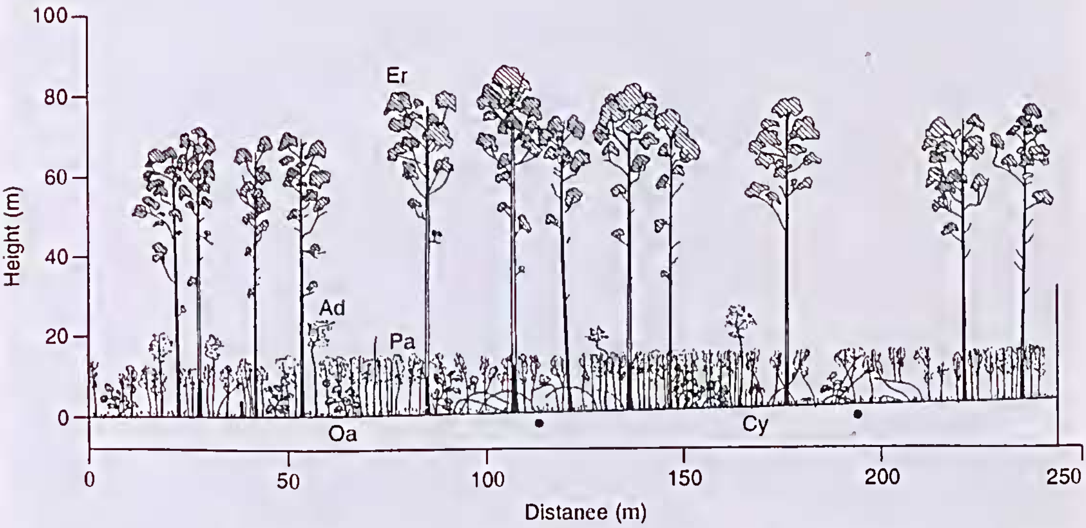


Fig. 42. Structure of the Big Ash on the plateau, profile showing areas of *Pomaderris* understorey bent and damaged by heavy snowfalls in 1951.

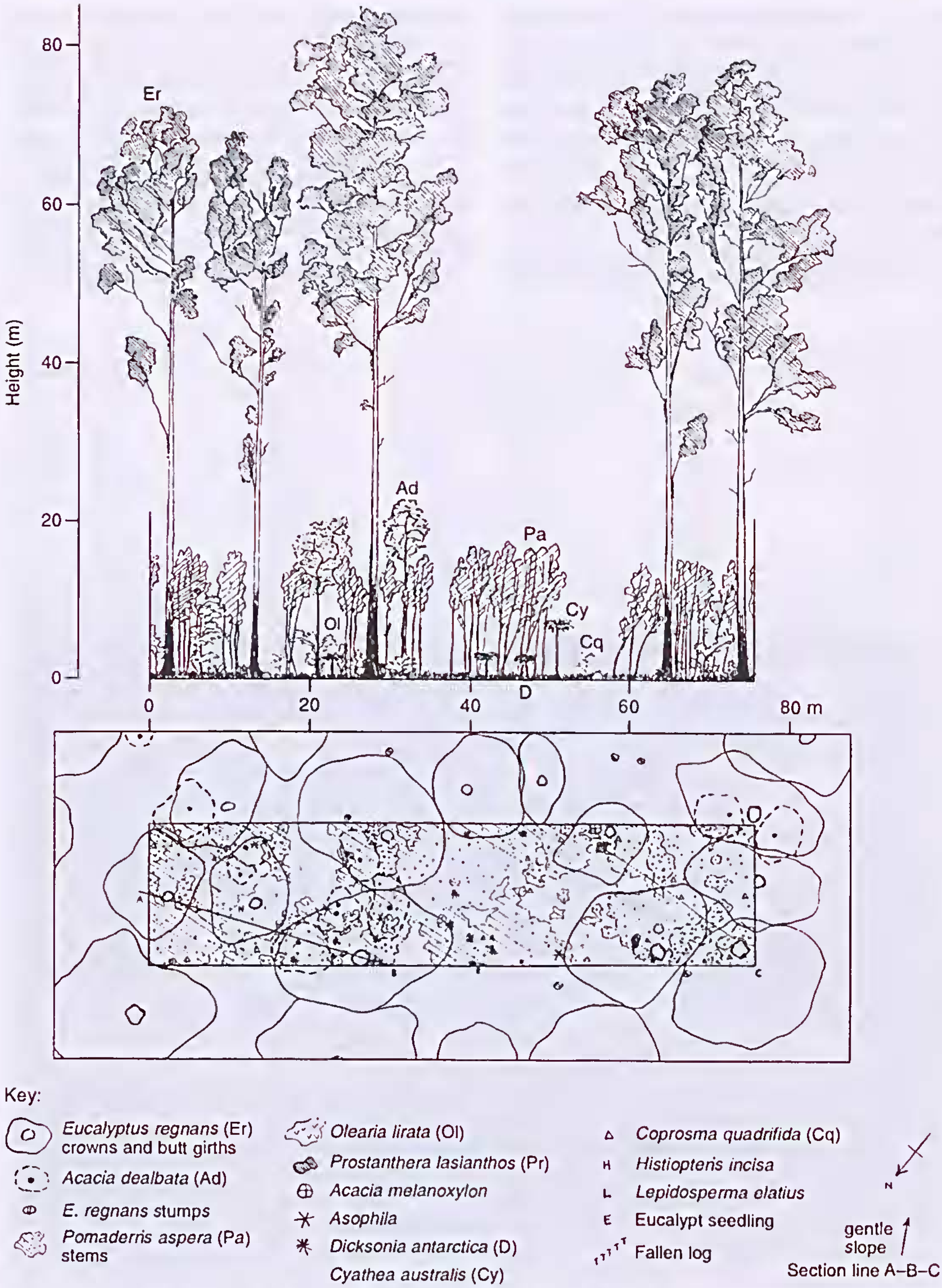


Fig. 43. Profile and plan of the mature *Pomaderris* understorey and Big Ash, 1949.

GENERAL VEGETATION

Floristics

The flora of the *E. regnans* and *E. obliqua* zones which occupy about 1500 km^2, is not particularly rich. The *E. regnans* area contains about 183 species of which 17% are introduced herbaceous species which occur mainly in disturbed, non-forested areas. The *E. obliqua* areas contain about 190 species of which 1 tree species, 23 shrub species, 4 fern species and 24 herbaceous species are common to to at least some of the *E. regnans* areas. Fern and monocotyledonous species are more prevalent in *E. regnans* forests, whilst dicotyledonous species are more prevalent in *E. obliqua* forests (Appendix 2).

Species usually found only in *E. regnans* areas include *Dicksonia antarctica*, filmy ferns, *Australina muelleri*, *Tasmannia lanceolata* and *Parsonsia brownii*—presumably because of their need for greater humidity, higher rainfall and more reliable soil moisture regime. Species in *E. obliqua* forest which do not enter *E. regnans* forests include *Epacris impressa*, *Stylidium graminifolium*, *Asterolasia astericophora*, *Drosera* spp. and most of the acacias and bush peas—presumably because of their inability to survive under the deeper shade of the taller understoreys.

Species which are confined to local areas include *Prostanthera melissifolia* found from Mt Disappointment north to Flat Rock as well as an outlier near the Wallaby Weir where it is associated with the rare *Pomaderris vacciniifolia*. *Olearia megalophylla*, which is normally found in *E. delegatensis* forests well to the east, is extremely rare in *E. obliqua* forest near Silver Creek Weir. *Tasmannia lanceolata* is found widely scattered in occasional gullies at higher altitudes (700 m), and *Baeckea utilis*, *Gymnoschoenus sphaerocephalus*, *Drosera binata*, *Almaleea subumbellata* and *Gleichenia microphylla* are found in an unusual community in local seepages on hornfels adjacent to the Nimmo Falls. *Ophioglossum lusitanicum* is found in the same area on seasonally wet granitic rock ledges. The rare saprophytic Burmanniaceae, *Thismia rodwayi*, was discovered in 1967 and 1980 in an uncharacteristically dry site of dense pole-stage stand of *E. regnans* on a rocky hornfels ridge.

Fig. 44. Photograph in riparian rainforest, four trees wide, of *Atherosperma moschatum* in the headwaters of Wallaby Creek, within the Big Ash forest area.

Fig. 45. Interior of *Atherosperma* forest, Big Ash Creek.

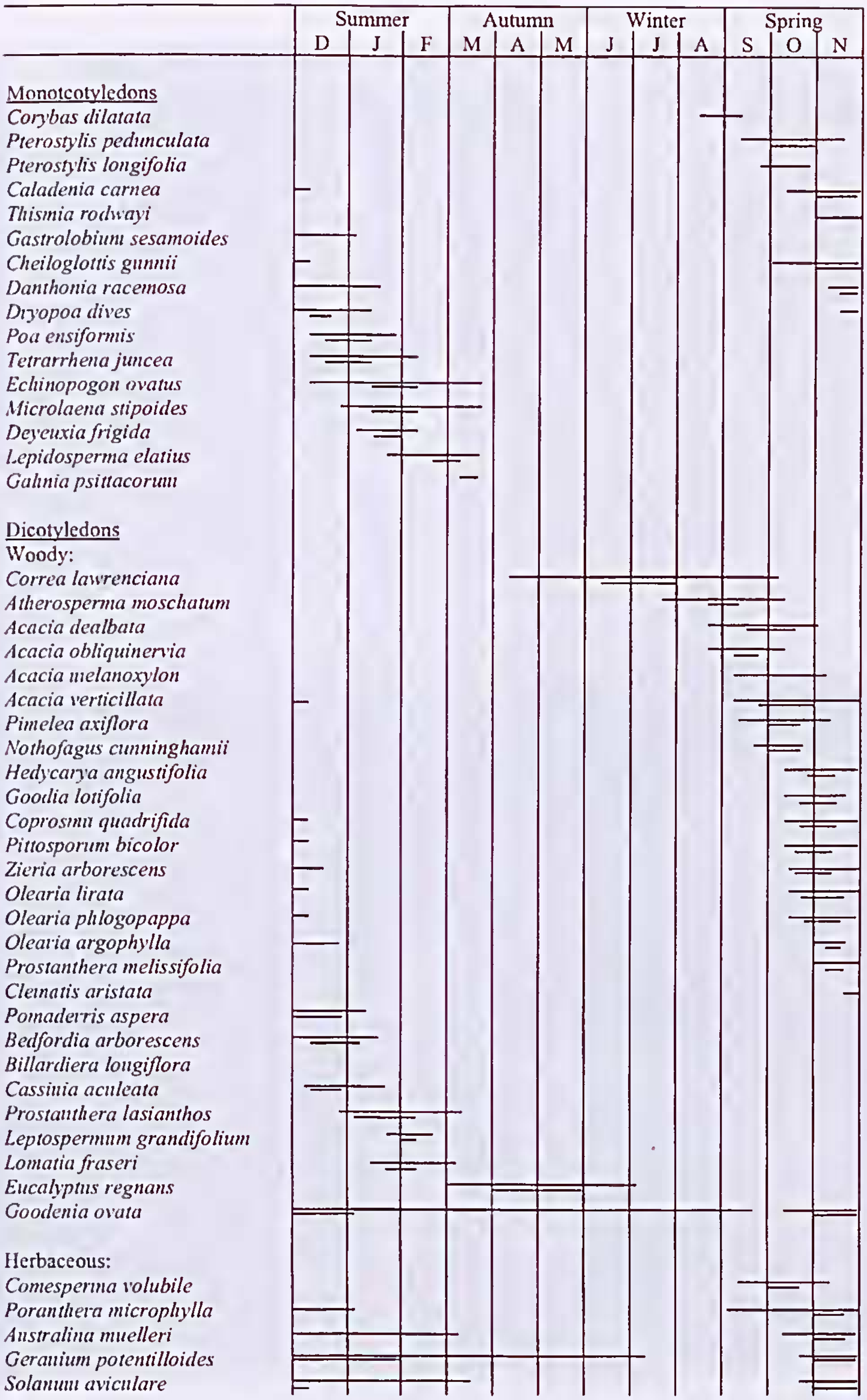
The explanation for the complementary distributions of *Acacia dealbata* and *A. melanoxylon* in the various catchments remains enigmatic. The former species is concentrated in the Wallaby Creek catchment whereas the latter species tends to occur widely to the north and south in the Silver Creek and Plenty River catchments. *Nothofagus cunninghamii* is evidently a relict extension of rainforest from further east on the Great Divide at Toolangi. It appears to be quite free of the associated gall-forming ascomycete, *Cyttaria gunnii*. Species which occur in wet forests to the east but not found so far on the Hume Range include *Pandorea pandorana*, *Persoonia arborea*, *Microrrhinum hexandrum*, *Phebalium bilobum*, *Eriostemon myoporoides*, *Rapanea howittiana*, *Sarcochilus australis* and *Fieldia australis*. In general terms, the vascular flora of the Hume Range (450 species) is somewhat poorer than the similar area of Dandenong Ranges (560 species; Clifford 1952) and the Toolangi–Healesville and Powelltown areas to the east.

Phenology

In *E. regnans* forests, November and December are the main months of flowering although many herbs and shrubs continue flowering until late summer or early autumn. Some acacias and orchids commence flowering in early spring and some sedges flower in early autumn. *E. regnans* is mainly an autumn-flowering species, whilst *Correa lawrenciana* and *Atherosperma moschatum* are unusual since they commence flowering in winter. *Goodenia ovata* on the other hand, flowers for most of the year, although its main activity occurs in late spring and early summer.

Both the time and duration of flowering are very variable between species (Table 4). Some of the local variation can be attributed to lower temperatures either as a response to increasing altitude or to the cold air drainage of frost hollows. A conspicuous delay of 4 weeks in the commencement of flowering occurs in the dominant understorey species *Pomaderris aspera*, *Olearia*

Fig. 46. Interior of *Nothofagus* forest along the Plenty River.



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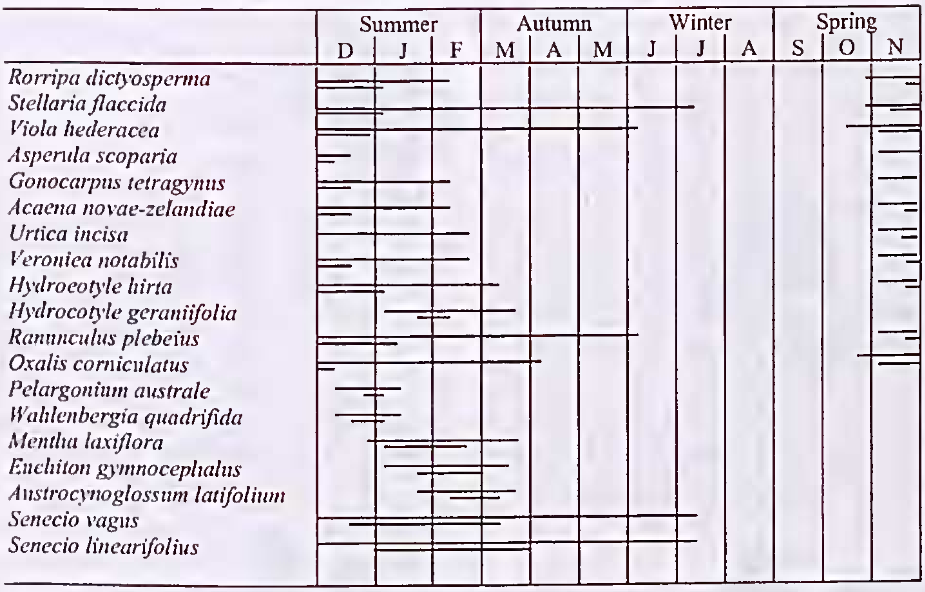


Table 4. Flowering phenology of 70 species in *E. regnans* forest, Hume Plateau (1950–70). Major period of flowering is underlined.

argophylla and *Bedfordia arborescens* from the Wallaby Creek aqueduct (490 m) to Yorktown Hill (670 m) which corresponds to a fall of mean annual temperature of about 1.8°C. This represents a delay of one week per 45 m increase in altitude in November–December. However, both the time and duration of flowering of individual trees of *E. regnans* in one stand can vary from year to year as well as from one site to another. The relative order of flowering times of *E. regnans* trees appears to be preserved from year to year suggesting a degree of genetic control (Ashton 1975d; Griffen et al. 1988).

Zonation

In general terms, the vegetation of the range can be thought of as a concentric series of vegetation types, convoluted in many places by the sharp relief imposed by the ridges and gullies radiating from the main plateau. Provided that soils are well drained, vegetation responds to increasing wetness of climate by growing taller and developing denser, taller and more complex understoreys. The area on the range occupied by *E. regnans* (Fig. 18) is about 58.8 km^2, 96% of which occurs above about 500 m. Much of this forest in a broad arc across the Wallaby and Sunday Creek catchments, has been badly damaged by logging, bullock grazing and especially by repeated fires from the middle of last century until the first decades of this. The fire regime imposed on the wetter vegetation since European occupation has had devastating consequences when it has occurred within the juvenile non-reproductive stage of obligate-seeding tree and shrub species.

The intermediate zone (300–600 m) is largely dominated by *E. obliqua* in association with *E. cypellocarpa* in wetter sites and *E. radiata* in drier sites. The understorey varies from wet sclerophyll in the wetter areas through a broad zone of damp sclerophyll with *Pultenaea* spp. and abundant ground fern (eg. *Calochlaena dubia* and *Pteridium esculentum*) to dry sclerophyll and grassy sclerophyll types.

Most of the vegetation in the drier zones withstands fire and returns to pre-fire condition within a few years. The foothill forests and woodlands are variable and both the eucalypt and understorey composition changes with variations of aspect, slope and altitude. Lower stature woodlands of *E. macrorhyncha*, *E. dives* and *E. goniocalyx*, 6–8 m tall, are the commonest and occur on hot, dry rocky slopes facing north to west. Extensive forests dominated by these species occur in the northern, drier extension of the plateau. Their sclerophyllous understoreys are often rich in species and may include *Xanthorrhoea australis*,

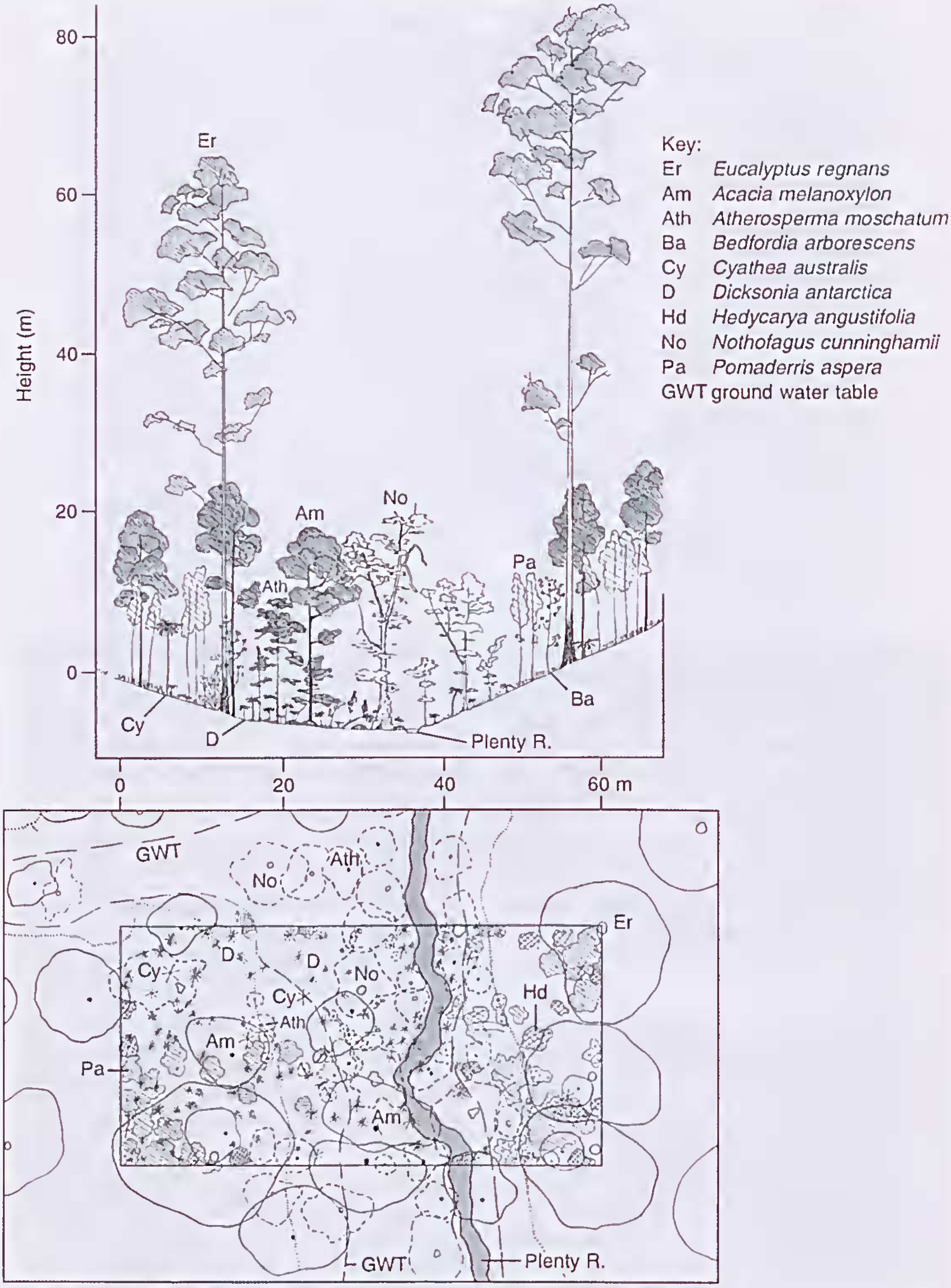


Fig. 47. Profile and plan of *Nothofagus cunninghamii* rainforest on Plenty River, 1953.

Acacia oxycedrus, A. brownii, A gunnii, Grevillea alpina, G. repens, Hibbertia prostrata, H. linearis, H. acicularis, Hovea linearis, Baeckea ramosissima, Banksia marginata, Lomatia ilicifolia, Correa reflexa, Monotoca scoparia, Leptospermum myrsinoides, Leucopogon virgatus, Podophyllum procumbens, Prostanthera hirtula and many species of lilies, orchids, grasses and sedges (Fig. 19). At higher altitudes *E. dives* stands merge into those of *E. radiata*, with or without *E. obliqua*. On the steeper rocky slopes, *E. macrorhyncha* may form pure stands with sparse understoreys of low grasses and shrubs (Fig. 20). On drier northerly slopes of foothills in the Sunday Creek Catchment *E. polyanthemos* mixes with *E. macrorhyncha* and *E. goniocalyx* with a species-rich herbaceous and shrubby understorey. On gentler slopes, especially in the north-west of the Hume Plateau near Strath Creek, *E. rubida* may form almost pure stands or, as in NE Victoria, mix with a form of *E. radiata* bearing very narrow juvenile leaves. Understoreys consist of very sparse grasses, forbs and shrubs. On gentle slopes where heavy clay subsoils occur, drainage may be seasonally poor and *E. cephalocarpa* may either dominate or mix with *E. radiata* and *E. obliqua*. In sites at lower altitude where slopes are moderate and soil somewhat better drained and deeper, *E. melliodora, E. goniocalyx* and *E. dives* commonly form open forest 8–10 m tall over an understorey of scattered *Acacia melanoxylon, A. genistifolia, Hibbertia obtusifolia, Gonocarpus tetragynus, Chionochloa pallida* and *Poa sieberana*, as well as many orchids and lilies, many of which had been rendered sparse by the proliferation of rabbits and grey kangaroos (Fig. 21). Following the reduction of the rabbit population by myxomatosis in 1950–60, the cover of this type of understorey has increased substantially. On the cooler south and east aspects in the lower foothills zone, forests of *E. radiata* are common and their understoreys may be

Fig. 48. Moss covered stream bank vegetation under deep shade in the *Nothofagus* forest, Plenty River.

Fig. 49. Photograph of old, even-aged *Leptospermum grandifolium–Blechnum nudum* swamp, Poley Creek bridge.

sparsely shrubby (*Cassinia aculeata*, *Acacia stricta*, *Indigofera australis*) with the ground stratum dominated by grasses such as *Microlaena stipoides*, *Poa sieberiana* and *Dichelachne sciurea*, together with ferns (*Adiantum aethiopicum*), lilies (*Arthropodium strictum*), orchids and mats of mosses (*Thuidium furfurosum*).

With increasing altitude and rainfall these forests give way to taller stands of *E. obliqua*, *E. radiata* and *E. goniocalyx* 15–25 m tall. Understoreys are of the dry sclerophyll type, sometimes equally dominated by grasses such as *Poa* spp. and *Tetrarrhena juncea*. Shrubs are diverse and include many acacias (*Acacia mucronata*, *A. oxycedrus*, *A. stricta*, *A. brownii*, *A. verticillata*), bush peas (*Daviesia ulicifolia*, *Pultenaea scabra*), *Goodenia ovata*, *Prostanthera hirtula*, *Hibbertia empetrifolia* and *Baeckea ramosissima*. In 1950, the understoreys of some of these forests which were dominated by *Acacia mucronata* as a result of the 1926 fires, had been replaced by understoreys dominated by bracken and *Goodenia ovata* in 1980 (Fig. 22).

In the intermediate altitudinal zone (*c*. 400–500 m), taller dry sclerophyll and damp sclerophyll forests 30–45 m tall are dominated by *E. obliqua*, *E radiata* and *E. cypellocarpa*. The understorey consists of a relatively dense shrub stratum 1–3 m tall of *Acacia verticillata*, *Pultenaea muelleri*, *P. scabra*, *Epacris impressa*, *Goodenia ovata*,

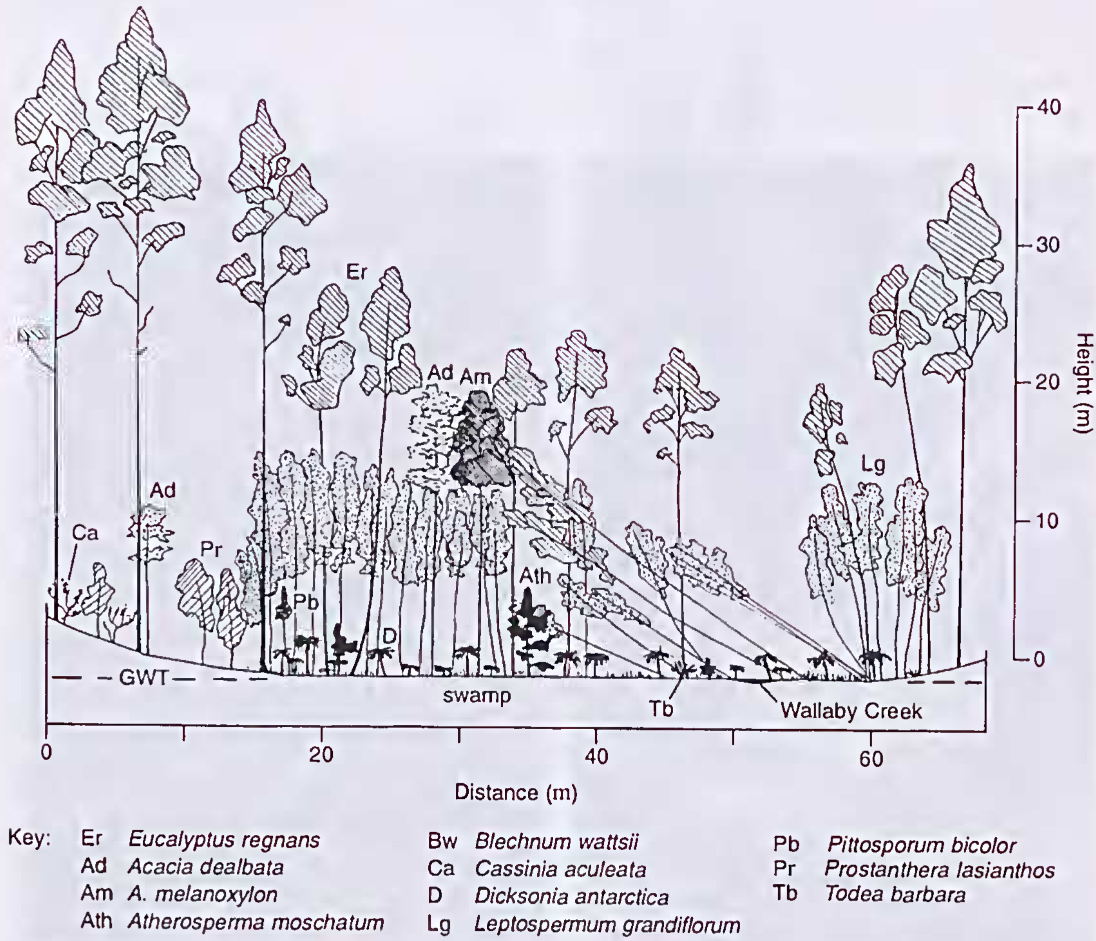


Fig. 50. Profile of unstable *E. regnans* post-fire regeneration in a swamp on the Wallaby Creek, 1957. The stand is contiguous with taller, 31-year-old *E. regnans* forest on the adjacent slopes. Much of the damage depicted was caused by winds and snow falls in 1951.

Asterolasia astericophora, *Asterotricha linearis* and *Spyridium parvifolium*. The ground stratum consists of *Tetrarrhena juncea*, *Gonocarpus humilis*, *Calochlaena dubia* and bracken as well as tussock grasses and forbs (Fig. 23). Towards the wetter end of this zone occasional broad-leafed shrubs (*Olearia argophylla*, *Bedfordia arborescens*) and the rough tree fern (*Cyathea australis*) anticipate the wet sclerophyll forests at higher altitudes (Fig. 24).

Above a mean altitude of about 500 m the forests are dominated by one eucalypt, *E. regnans*, whose height varies from 45–89 m depending on the age of stand and the quality of the site. The precise altitudinal boundary of its distribution fluctuates by as much as 250 m in response to aspect, slope and the regolith moisture differential of ridges and gullies (Fig. 18). There is also a tendency for its general boundary to rise with increasing distance north of the Great Dividing Range. This could be interpreted as a response to a greater seasonality of rainfall and a diminution of frequency of low cloud and consequent fog drip. The boundary itself is frequently very sharp on the eastern and southern areas where the change may occur over a distance of 50 m. In the north and west however, where tree heights are generally lower, the competitiveness of *E. regnans* appears to be reduced and mixed stands may form an ecotone several hundred metres wide (Ashton 1981b).

On rocky knolls such as at Yorktown Hill, *E. cypellocarpa* may mix with or replace *E. regnans*. On larger granitic outcrops, such as at Stoke's Hill, *E. obliqua* may occur in the driest local sites. Near Yorktown Hill a dense, post-fire stand of *E. globulus* occurs, the parent trees of which were presumably planted last century.

The understorey of *E. regnans* forest is characteristically of the wet sclerophyll type with broad-leafed mesophytic shrubs and small trees 8–25 m tall together with abundant tree ferns and ground ferns and mesophytic forbs. This understorey tends to extend several hundred metres down the south fall beneath *E. obliqua* and *E. cypellocarpa* but on the plateau it peters out in *E. regnans* forest in the middle of the Wallaby Creek Catchment (Fig. 25). It is replaced by understoreys of the damp sclerophyll type 2–3 m tall, which consist of *Olearia phlogopappa*, *Goodia lotifolia*, *Pimelea axiflora*, *Acacia verticillata* and *Coprosma quadrifida*, with a ground stratum of bracken and wire grass (*Tetrarrhena juncea*) and forbs.

However, in the 1950s, near the ecotone between *E. regnans* and *E. obliqua–E. cypellocarpa* forests—either on deep soils around frost hollows or on bouldery sites such as the summit of Mt Disappointment—an understorey of tussock grasses (*Poa ensiformis*. *P. labillardieri*) occurred in young stands of *E. regnans*, reminiscent of some forests of *E. delegatensis* at higher altitudes in NE Victoria. The general relationships of tree dominants and environment are indicated in a north–south profile of the range (Fig. 26).

Radiation of species groupings across the Hume Range from E. regnans *forest to* E. obliqua *forest.*

In order to attempt to quantify the species zonation with altitude in the *E. regnans* and *E. obiqua* zones a series of long transect lines E–W and N–S in which species contribution were assessed in quadrats 30 × 4 m at 200–500 m intervals. These data, consisting of 82 quadrats containing 182 species, were subjected to a polythetic divisive sorting program (MACINF) and ordinated (PCOA)

Fig. 51. Old *Leptospermum grandifolium* scrub with young bushes of *Atherosperma moschatum* (arrow) in one of the many swamps along the Wallaby Creek.

Groups	1	2	3	4	5	6	7
No. quadrats	12	17	15	8	11	9	8
Species							
Trees	(*E. regnans* forest)			(*E. obliqua* forest)			
E. regnans	**100**	**100**	**93**	12	36	22	—
E. obliqua	—	—	13	75	**100**	**100**	**100**
E. cypellocarpa	—	6	20	37	27	44	**100**
E. radiata	—	—	—	—	36	33	50
Shrubs, small trees							
A. dealbata	—	24	47	—	—	—	—
A. melanoxylon	33	—	47	25	—	33	—
Pomaderris aspera	**83**	59	53	12	9	11	—
Olearia argophylla	**100**	**94**	73	62	9	—	—
Bedfordia arborescens	**100**	59	47	37	36	—	—
Prostanthera lasianthos	9	24	53	—	—	—	—
Coprosma quadrifida	**92**	**88**	**87**	62	**91**	67	**100**
Cassinia aculeata	9	18	**93**	62	46	56	75
Goodenia ovata	9	29	20	**87**	**100**	**89**	62
Goodia lotifolia	—	—	13	—	6	33	62
Pimelea axiflora	—	12	—	37	**82**	67	**100**
Pultenaea muelleri	—	—	—	—	64	33	50
Spyridium parvifolium	—	—	—	—	55	22	—
Pultenaea scabra	—	—	—	—	46	22	25
Tetratheca ciliata	—	—	—	—	55	—	37
Amperea xiphoclada	—	—	—	—	55	—	—
Lianes							
Clematis aristata	**82**	**88**	**93**	37	**82**	**78**	**100**
Billardiera longiflora	—	12	20	50	—	11	—
Ferns							
Cyathea australis	64	59	27	62	46	—	—
Polystichum proliferum	**100**	53	60	25	—	—	—
Pteridium esculentum	**92**	53	**93**	**100**	**100**	**100**	**100**
Graminoids							
Tetrarrhena juncea	41	**88**	**100**	**87**	**100**	**100**	**100**
Poa ensiformis	18	12	33	62	**91**	—	75
Deyeuxia frigida	27	12	53	**87**	36	33	37
Lepidosperma elatius	41	71	40	62	18	33	—
Microlaena stipoides	—	—	53	—	9	11	**100**
Echinopogon ovatus	—	—	53	62	—	22	37
Forbs							
Australina muelleri	75	12	27	12	—	—	—
Stellaria flaccida	55	18	47	—	9	—	—
Sambucus gaudichaudiana	46	18	53	37	—	—	—
Senecio vagus	9	12	53	—	—	—	—
Veronica notabilis	27	6	53	—	—	—	6
Viola hederacea	58	53	**100**	**100**	**100**	**100**	**100**
Geranium potentilloides	64	53	**100**	62	**82**	67	**100**
Hydrocotyle hirta	36	41	**93**	62	75	33	75
H. geraniifolia	—	6	20	**87**	—	22	—
Ranunculus gunnianus	55	6	53	62	—	33	37
Oxalis corniculatus	18	6	53	**87**	27	67	75
Gonocarpus tetragynus	—	6	60	37	**100**	56	**87**
Mentha laxiflora	—	12	—	75	36	—	25
Galium gaudichaudii	—	6	67	50	19	33	62
Acaena novae-zelandiae	—	6	**100**	62	9	**78**	62
Veronica calycina	—	6	40	25	—	56	75
Hypochoeris radicata	9	—	—	50	27	33	62
Lagenofera stipitata	—	—	7	12	9	22	**100**
Stackhousia monogyna	—	—	—	—	82	—	75
Asperula scoparia	—	—	—	—	—	11	75
Hypericum japonicum	—	—	—	—	—	—	50

Table 5 continued next page

Groups	1	2	3	4	5	6	7
No. quadrats	12	17	15	8	11	9	8
Species (*continued*)							
Bryophytes, lichens	(*E. regnans* forest)				(*E. obliqua* forest)		
Chiloscyphus fissistypus	55	12	—	—	—	—	—
Peltigera polydactyla	67	18	—	—	—	—	—
Lembophyllum clandestinum	**91**	71	40	—	18	—	—
Isopterygium limatum	**92**	41	7	—	9	—	—
Calyptopogon mnioides	**82**	24	—	12	—	—	—
Frullaria falciloba	67	29	13	12	9	—	—
Lepidozia albula	**82**	59	47	62	73	—	—
Zygodon intermedius	**92**	47	27	12	18	—	25
Lophocolea semiteres	**91**	41	60	**100**	**91**	11	**100**
Bryum truncorum	64	41	47	12	36	—	25
Wijkia extenuata	**92**	**82**	40	37	73	11	—
Hypnum cupressiforme	**100**	**94**	**93**	**100**	73	—	**100**
Thuidium sparsum	**83**	**82**	25	67	33	37	67
Cladonia fimbriata	18	35	35	75	—	—	25
Campylopus introflexus	9	6	27	**87**	64	44	**100**

Table 5. Percentage frequency of species in seven MACINF groupings on the Hume Range. Transects N–S, E–W across the Hume Range, quadrats 30 × 4 m at ± 500 m intervals. Values >75% in **bold** type. (Only species reaching 40% frequency in one or more groups are included.)

(Ross 1982). The classification was terminated at the 7-group stage and the species composition of each shown in Table 5. The ordination of the quadrats on vectors 1 and 2 accounted for 42% of the variation. The clustering of the groups (Fig. 27) can be interpreted in terms of their altitude and geographic position on the range—three being in *E. regnans* areas and four in *E. obliqua* areas. The two moistest sites (groups 1 and 2) consisted of *E. regnans* with *Pomaderris* understoreys and abundant ferns and bryophytes on both the plateau and the south fall. The third community (group 3) consisted of *E. regnans* forest with mixed understorey of *Olearia argophylla*, *Bedfordia arborescens* and *Lepidosperma elatius* on the higher part of the plateau. The *E. obliqua* groups were distributed to the east (Kinglake West) with a complex shrub understorey (group 5), at lower altitude on the south where shrubs were few and forbs common (group 4) and to the west and north of Mt Disappointment where groups differed mainly in the openness and grassiness of the understorey (groups 6 and 7). Groups 3, 4 and 5 are to some extent ecotonal with reciprocal mixtures of *E. regnans* and *E. obliqua*. Thus, although the primary division indicated a discrimination by rainfall and altitude, the secondary subdivisions indicated the importance of direction from the main plateau centre which in turn could be linked with subtleties of climate variation. An analysis of 75 random quadrats, carried out by the Department of Conservation, Forests & Lands in the 1980s (unpublished), 10 km north and 5 km south of the divide in the Hume Range, delineated 5 types: wet sclerophyll forest; moist sclerophyll forest; mixed sclerophyll forest; and northern and southern dry sclerophyll forests. Only the first and the last of these could be equated with the quadrat groups along the transects studied in this paper.

In 1952, the vegetation change from *E. regnans* on krasnozem to *E. obliqua* on podzol soils, was determined along a 1.5 km transect in the Cascades area. Species were recorded in 20 × 1.5 m quadrats at 30 m intervals. Forty years later, the transect was reassessed and the changes indicated in Table 6. The main changes include an increase in wet sclerophyll shrubs and tree fern in *E. obliqua–E. cypellocarpa* forest and a diminution of typical dry sclerophyll components, such as *Epacris impressa*. These changes may be due to the maturation of the forest which has lessened the demand for water, and resulted in an understorey of wet sclerophyll elements which now cast denser shade.

In 1962, the changes in species composition of *E. obliqua–E. radiata–E. cypellocarpa* forest were recorded from krasnozem to podzol soils over 2 km of flat terrain on the Great Divide in the Cascades area (Gill & Ashton 1971). This study showed that although the climate was

	Krasnozem											Transition			Podsolic					
Quadrat	1	2	3	4	5	6	7	8 ↓	9	10	11	12	13	14	15	16	17	18	19	20
Trees																				
E. regnans	+•	—	+•	+•	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
E. cypellocarpa	•	—	•	—	+•	+	+•	+•	—	—	+	+•	+•	+	—	—	—	—	—	—
E. obliqua	+•	+•	+•	+•	+•	+•	+•	+	+•	+•	+•	+•	—	+•	—	+•	—	+•	—	—
E. radiata	—	—	—	—	—	—	—	•	—	—	+•	+	+•	+	•	+•	+•	+•	+•	+•
Shrubs, small trees																				
Acacia verticillata	+•	+•	•	+•	+•	+•	+•	+•	+•	+•	+	—	—	—	—	—	—	—	—	—
Bedfordia arborescens	+•	•	•	•	•	+•	+•	—	•	•	—	—	—	—	—	—	•	•	—	—
Pomaderris aspera	—	+	+	—	•	—	—	—	—	—	•	—	•	•	—	•	—	—	—	—
Olearia argophylla	—	—	—	+	—	—	—	—	•	—	—	—	—	—	—	—	•	—	—	—
Cassinia aculeata	+	+	+	—	+	—	—	—	—	—	—	+	+	+	+	+	+	+	—	+
Coprosma quadrifida	+•	+•	+•	+•	•	+•	+•	•	+•	+•	•	+•	•	•	•	•	•	•	•	•
Pimelea axiflora	+•	+•	+•	+•	+•	+•	•	•	—	•	•	—	—	—	—	•	—	•	—	—
Pultenaea muelleri	—	•	•	+	+•	•	—	+•	+•	•	+•	+•	+•	+•	+	+•	+•	+•	+	+•
Goodenia ovata	+•	+•	+•	+•	+•	•	+•	+•	•	•	•	•	•	•	•	•	•	•	•	•
Clematis aristata	+•	+•	+	+•	•	+•	+•	•	•	•	+•	•	•	•	+•	+•	•	•	•	•
Amperea xiphoclada	—	•	—	•	•	•	+•	+•	+•	•	+•	+•	+•	+•	+•	+•	+•	+•	—	+
Pultenaea scabra	—	—	—	—	—	—	+•	+	+	+	—	—	+	—	+	—	—	+•	—	+
Acacia mucronata	—	—	—	—	—	—	—	•	—	—	•	—	—	—	—	—	—	—	—	—
A. diffusa	—	—	—	—	—	—	—	—	—	—	—	+•	—	—	•	—	—	—	—	—
Spyridium parvifolium	—	—	—	—	+	—	+•	+•	+•	+•	+	+•	+•	+	+•	+•	+	+•	+	+
Asterolasia asterichophora	—	—	—	—	—	—	—	+	+	+•	+	+•	+	+•	+	+	—	—	—	—
Asterotricha ledifolia	—	—	—	—	—	—	+	+	—	—	—	—	—	—	—	—	—	—	—	—
Epacris impresa	—	—	—	—	—	—	—	—	—	+	—	+	+	+	+	—	+	•	+	+
Olearia myrsinoides	—	—	—	—	—	—	—	—	—	—	—	—	—	+	•	+	+	+•	+	+
Dampiera stricta	—	—	—	—	—	—	—	—	—	—	—	—	+	+	—	—	+	—	—	+
Prostanthera hirtula	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	•	—	—	—	+
Ferns																				
Pteridium esculentum	•	+•	+•	•	+•	+•	•	•	—	+•	•	+	+•	+•	+•	+•	+•	+•	+•	+•
Calochlaena dubia	+	+	—	+	+	+	+•	•	—	+	+•	—	•	•	•	+•	+•	+•	—	—
Cyathea australis	—	•	—	•	—	—	—	—	•	—	•	—	•	—	•	•	•	•	—	—

Graminoids																				
Poa ensiformis	+•	+•	+•	+•	+•	+•	•	—	—	—	•	—	+	—	—	—	•	—	—	—
Dianella tasmanica	•	•	+•	—	•	—	—	•	•	•	•	—	—	—	•	—	—	—	—	—
Lepidosperma elatius	—	•	•	—	—	—	—	—	•	—	—	—	—	—	—	—	—	—	—	—
Tetrarrhena juncea	+•	+•	+•	+•	+•	•	+•	+•	•	+•	+•	+•	+•	+•	+•	+•	•	+•	+•	+•
Lomandra longifolia	—	•	—	+	—	—	—	+	—	—	—	—	—	—	+	—	—	—	—	+
L. filiforme	—	—	—	—	—	—	•	—	—	—	—	—	—	+	—	—	—	—	—	+
Poa sieberiana	—	—	—	—	—	—	•	•	+•	—	+	+	—	•	—	—	—	—	—	+
Forbs																				
Mentha laxiflara	+	+•	+	+	+•	+	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Oxalis corniculata	+	+•	+•	•	•	+	+	•	—	—	—	—	—	—	—	—	—	—	—	—
Geranium potentilloides	+	+•	+•	+•	+	+•	+•	+•	•	+	—	—	—	—	—	—	—	—	—	—
Hydrocotyle hirta	+	+	+	+	+	+•	+•	+	—	—	—	—	+	—	—	—	—	—	—	—
Viola hederacea	+•	+•	+•	+•	+	+•	+•	+•	+•	+•	+•	+•	+•	+•	+•	+•	+•	+•	+•	+•
Gonocarpus humilis	—	+•	+	•	—	•	•	•	•	+•	•	+•	•	+•	+•	+	+	+	+	—
Stackhousia monogyna	—	—	•	—	—	—	+•	—	—	+	+	+	+	+	+	•	+	+	—	—
Billardiera scandens	—	—	—	—	—	—	•	—	•	—	•	—	•	•	—	•	•	•	—	+
Lagenofera stipitata	—	—	—	—	—	+	+	—	•	—	—	—	—	—	—	—	—	—	—	—
Stylidium graminifolium	—	—	—	—	—	—	—	•	—	—	—	•	—	—	+•	•	+	—	—	—
Xanthasia dissecta	—	—	—	—	—	—	—	—	—	—	—	—	+	+	+	+	+	—	+	+
Bryophytes, lichens																				
Zygodan intermedius	•	—	•	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Thuidium furfurosum	+•	+	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Wijkia extenuata	+•	+	—	•	+•	•	—	—	—	—	•	—	—	•	—	•	•	•	—	—
Hypnum cupressiforme	—	•	+	+•	+	+	—	—	+	+	•	•	—	—	—	+	—	+	+	—
Lophocalea semiteres	+	•	+•	+•	+	+	•	—	—	—	+•	—	+	—	+	•	•	•	—	—
Frullania reptans	+	—	+	•	—	—	—	—	—	—	•	—	•	—	—	—	—	—	—	—
Campylopus introflexus	—	—	+	—	+•	—	—	•	+	+•	+•	+•	—	—	—	+•	—	•	+	—
Cladia aggregata	—	—	+	•	+•	—	—	—	+	+	+•	+•	—	+	+	+	—	—	—	—

Table 6. Changes in species occurrence from 1953 to 1992, from krasnozem to podsolic soils along an E–W transect down the Great Divide in the Cascades area (750–470 a.s.l.). Quadrats 20 × 1.5 m every 30 m over 750 m. + = present in 1953; • = present in 1992; ↓ = main water channel. (Species included if ≥2 records.)

relatively uniform and the species occurrence similar, the relative cover-abundance of various species changed markedly over the 1 km of soil transition. On krasnozem near the Wallaby Creek channel, *E. cypellocarpa* was more common and the understorey was dominated by *Pultenaea muelleri* in association with several other dry sclerophyll shrubs, *Tetrarrhena juncea* and the ferns, *Calochlaena dubia* and *Pteridium esculentum*. In local niches wet sclerophyll species such as *Bedfordia arborescens*, *Olearia argophylla* and *Cyathea australis*, were establishing. Further east on the podzol soil *Leptospermum continentale*, *Pultenaea gunnii*, *Tetrarrhena juncea* and bracken, were more common. Whilst the changes in species abundance could reflect the physical and chemical effects of the soil type, it could also be due to different rates of secondary succession since the 1926 and 1938 fires.

By 1990, most of the acacias (*A. obliquinervia*, *A. mucronata*), had died out. *Pultenaea muelleri* was exhibiting large scale regeneration pattern and process (Watt 1947) on the krasnozem due to root-suckering and had become more common on the podzol. This observation highlights the need to interpret vegetation not only in terms of environmental factors but also in relation to its dynamic processes.

Vegetation of the E. regnans *zone*

Forested areas. Even-aged and multi-aged forests of *E. regnans*.—The wide range of even-aged forests on the Range are the consequence of numerous severe fires especially over the last 100–150 years (Fig. 28). Multi-aged forests are largely related to the less severe surface fires which have occurred in forests where trees have been sufficiently old to have developed fire-resisting bark at their butts.

Fig. 52. Burnt-out rainforest on Poley Creek, now vegetated by rushes and mesic herbs in areas between *A. melanoxylon* wet sclerophyll scrub.

The area is renowned (Brookes & Turner 1963) for the persistence of 10 km^2 of mature forest 280 years old (Fig. 29). The mosaic of forest ages and non-forested areas has been mapped (Fig. 30) from an aerial mosaic prepared in 1939. Major areas of obvious two-aged stands are indicated. It is realised that the definition of even-agedness is to some extent subjective—depending on the relative areas of various cohorts in a given stand. Even in a physiognomically even-aged stand there may be a one or two trees which have escaped the fire and show butt scars and larger crowns or branches that extend well down the trunks. Such trees would have been dominant trees, which survived because of their larger diameters and thicker bark and, because of their vigour, may eventually callus-over the damage inflicted by the fire.

Understorey types vary in species composition from complex wet sclerophyll to damp sclerophyll or tussock grass types (Table 7), depending on the local climate, topography, history of burning and the age of the community. In many places where fire intensities have been less intense and the original stands sufficiently opened, regeneration has occurred producing 2- or 3-aged stands with generations separated by intervals of 50–100 years. More frequent cohorts are unlikely because of the extreme fire-sensitivity of young *E. regnans* forests (Ashton 1976a, 1981a, 1981b; Ashton & Martin 1996a; Ashton & Attiwill 1994). Regeneration of *E. regnans* in the dense understoreys of the mature forest in the absence of fire is extremely rare. Saplings which establish on root balls of fallen trees in light patches of *Olearia lirata–Cassinia aculeata* understorey, above the browse reach of wallabies (and perhaps sambur deer), are invariably suppressed with flat topped, shallow crowns. Such plants usually die in years of drought. In heavier understoreys of *Pomaderris aspera* and *Olearia argophylla*, seedlings of *E. regnans* on logs and tree fern trunks never advance beyond the relatively shade-bearing juvenile stage (Ashton & Chinner 1999). However, in a large gap in this forest in a

Fig. 53. Photograph of burnt-out fern gully on Wallaby Creek, now a tussock grass, frost hole area, 71 years after the last fire. The creek bank vegetation consists of *Carex apressa*, *Juncus planifolius*, *Isolepis fluitans* and mesic herbs such as *Gratiola pedunculata* and *Mimulus moschatus*.

	Wet sclerophyll				Damp sclerophyll		Grassy		
	Plenty River	Mt Disappointment			Wallaby Creek	Channel	Wallaby Creek	Mt Disappointment	Yorktown
	Spar	Pole	Spar and pole	Spar	Spar	Pole	Pole	Pole	Pole
	Old *Pom.* musk	Young *Pom.*	Young *Pom. Bed.* musk	Young *Bed.*	Young *Cass.–Ol.*	Young *Cass.*	Frost hole tussock *Poa*	*Poa–M.* rocky	*Poa* rocky
	Q 402 m² n = 13 1953	Q 402 m² n = 10 1953	Q 805 m² n = 10 1953	Q 805 m² n = 5 1953	Q 805 m² n = 5 1953	Q 182 m² n = 5 1953	Q 28 m² n = 5 1978	Q 28 m² n = 5 1978	Q 28 m² n = 5 1978
Tall trees									
E. regnans	**100(100)**	**100(100)**	**100(100)**	**100(100)**	**100(100)**	**100(100)**	**100(100)**	**100(100)**	**100(100)**
Understorey trees/shrubs									
Acacia dealbata	—	50(20)	—	60(10)	**80(40)**	—	60(40)	—	60(20)
Acacia melanoxylon	38(7)	—	30	60	40(20)	—	—	60	—
Pomaderris aspera	**100(100)**	**100(100)**	**100(100)**	40(20)	40(20)	—	—	—	—
Bedfordia arborescens	54(7)	**90(10)**	**90(80)**	**100(100)**	40	—	—	—	—
Olearia argophylla	77(31)	50(10)	**100(60)**	60(40)	20	—	—	60(20)	20
Olearia phlogopappa	—	—	—	—	**100(20)**	—	—	—	40
Olearia lirata	—	10	—	—	—	—	—	—	—
Cassinia aculeata	—	40	20	—	**100(80)**	**100(80)**	—	60	40
Correa lawrenciana	—	50(30)	10(10)	—	—	—	—	—	—
Hedycarya angustifolia	—	—	—	**80(40)**	—	—	—	—	20
Coprosma quadrifida	69(15)	**80(30)**	70(10)	**100**	**100(10)**	—	40	60(20)	**100(80)**
Coprosma hirtella	—	20	10	60	—	—	—	40	—
Lomatia fraseri	—	—	10	60	—	60	—	—	—
Notelaea ligustrina	—	—	—	20	—	—	—	—	20
Pittosporum bicolor	7	—	20	—	20	—	—	—	—
Prostanthera lasianthos	—	—	—	—	20	—	—	—	—
Polyscias sambucifolia	—	10	—	—	—	—	—	—	—
Pimelea axiflora	—	—	—	—	—	80(20)	—	—	20
Ozothamnus ferrugeneus	—	—	—	—	—	60	—	—	—
Goodenia ovata	—	—	—	—	—	—	—	—	20(20)
Goodia lotifolia	—	—	—	—	—	—	—	40(10)	—
Ferns									
Cyathea australis	23(7)	30(10)	20(10)	100(40)	40	—	—	—	—
Dicksonia antarctica	54(38)	—	20	60(20)	—	—	—	—	—
Polystichum proliferum	**100(100)**	20	**90(50)**	—	60	—	—	—	—
Pteridium esculentum	23	60	60	—	**100(60)**	**100(50)**	**100(100)**	40(20)	**100(30)**
Histiopteris incisa	—	20	30	—	40(10)	—	—	—	—
Blechnum nudum	7	—	—	40	20(20)	—	—	—	—
Blechnum wattsii	—	—	10	—	—	—	—	—	—
Calochlaena dubia	—	—	—	—	—	40	—	—	—
Lianes									
Clematis aristata	77	50	40	**80**	60	40	—	20	40(20)
Billardiera longiflora	—	10	50	60	60	—	—	—	20
Gramminoides									
Tetrarrhena juncea	—	**90**	70	**80**	40	**100**	20	**100**	**100**
Echinopogon ovatus	—	—	10	20	**100**	40	—	40	40
Lepidosperma elatius	7	50(40)	—	**80**	40	—	—	20	60(20)
Deyeuxia frigida	—	—	—	—	—	—	—	—	—
Poa ensiformis	—	—	—	—	—	—	**100(100)**	**100(100)**	**100(80)**

Table 7 continued next page

	Wet sclerophyll				Damp sclerophyll		Grassy		
	Plenty River	Mt Disappointment			Wallaby Creek	Channel	Wallaby Creek	Mt Disappointment	Yorktown
	Spar	Pole	Spar and pole	Spar	Spar	Pole	Pole	Pole	Pole
	Old *Pom.* musk	Young *Pom.*	Young *Pom. Bed.* musk	Young *Bed.*	Young *Cass.–Ol.*	Young *Cass.*	Frost hole tussock *Poa*	*Poa–M.* rocky	*Poa* rocky
	Q 402 m^2 n = 13 1953	Q 402 m^2 n = 10 1953	Q 805 m^2 n = 10 1953	Q 805 m^2 n = 5 1953	Q 805 m^2 n = 5 1953	Q 182 m^2 n = 5 1953	Q 28 m^2 n = 5 1978	Q 28 m^2 n = 5 1978	Q 28 m^2 n = 5 1978
Gramminoides (*continued*)									
Microlaena stipoides	—	—	—	—	—	—	20	20	40
Poa sp.	—	—	—	—	—	—	—	—	—
Dianella tasmanica	—	—	—	—	—	—	—	—	20
Dryopoa dives	—	—	—	—	20	—	—	—	—
Danthonia pilosa	—	—	—	—	—	—	—	20	20
Forbs (dicot)									
Viola hederacea	7	70	—	**100**	**100**	**100**	60	**100**	**80**
Hydrocotyle hirta	15	70	30	**100**	**100**(20)	**100**	**80**	**100**	**100**
Hydrocotyle geraniifolia	—	—	—	60	—	—	—	—	—
Geranium potentilloides	15	50	30	**100**	**100**	**80**	**100**	**100**	**80**
Australina muelleri	**100**(15)	—	10	60	**100**(40)	—	—	—	—
Urtica icisa	54	—	—	20	—	—	—	—	—
Stellaria flaccida	15	—	—	20	**100**(60)	—	—	60	—
Ranunculus plebeius	15	—	—	40	**100**	—	20	**100**(20)	60
Sambucus gaudichaudiana	69	10	20	40	**80**	60	20	—	—
Aceana novae-zelandiae	—	—	20	**100**	**100**(20)	60	**80**	**100**(40)	60
Veronica notabilis	—	—	—	40	60	—	20	—	—
Veronica calycina	—	—	—	40	—	—	20	—	—
Galium gaudichaudii	—	—	—	20	—	60	60	60	20
Rorippa dictyosperma	7	—	—	—	—	—	—	—	—
Solanum aviculare	7	—	—	—	20	—	—	—	—
*Solanum nigrum**	—	—	—	—	—	—	—	—	—
Senecio vagus	15	—	10	—	40	—	—	—	—
Senecio quadridentatus	—	—	—	—	—	—	—	—	—
Senecio linearifolius	—	—	—	—	—	—	—	—	20
Senecio minimus	—	—	—	—	—	—	—	—	—
Dichondra repens	—	—	—	—	—	—	20	—	40
Leptinella filicula	—	—	—	—	—	—	—	20	—
*Sonchus oleraceus**	—	—	—	—	—	—	—	—	—
*Cerastium glomeratum**	—	—	—	—	—	—	—	—	—
Mentha laxiflora	—	—	—	—	—	60	—	—	—
Lagenofera stipitata	—	—	—	—	—	—	—	—	20
Stackhousia monogyna	—	—	—	—	—	—	20	—	—
*Cirsium vulgaris**	—	—	—	—	20	—	20	—	—
*Hypochoeris radicata**	—	—	—	20	—	20	—	40	—
Oxalis corniculatus	—	—	—	—	—	40	60	—	**80**
Gonocarpus tetragynus	—	—	—	—	—	—	—	—	40
Euchiton gymnocephalus	—	—	—	—	—	—	—	—	20

Table 7. Percentage frequency of species in spar and pole stage even-aged forests of *E. regnans* in a variety of habitats on the Hume Range. Values ≥ 75% in **bold** type; ( ) = cover ≥ 5%; * = introduced.

Fig. 54. Remnant rainforest patch of *Atherosperma moschatum* and *Acacia melanoxylon* (arrow) at the Wallaby Creek bridge (1951), surrounded by a post-fire wet sclerophyll understorey, 250 m upstream from the grassland site shown in Fig. 53.

Fig. 55. Riparian wet sclerophyll forest (*Pomaderris aspera*, *Olearia argophylla* and *Prostanthera lasianthos*) on King Parrot Creek with an overstorey of *E. cypellocarpa* and *E. viminalis.*

dense grove of *Dicksonia antarctica* a sapling of *E. regnans* established for 10–11 years after which time its instability ultimately caused its collapse to the ground (Ashton & Chinner 1999). The fibrous root mat on tree fern trunks is a very favourable site for the establishment of many, if not most, understorey species. *Olearia argophylla*, *Bedfordia arborescens* and *Pomaderris aspera* produce adventitious roots up to 1 m above ground in the humid cooler months of winter. Should trunks of these species lean against tree fern trunks they will establish a root system which may bring about the death of the host. Not surprisingly, prostrate trunks of these species will layer, at least if the plants are young and vigorous.

The predominant tall shrub–small tree stratum is often younger than the overstorey although lignotuberous species and tree ferns may live for some centuries and resprout following each fire (Mueck et al. 1996). However, they may die or the lignotubers burnt out by repeated fires or by the slow ignition of heavy accumulations of humus at their base. The course of post-fire succession depends to some extent on the intervals between fires. If this is measured in centuries, soil seed may die; if it is very frequent, species may be removed before the soil seed bank can be replenished. Both these scenarios appear to have occurred in the broad plateau valley of the Wallaby Creek where many understoreys consist of rapidly dispersed composites, such as *Cassinia aculeata* and *Olearia phlogopappa* (Table 8). The paths of the various fires have been variable and pockets of *Pomaderris aspera* and *Prostanthera lasianthos* have remained to become focal points for re-invasion. *Cassinia aculeata*, which arose after the 1926 fires, had largely died out by 1960, infested with the ascomycete gall, *Syncarpella congesta* (Cooke) Boise. Understoreys dominated by this shrub in 1950 had been replaced in 1990 by the root-suckering shrub, *Coprosma quadrifida*, and the obligate seeder, *Pimelea axiflora*. In some places near the Poley Creek, the succeeding species is *Hedycarya augustifolia*—no explanation can be offered for the various trends in replacement except by way of chance seed supply and establishment.

Pole and spar stage stands of *E. regnans* in moist sites near the boundaries of the mature forest have developed distinct wet sclerophyll understoreys dominated by *Olearia argophylla*, *Bedfordia arborescens* (Figs 31, 32), or *Pomaderris aspera* (Fig. 33). Since 1980, a great many pole and spar-stage stands of *E. regnans* with moribund *Cassinia aculeata* understoreys have been actively invaded by *Olearia argophylla* (Figs 34, 35) or, where seed supply is close, by *Pomaderris aspera* (Fig. 36). Ring count frequencies of seedlings and saplings of the latter species illustrate the continuance of invasion (Fig. 37) of moribund *Cassinia aculeata* understoreys. Although there is an abundance of *Cassinia aculeata* seed stored in the soil very little germinates unless the soil is disturbed and

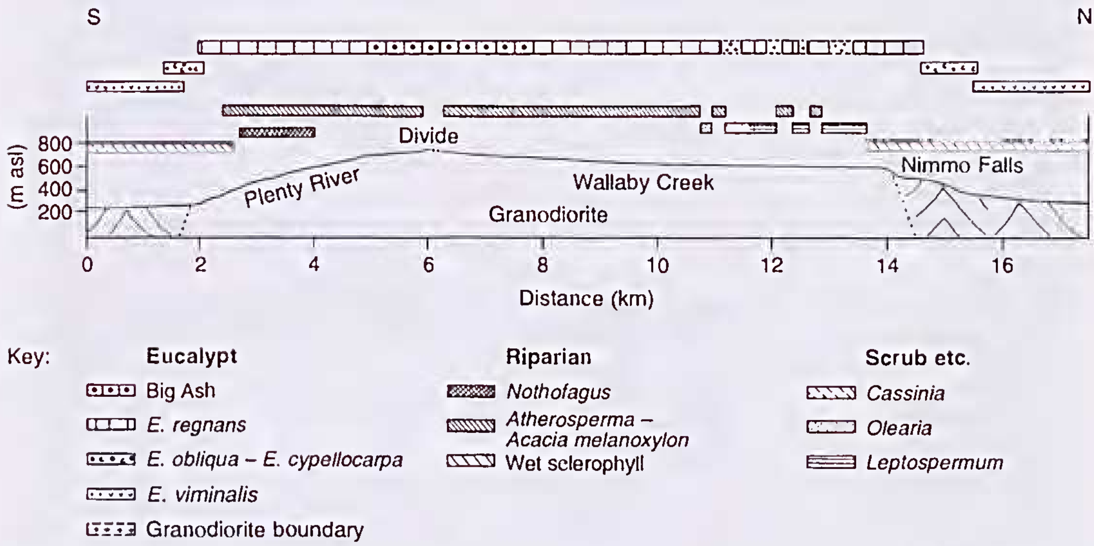


Fig. 56. Stream course profiles of Plenty River and Wallaby Creek from north to south across the Hume Range, indicating riparian and adjacent communities.

	Scrubland			Fernland		Grassland		
	Pomaderris ridge (dry)	*Cassinia* valley (moist)	*Cassinia* hill (dry)	Bracken valley (moist)	Bracken ridge (dry)	*Poa* tussock frost hollow	*Danthonia* frost hollow	Holcus frost hollow
	Q 108 m^2 n = 5 1952	Q 7.3 m^2 n = 7 1955	Q 7.3 m^2 n = 6 1955	Q 1 m^2 n = 20 1955	Q 1 m^2 n = 17 1955	Q 1 m^2 n = 26 1954	Q 1 m^2 n = 12 1954	Q 1 m^2 n = 20 1954
Trees/shrubs								
Acacia dealbata	60(40)	—	—	—	—	—	—	—
Pomaderris aspera	**100(100)**	—	—	5	12	—	—	—
Bedfordia arborescens	**80(20)**	—	—	—	—	—	—	—
Cassinia aculeata	40	**100(100)**	**100(100)**	25	6	—	—	—
Prostanthera lasianthos	—	—	—	—	—	—	—	—
Coprosma quadrifida	**100(60)**	42	—	—	6	—	—	—
Olearia phlogopappa	—	14	—	—	—	—	—	—
Ferns								
Pteridium esculentum	40	**100(42)**	**100(50)**	**100(100)**	**100(100)**	4	—	10
Polystichum proliferum	—	57	—	—	—	—	—	—
Lianes								
Clematis aristata	**80**	14	—	—	—	—	—	—
Billardiera longiflora	20	—	—	—	—	—	—	—
Graminoids								
Poa ensiformis	—	—	42	—	—	**100(100)**	—	5
Tetrarrhena juncea	60	—	—	75(15)	100(29)	—	—	—
Lepidosperma elatius	80(40)	—	—	—	—	—	—	—
Microlaena stipoides	—	—	—	35	12	4	25	15
Carex inversa	—	—	42	—	—	4	25	**85**
Luzula meridionalis	—	—	33	—	12	61	67	15
Agrostis venusta	—	28	42	—	29	—	—	—
Agrostis avenacea	—	—	—	—	—	—	17	—
Echinopogon ovatus	—	71	33	35	—	—	—	—
Danthonia penicillata	—	14	17	5	—	—	**100(50)**	50
Danthonia pilosa	—	—	—	—	—	31(4)	—	—
Danthonia geniculata	—	—	—	—	—	—	33	5
*Holcus lanatus**	—	—	17	—	6	8	17	**100(100)**
Dryopoa dives	—	42	—	—	6	—	—	—
*Aira caryophyllea**	—	—	67	—	—	**85**	**100**	**85**
*Aira praecox**	—	—	17	—	—	—	17	10
*Vulpia bromoides**	—	—	67	—	—	42(8)	**100(15)**	55
*Briza minor**	—	—	—	—	—	11	8	5
Forbs (dicot)								
Viola hederacea	60	**86(28)**	**100(33)**	75	76(18)	31	**83**	20
Hydroctyle hirta	—	28	**100(50)**	—	35	—	—	—
Geranium potentilloides	—	**86**	**83**	—	**100**	—	—	—
Australina muelleri	—	**100(28)**	—	25	—	—	—	—
Urtica incisa	—	14	—	—	—	—	—	—
Stellaria flaccida	—	**100(28)**	—	70	—	—	—	—
Gonocarpus tetragynus	—	—	17	—	6	—	—	—
Galium gaudichaudii	—	28	**100**	15	29	—	8	—

Table 8 continued next page

	Scrubland			Fernland		Grassland		
	Pomaderris ridge (dry)	*Cassinia* valley (moist)	*Cassinia* hill (dry)	Bracken valley (moist)	Bracken ridge (dry)	*Poa* tussock frost hollow	*Danthonia* frost hollow	Holcus frost hollow
	Q 108 m² n = 5 1952	Q 7.3 m² n = 7 1955	Q 7.3 m² n = 6 1955	Q 1 m² n = 20 1955	Q 1 m² n = 17 1955	Q 1 m² n = 26 1954	Q 1 m² n = 12 1954	Q 1 m² n = 20 1954
Forbs (dicot) (*continued*)								
Acaena novae-zelandiae	—	86(28)	**100**(33)	—	24	27	**100**(20)	30
*Crepis capillaris**	—	—	—	—	6	**88**	—	—
*Centaurium erythraea**	—	14	67	—	6	77	67	55
Epilobium glabellum	—	14	**100**	5	24	**81**	67	**90**
Veronica notabilis	20	28	—	15	18	—	—	—
Veronica calycina	—	—	17	—	—	—	—	—
*Veronica agrestis**	—	—	33	—	—	15	33	—
Oxalis corniculatus	—	28	33	—	—	8	42	25
Sambucus gaudichaudii	—	71	—	15	—	—	—	—
Ranunculus plebeius	—	42	—	5	35	4	—	—
Mentha laxiflora	—	14	—	10	—	—	—	—
Hypericum gramineum	—	14	—	5	35	38	**83**	25
Wahlenbergia quadrifida	—	—	17	—	6	—	—	—
*Acetosella vulgaris**	—	—	42	—	—	61	**83**(17)	—
Dichondra repens	—	—	17	—	—	—	—	10
Myosotis australis	—	—	17	5	—	—	—	—
Lagenofera stipitata	—	—	—	—	6	—	—	—
Senecio linearifolius	—	14	—	—	—	—	—	—
Senecio quadridentatus	—	—	—	—	6	—	—	—
Senecio minimus	—	71	—	—	35	—	—	—
Senecio hispidulus	—	14	—	5	—	—	—	—
*Cirsium vulgare**	—	—	—	20	—	11	33	—
*Cerastium glomeratum**	—	—	**83**	—	—	73	50	20
*Hypochoeris radicata**	—	—	17	—	—	26	25	15
*Hypochoeris glabra**	—	—	—	—	—	11	17	5
*Sonchus oleraceus**	—	—	—	5	—	8	—	—
Poranthera microphylla	—	—	—	—	6	4	—	—
*Mentha satureioides**	—	—	—	—	—	—	—	—
*Verbascum virgatum**	—	—	—	—	—	4	42	10
Euchiton gymnocephalus	20	—	42	—	24	19	**83**	**85**
Asperula scoparia	—	—	—	—	—	4	—	—
*Erophila verna**	—	—	—	—	—	8	42	10
*Moenchia erecta**	—	—	—	—	—	4	—	—
*Trifolium dubium**	—	—	—	—	—	4	—	75
*Trifolium repens**	—	—	—	—	—	—	—	5
*Trifolium campestre**	—	—	—	—	—	—	—	5
*Aphanes arvensis**	—	—	—	—	—	—	17	—
*Sonchus asper**	—	—	—	—	—	—	8	15
Cymbonotus preissianus	—	—	—	—	—	—	—	5
*Anagallis arvensis**	—	—	—	—	—	—	—	5

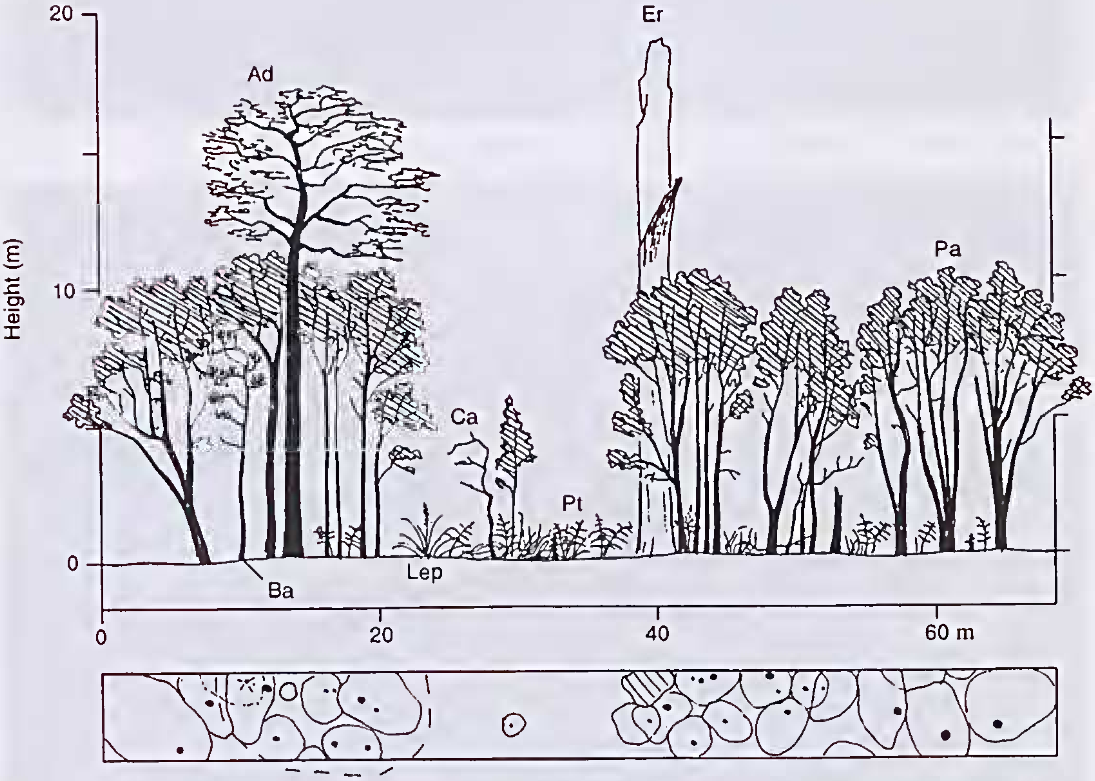
Table 8. Percentage frequency of species in scrubland, fernland and grassland communities (Wallaby Creek Catchment). Values ≥ 75% in **bold** type; ( ) = cover ≥ 5%; * = introduced.

Fig. 57. Mosaic of scrub, bracken and forest in the mid Wallaby Creek valley in 1951 with the burnt spars of the original *E. regnans* forest.

Fig. 58. Scrub of *Pomaderris aspera* and *Acacia dealbata* on a hornfels ridge, Wallaby Creek.

subjected to solarisation. In some ridge top sites near Yorktown Hill, where in 1950 tussock grass (*Poa ensiformis*) had developed beneath *Cassinia aculeata*, dense invasion of musk (*Olearia argophylla*) over a period of 30–40 years has resulted in the replacement of tussock grass by tall, vigorous swards of *Lepidosperma elatius* (Fig. 38). Similarly, at the summit of Mt Disappointment the tussock grass–*Cassinia* understorey which was present in 1950, has been largely suppressed by the continued invasion of *Olearia argophylla*, *Pomaderris aspera* and *Hedycarya angustifolia* over the last 40 years.

In lower topographic sites on the plateau, *Olearia phlogopappa* has regenerated at the expense of *Cassinia aculeata* and now dominates the understoreys of many pole-stage stands. Around some frost hollows in the 1950s tussock grass (*Poa ensiformis*) had formed an understorey to pole-stage *E. regnans*. In some of these stands occasional pioneer-form *E. regnans* indicate open conditions, perhaps at the margin of an earlier, much larger *Poa* frost hollow. Encroachment of *E. regnans* into grassland has occurred markedly since the 1960s, often preceded by an apron of bracken and a light cover of frost tolerant *Acacia dealbata* bushes developed from root suckers. It is possible that in the preceding decades such regeneration occurred around scattered trees forming by 1950, a pole-stage stand over a tussock grass understorey. By the 1990s this understorey had been invaded and largely replaced by bracken (Fig. 39), possibly as a consequence of the progressive shrinkage of the area of frost hollow and the amelioration of the local climate.



Key:
Er *Eucalyptus regnans*
Ad *Acacia dealbata*
Ba *Bedfordia arborescens*
Ca *Cassinia aculeata* (dead)
Lep *Lepidosperma elatius*
Pa *Pomaderris aspera*
Pt *Pteridium esculentum*

Fig. 59. Profile of *Pomaderris aspera* scrub, on a hornfels ridge.

Fig. 60. Bare floor in *Pomaderris aspera* scrub on a hornfels ridge top site.

Fig. 61. Vigorous, young flowering *Cassinia aculeata*, Plenty Valley, 1955.

Fig. 62. Moribund *Cassinia aculeata* infested with galls of *Syncarpella congesta*, 1965.

Fig. 63. Replacement of *Cassinia* scrub by tall bracken 1980, Poley valley.

In the Silver Creek valley at the northern limits of *E. regnans*, pole-stage stands occur with damp sclerophyll understoreys of *Acacia verticillata*, *Coprosma quadrifida*, *Pimelea axiflora*, *Goodenia ovata* and *Goodia lotifolia*, with ground strata of bracken, forbs and wiregrass (*Tetrarrhena juncea*) (Fig. 40). These stands too, are changing with the demise of *A. verticillata* and *Goodia lotifolia* 70 years after the fire which initiated their establishment and are becoming dominated by *Coprosma quadrifida*. In November 1982, severe fires killed and regenerated many of these stands with dense *E. regnans*, *Acacia verticillata*, *Goodia lotifolia*, *Goodenia ovata*, *Cassinia aculeata*, as well as bracken and wiregrass. Where only the understorey was killed it was replaced by *Goodia lotifolia*, herbs and light bracken (Ashton & Martin 1996a). In some of the drier sites in the Wallaby Creek valley, very dense stands of 30-year-old *E. regnans* occurred, with a virtually bare floor consisting of sparse bracken and a veneer of *Tetrarrhena juncea* (Fig. 41). This stand probably originally had an understorey of *Cassinia aculeata* and now represents an extreme contrast to the wet sclerophyll forests of the same age on the Great Divide, 2–3 km to the south.

In the young understoreys dominated by *Pomaderris aspera* extreme density of stems precludes any development of the usual ground stratum of ferns. Bare floors are found much earlier on good sites than poor sites because faster growth rates has resulted in greater, more rapid, thinning out of the understorey stems. In old *Pomaderris–Olearia–Bedfordia* understoreys in the mature forest ground stratum ferns (*Polystichum proliferum*, *Blechnum wattsii*) may approach 100% cover and epiphytic bryophytes and lichens abound. Both species of tree fern have increased in density as a result of sporeling regeneration on rotten logs and the root balls and hollows produced by fallen trees. Some, but by no means all, small specimens of *Dicksonia antarctica* are clearly the distal re-orientation of old prostrate plants (Chesterfield 1996; Mueck et al. 1996). In general, the latter species occurs in wetter sites of the gullies and plateau whilst *Cyathea australis* extends up hill-sides and into *E. obliqua–E. cypellocarpa* forests where it is frequently associated with the microsites formed by root-ball pits. The structure of the mature forest and *Pomaderris* understorey on the plateau in 1978, after the damaging snowfalls between 1951 and 1972, is illustrated in Fig. 42. A profile and plan of this forest undamaged in 1949 is shown in Fig. 43.

Riparian communities.—In the mature forest and spar forest areas a narrow strip of cool temperate rainforest, dominated by *Atherosperma moschatum* and *Acacia melanoxyon*, is the commonest community along stream courses (Figs 44, 45). Although it is in a sense a gallery forest, it is similar to some widespread callindendrous rainforests in Tasmania (Busby & Brown 1994).

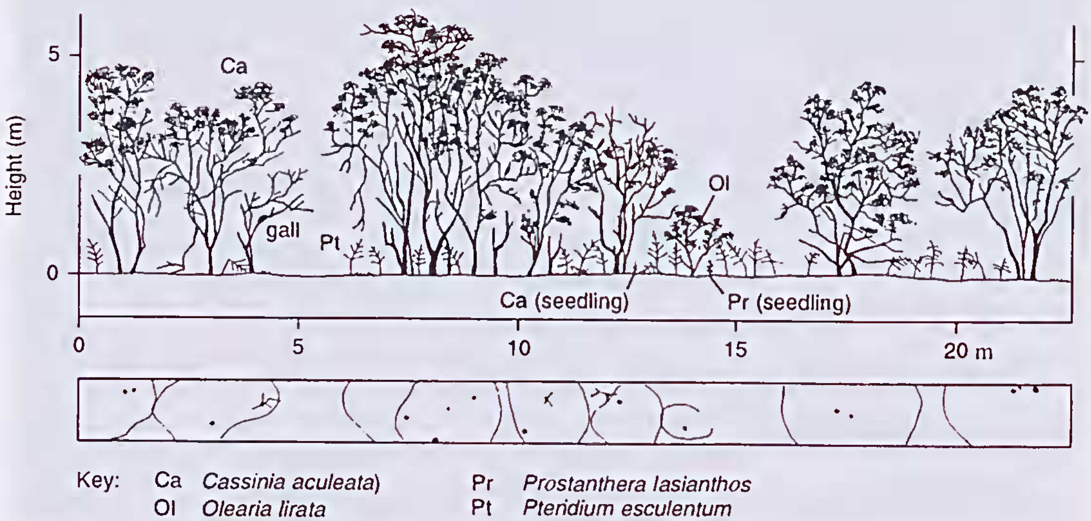


Fig. 64. Profile and plan of *Cassinia aculeata* scrub, Wallaby Creek Valley, 1956.

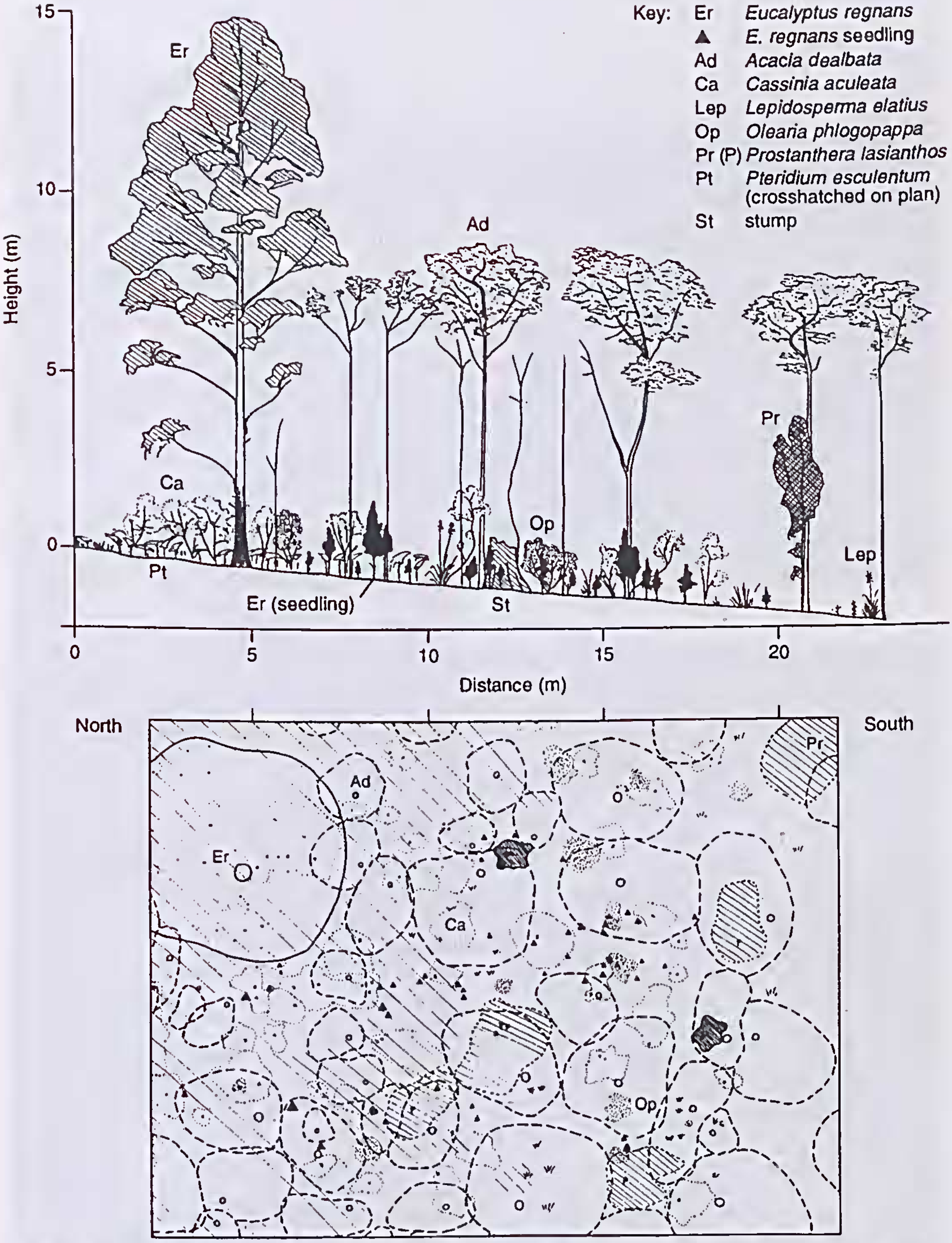


Fig. 65. Profile and plan of the invasion of *Acacia dealbata* scrub by *E. regnans*, Wallaby Creek valley (1954) in the absence of of fire.

It may be 10–100 m wide depending on the stream course, the confluence of tributaries and the time since the last fires. The soft tree fern, *Dicksonia antarctica*, is very common and in breaks between the trees its canopy may be continuous. The commonest ground fern, *Blechnum wattsii*, is associated with *Lastreopsis acuminata* and *Asplenium bulbiferum*. Tree fern trunks are typically clothed with bryophytes and filmy ferns below the collar of old dead fronds. *Microsorium pustulatum* is unusual in being able to colonise the crown of the tree fern itself. Areas of bare ground occur which may be either disturbed by land crayfish (*Engaeus*) or colonised by dendroid mosses, small sedges and forbs. Old logs are typically carpeted by bryophytes (*Wijkia extenuata*, *Lepidozia ulothrix*, *Bazzania adnexa*), in association with sedges (*Uncinia tenella*) and filmy ferns (*Hymenophyllum australe*, *H. flabellatum*), as well as seedlings and saplings of rainforest trees and shrubs. Epiphyllous mosses, such as *Weymouthia mollc*, were aptly described by Patton (1933) as hanging from the stems and foliage of *Atherosperma*, 'in *Tillandsia*-like masses'. In the deepest section of the Plenty valley *Nothofagus cunninghamii* occurs in this community (Figs 46, 47), the margins of which are flanked with mature *E. regnans* and very large and obviously very old *Olearia argophylla* and *Bedfordia arborescens* with DBHs of up to 45 cm. The shadiest stream banks are clothed with dendroid bryophytes (Fig. 48). The regeneration of the rainforest trees takes place in gaps in the stands on logs, bare ground and tree fern trunks (Ashton & Chinner 1999). Both *Atherosperma* and *Nothofagus* produce adventitious roots on their lower trunks which enable them to layer on the ground or on adjacent tree fern trunks. Up to 50% of trees (*Atherosperma*, *Acacia melanoxylon* and *Nothofagus*) bear tree fern fibres wedged in the furrows of their trunks as evidence of the early mode of their establishment. The lateral roots of *Atherosperma* are commonly on the soil surface—possibly as a result of exposure by lyrebird activity—and not infrequently ascend through the 'bark' of adventitious root fibre of nearby *Dicksonia antarctica* trunks.

Established bushes of *Atherosperma* 1–3 m tall may occur 100 m, and *Nothofagus* 30 m, upslope from the gullies under mature wet sclerophyll understoreys of mature and spar stage *E. regnans* on the south fall of the range. There is thus a strong tendency for rain forest species to succeed mature wet sclerophyll forest in the long absence of fire.

In the Wallaby Creek valley, the Poley Creek and the Sunday Creek near Mt Disappointment, within the general area of pole and spar stage *E. regnans* forest or scrublands, peaty waterlogged flats 50–100 m wide occupy areas of 1–1.5 ha. They are almost invariably covered with dense stands of *Leptospermum grandifolium* 8–12 m tall. The ground stratum often consists of dense *Blechnum nudum* and *B. wattsii* with scattered *Dicksonia antarctica* and *Todea barbara* (Fig. 49). Spaces between the ferns are often occupied by a turf of bryophytes (*Bryum billardieri*, *Hypnodendron arcuatum*).

From the presence of old charred tree fern stumps and ring counts in *Leptospermum* it is clear that many swamp communities are even-aged and have arisen following fires in 1908, 1914 and 1926, which also enabled the establishment of pole stage trees of *E. regnans* in the swamps where the water-table in late summer may be within 45 cm of the surface and close to the surface in winter. A great discrepancy in height occurs in contemporanous stands of *E. regnans* on the waterlogged flats

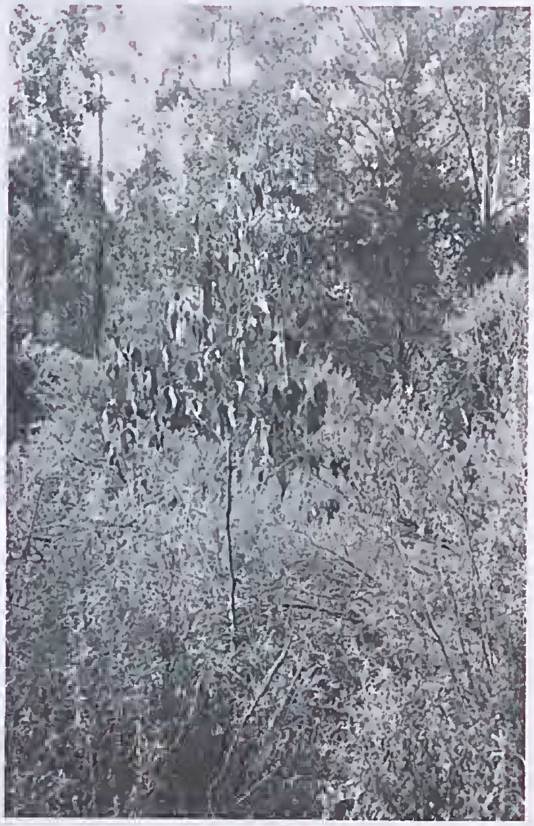


Fig. 66. Invasion of *Cassinia* scrub by *E. regnans*, seedlings, Wallaby Creek valley.

Fig. 67. A sweeping view of brackenland, Wallaby Creek plateau, 1951.

Fig. 68. Moist bracken community on a south-east aspect with a ground stratum of *Australina muelleri* and *Stellaria flaccida*.

Fig. 69. Replacement of moist bracken and *Cyathea australis* in 1950 (A), by wet sclerophyll scrub in 1998 (B), on the Great Divide west of the Cascades.

Fig. 70. Dry bracken community on a hornfels ridge. The sparse ground stratum consists of *Viola hederacea*, *Centaurium erythraea* and *Acaena anserinifolia*.

Fig. 71. Invasion of bracken by wet sclerophyll shrubs and *E. regnans*, ridge top site.

and the adjacent well-drained slopes. *E. regnans* trees on the wet soils are unstable and many lean badly and were seriously affected by the very heavy snowfalls in 1951. It is likely that none of these trees will survive to maturity (Fig. 50). Because of the waterlogged soil, large lateral roots of *E. regnans* which may be elliptical in cross-section, 10–12 cm wide and 30–37 cm deep, may protrude 15 cm above the soil surface.

Where gaps occur in these communities, due to tree fall from adjacent slopes or from snow damage, vigorous regeneration of *Leptospermum* seedlings and saplings takes place. It seems likely that the fire regimes of last century removed *Atherosperma* and favoured the proliferation of *Leptospermum*. In older stands (eg. >45 years) trees of *Atherosperma moschatum* are occasionally present and seedlings and saplings in some places may form a stratum 1–3 m high (Fig. 51). In swamp flats, unburnt since the turn of the century, *Leptospermum* and *Atherosperma* are co-dominant. Succession to a form of rainforest is undoubtedly now taking place, possibly as a result of the maturation of the post-fire scrub and the prolific although erratic production of wind dispersed *Atherosperma* seed from areas of unburnt rainforest.

Along some sections of the Wallaby, Poley and Sunday creeks, severe and frequent fires have eliminated rainforest from the riparian environment, where it has been replaced by wet sclerophyll forest of *Acacia melanoxylon* and *A. dealbata* with understoreys of *Prostanthera lasianthos*, *Olearia lirata* and *O. phlogopappa*. Large gaps along the creeks are usually occupied by herbaceous swards of *Juncus planifolius*, *Isolepis fluitans*, *Grattiola pedunculata*, *Callitriche stagnalis*,

Fig. 72. Advanced stage of *Pomaderris aspera* scrub development from a bracken community.

Mimulus moschatum and *Polytrichum commune* (Fig. 52). Where the Wallaby Creek flows through the tussock grass frost hollow, dense swards of *Poa ensiformis* occur down to the stream banks—interspersed by rushes, sedges and mesophytic perennial herbs in wetter areas (Fig. 53). Near the Wallaby Creek bridge 250 m upstream from the burnt out forest, a small patch of rainforest, 20 m in diameter is dominated by old, unburnt *Atherosperma moschatum* and *Acacia melanoxylon* with *Dicksonia antarctica* and filmy ferns, and is surrounded by post-fire wet sclerophyll scrub

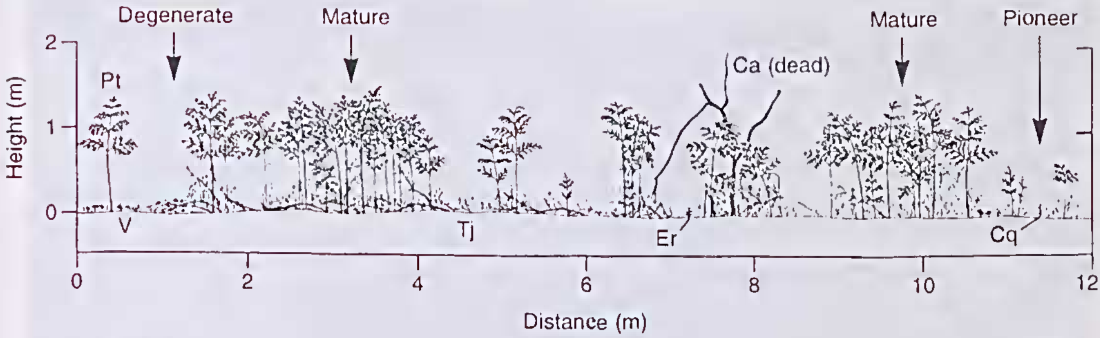


Fig. 73. Profile of patchy bracken on a ridge top site showing related growth phases.

Fig. 74. The contracted area of *Poa ensiformis* frost hollow, surrounded by a rim of *Acacia dealbata*, Wallaby Creek, 1990.

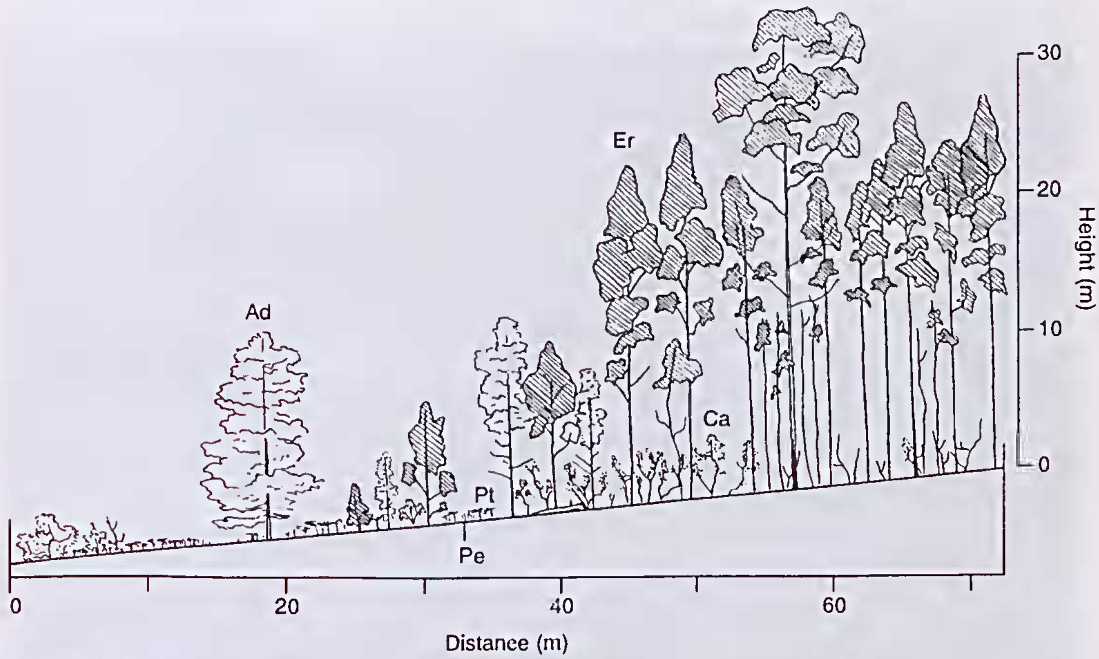
Note to printer: "A." & "B." are text boxes and not on photo images.

Fig. 75. A. Tussock grassland of *Poa ensiformis* in the same frost hollow in 1950, with abundant flowering of *Hypochoeris radicata* in the foreground and a low bracken-covered hill in the background. B. Photograph of the same frost hollow in 1990, showing the low hill colonised by a young forest *E. regnans* and *A. dealbata*.

(Fig. 54). It is clear from this sort of evidence that much of the riparian environment was once rainforest. In 1996 seedlings and severely browsed bushes of *Atherosperma* were present in nearby scrub up to 25 m from the creek suggesting, that in time, the rainforest may reclaim much of the riparian habitat, especially if preceded by tree ferns whose trunks provide browse-free niches for many woody species.

On the alluvial flats of the Plenty River and King Parrot Creek where streams are broader and more slow moving, tall, open forest of *E. viminalis* and *E. cypellocarpa* occurs, with a riparian strip 10–20 m wide of wet sclerophyll understorey species (*Acacia melanoxylon*, *Pomaderris aspera*, *Prostanthera lasianthos*, *Olearia argophylla*, *O. lirata*, *Bedfordia arborescens*, *Hedycarya angustifolia*, *Gynatrix pulchellus*, *Coprosma quadrifida*), with a ground stratum of *Blechnum nudum*, *Pellaea falcata*, *Calochlaena dubia*, *Adiantum aethiopicum*, *Gahnia clarkei*, *Lepidosperma elatius* and the ubiquitous bracken (Fig. 55). Where the flats are broader, some of the wet sclerophyll species may show drought stress in late summer if they are >2 m above the summer creek level—presumably a reflection of the depth of the root system in relation to the capillary fringe above the ground watertable.

In drier sites near the margins of the flats, *E. obliqua* and *E. radiata* (as well as a local population of introduced *E. globulus* near Toorourrong Reservoir) frequently develop a grassy understorey of *Poa labillardieri*, *Microlaena stipoides*, *Dichelachne sciurea* and *Echinopagon ovatus*, together with *Cymbonotus preissianus*, *Glycine clandestina*, *Mentha laxiflora* and lilies such as *Arthropodium paniculatum* and *Caesia parviflora*. However, in the mid valley tract, the wet sclerophyll strip grades laterally into damp sclerophyll and, with distance, upslope into dry sclerophyll forest. In more waterlogged sites, such as on the delta spreading into Toorourrong Reservoir, *E. ovata* is found in association with *Leptospermum lanigerum* and *Carex appressa*. The relationships of riparian and adjacent communities are illustrated on a north–south profile of streams across the range (Fig. 56).



Key: Er *Eucalyptus regnans* Ca *Cassinia aculeata* Pt *Pteridium esculentum*
Ad *Acacia dealbata* Pe *Poa ensiformis*

Fig. 76. Profile of the forest margin advance in *Poa* frost hollow, with a 'nurse crop' of *Acacia dealbata*, 1950.

Fig. 77. Advance of *E. regnans* seedlings from the forest edge in a more protected site of the frost hollow, 1975.

Fig. 78. Patchiness of *Poa ensiformis* grassland; bare soil gaps are subjected to severe frost heaving.

Non-forested areas

These areas were extensive in 1949 before the full implementation of the Melbourne & Metropolitan Board of Works policy of reforestation of the catchments. The wide distribution of burnt, dead spars of *E. regnans* in 1950 testifies to the long fire history of this area (Fig. 57). The following description relates to this area before much of it was converted to plantations of *E. viminalis*, *E. delegatensis* and *E. regnans*. It describes the extent of degradation wrought upon the original forest in less than 100 years. Evidence of the original trees and tree ferns has been often preserved *in situ* by their partial carbonisation.

Scrub. Pomaderris aspera type.—This scrub occurs in large patches up to several hundred metres in diameter. In the Wallaby Creek Catchment they consist of dense stands 8–12 m tall with emergent *Acacia dealbata*. These species may be associated with *Prostanthera lasianthos*, *Olearia argophylla*, *Bedfordia arborescens*, *Lomatia fraseri* and *Coprosma quadrifida*. Large burnt butts of *E. regnans* testify to the prior forest status of these sites (Figs 58, 59).

On the plateau, the floor of these stands is usually bare except for scattered clumps of *Lepidosperma elatius* and patches of wiregrass (Fig. 60). If this community on relatively dry ridge tops is undisturbed by lyrebirds for a long time, it develops a floor of deep matted litter resembling a fibrous mor. If thoroughly cultivated by lyrebirds it reverts to normal thin mull litter for at least 40 years (Ashton 1975b). Some dense patches of *Pomaderris aspera* occur beneath large pioneer form *Acacia dealbata*, which suggests that a previously open-grown stand of *Acacia* has been converted to scrub.

Small gaps in even-aged *Pomaderris* scrub 52 years old are commonly colonised by *Pomaderris aspera* or *Prostanthera lasianthos* which have 10–12 annual rings. The possibility of eucalypt invasion is unlikely due to the remoteness of seed source, the smallness of gaps and the presence of relatively shade tolerant competitors. However, some large patches of scrub may be dominated by *Prostanthera lasianthos*, which senesces and dies out after 60–70 years This species regenerates well in small gaps but if large gaps are produced, invasion by *E. regnans* may occur under favourable conditions.

In the moist mid-tract of the Plenty River valley, large patches of *Pomaderris aspera* scrub with an overstorey of *Acacia melanoxylon* also occur. In contrast to that of the ridge communities, the floor of these stands is covered with dense *Polystichum proliferum* and trunk and logs are covered with copious bryophytes, lichens and small ferns such as *Grammitis billardierei* and *Ctenopteris heterophylla*.

Cassinia aculeata type.—Until about the mid 1950s, this 1–3 m tall community was wide-spread throughout the various catchments (Fig. 61), but by 1970 most of it had senesced and been badly galled by the ascomycete, *Syncarpella congesta* (Fig. 62). In some areas of the Poley Creek valley

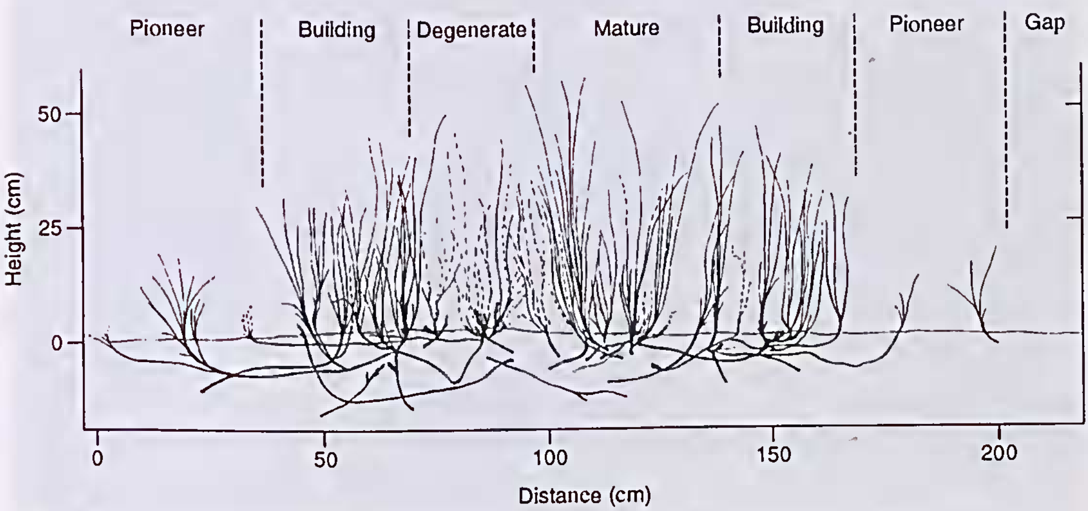


Fig. 79. Profile of phases of patchiness and rhizome development in *Poa ensiformis* tussock grassland.

Cassinia aculeata senesced and died out in the 1960s and 1970s, leaving tall, dense bracken (Fig. 63). However, the density of soil-stored seed is considerable and regeneration occurs readily when the soil is disturbed by animals or vehicle tracks. The understorey of the scrub invariably consisted of bracken, numerous grasses and forbs (Fig. 64), many of which were non-indigenous (Table 8). In many places *Acacia dealbata* is present either as a scattered emergent or dense enough to form a light but complete canopy cover. If scattered *E. regnans* trees or stands are nearby, invasion by *E. regnans* can occur readily in *Cassinia* scrub or under a canopy of *A. dealbata* without the advent of fire (Figs 65, 66). Invasion by wet sclerophyll species *Prostanthera lasianthos*, *Pomaderris aspera*, *Olearia argophylla*, *O. phlogopappa* and *Bedfordia arborescens*, is now common.

In moist sites, *Cassinia aculeata* is taller and the associated mesophytic forbs (eg. *Australina muelleri*, *Stellaria flaccida*) and grasses are more prolific than in the drier sites. In general, *Cassinia aculeata* scrub is seral, being commonly replaced in moist sites by *Pomaderris aspera*, in cool sites on the plateau by *Olearia phlogopappa* and in the drier northern sites by *Goodia lotifolia*.

Brackenland (Pteridium esculentum). This community was widespread in 1950 (Fig. 67) but is now relatively uncommon. Those areas in the Wallaby Creek Catchment not planted with eucalypts, have been invaded by trees (*Acacia dealbata*, *A. melanoxylon*, *E. regnans*) and shrubs (*Pomaderris aspera*, *Olearia argophylla*, *Bedfordia arborescens*, *Prostanthera lasianthos*, *Lomatia fraseri*, *Cassinia aculeata*, *Olearia phlogopappa*). On moist sites such as south-east slopes and near gullies, bracken is often tall (1.5–2.0 m) with a ground stratum of mesic herbs such as *Australina muelleri*, *Stellaria flaccida*, *Hydrocotyle hirta* and *Viola hederacea* (Fig. 68). On the south and east fall of the plateau over the last 40 years, large patches of tall bracken with emergent relic *Cyathea australis* have been infilled by *Acacia melanoxylon*, *Bedfordia arborescens* and *Olearia argophylla* (Fig. 69). The post fire community was similar to what Petrie et al. (1933) recognised as the

Fig. 80. Grassland in the Poley Creek valley frost plain with *Holcus–Danthonia* complex, 1951. Note perched grassland above the bracken slope. All of this community has since been planted with various Victorian montane eucalypts.

'*Pteridium–Alsophila* (*Cyathea*) associes' on the Blacks' Spur. In relatively dry ridge top sites bracken is often short (0.5–1.0 m) with an interrupted ground stratum of both indigenous and exotic herbs such as *Viola hederacea*, *Epilobium glabellum*, *Acaena novae-zelandiae*, *Hypochoeris glabra* and *Centaurium erythraea* (Fig. 70). Many of these areas have been colonised by *Cassinia aculeata* and wet sclerophyll shrubs (Figs 71, 72).

By 1950, most areas of bracken had developed a marked patchiness of vigour and frond density, similar to that described by Watt (1947) for *Pteridium aquilinum* in the Breckland of south-east England. In ridge top sites, bracken is less vigorous and gaps retain relatively little litter of dead fronds. Under these conditions establishment of shrubs and *E. regnans* can occur if seed is available and seed harvesting not intense. In moist sites, bracken is tall and dense and the gap phase is usually clogged with dead frond litter. Only the more shade tolerant species are able to successfully colonise these microsites. The structure of the dry type bracken stand is shown in Fig 73, the species composition in Table 8. Thus the development of patchiness, which had developed 25 years after the 1926 fires, provided the niches for woody plants to establish and ultimately largely suppress the original community.

Grasslands. Tussock grassland (*Poa ensiformis*).—This grassland forms a spectacular frost hollow community where cold air accumulates in the lower Wallaby Creek valley (Fig. 74). Other small areas occur further west. Long lines of charcoal mark the remains of the original trees and tree fern trunks. In 1949–59 one major area of tussock grassland occupied several hectares and was separated from surrounding *E. regnans* forest by a broad band of bracken (Fig. 75A). Conspicuous changes include the colonisation of a low bracken hill 40 years later by *Acacia dealbata* and *E. regnans* (Fig. 75B). On the margins of the surrounding forest, root suckering, frost hardy *Acacia dealbata* encroaches many metres into the grassland and acts as a 'nurse crop' to *E. regnans* which follows as a wave of regeneration (Figs 76, 77). By 1990, the area of grassland in 1950 had shrunken by 40–50% due to an encroachment by bracken of up to 65 m. The drainage of cold air also may have been reduced by the great increase

Fig. 81. Sheet erosion in rabbit-grazed *Danthonia–Holcus–Acaena* grassland, 1951.

in height and complexity of the 1926 regeneration of *E. regnans* on the surrounding slopes. A few frost hardy *E. viminalis* trees and saplings also occur in this frost hollow. It is not known whether they are indigenous or the result of informed planting 60–70 years ago.

The grassland of *Poa ensiformis* shows marked patchiness of vigour and cover which could be identified with the scheme of pattern and process enunciated by Watt (1947). Mature tussocks contained few associates whereas gaps and young phases were associated with species of herbs (*Danthonia racemosa*, *Acetosella vulgare*, *Acaena novae-zelandiae*, *Hypochoeris radicata*, *Moenchia erecta*, *Centaurium erythraea*) as well as mosses (*Polytrichum juniperinum*, *Bryum dichotomum*, *Triquetrella curvifolia*). Bare ground in gaps is a particularly severe microhabitat in winter because of severe frost heaving (Fig. 78). Such areas may develop surface films of the filamentous green alga, *Zygogonium* sp. Detailed study of rhizome distribution indicated that some, if not most, tussocks are a product of the convergence of two or more independent rhizomes (Fig. 79). A similar development was described for *Poa foliosa* at Macquarie Island (Ashton 1965) and *Calamogrostis neglecta* in Iceland (Kershaw 1964). Over the last two decades *Anthoxanthum odoratum* has spread widely from the roadside into the *Poa* community. On slopes beside Wallaby Creek, severe grazing by rabbits in the 1950s led to a certain amount of wind and water erosion. However, since the reduction of this population by myxomatosis, considerable regeneration of grass and shrub species has taken place.

Danthonia–Holcus–Acaena complex.—This community used to occur on the Wallaby and Poley Creek valleys but in the colder sites over the last few decades has been converted to plantations of frost resistant Victorian eucalypts (*E. viminalis*, *E. delegatensis*). It is possible that deforestation over large areas was not only the result of a long history of repeated fires and bullock grazing but also a consequence of the development of paling-splitter settlements. Paling splitter stumps still present in 1950 suggested that not all the area

Fig. 82. Rock outcrop of granodiorite in mature *E. regnans* forest with bryophytes, lichens, herbs (*Australina muelleri*) and litter accumulation on the summit.

was burnt in fires and that some of the vegetation mosaic of the area could have been related to secondary succession in the absence of fire.

The grasslands in frost hollows and frost plains (Fig. 80), consisted of native perennial (*Danthonia racemosa*, *D. setacea*, *D. geniculata*) as well as introduced annual grasses (*Holcus lanatus*, *Aira caryophyllea*, *A. praecox*), as well as numerous forbs (*Verbascum virgatum*, *Cirsium vulgare*, *Mentha satureoides*, *Prunella vulgaris*, *Acaena novae-zelandiae*, *Euchiton gymnocephalus*) and occasional mosses (*Triquetrella curvifolia*, *Polytrichum juniperinum*).

Sometimes, such grasslands occurred at the foot of slopes where cold air pooled against pole-stage stands of *E. regnans*. Presumably such forest stands were initially protected from frost by relatively frost-resistant regeneration of *Acacia dealbata* and *Cassinia aculeata*. Mostly the grassland areas were surrounded by short bracken which could be severely burnt at the crozier stage by late spring frosts. In some places a spill-over of lethally cold air from perched frost hollows could be traced by the swathe of killed bracken croziers.

In parts of the Wallaby–Poley Creek divide where grasslands are exposed to prevailing westerly winds, erosion had exposed patches of soil 5–10 cm below the general surface and winnowed quartzose gravel into deposits 1–2 cm deep on the lee side (Fig. 81). This erosion demonstrates the extent of the degradation of a once tall and mesic forest which was present one century earlier. The species composition of the grassland communities is given in Table 8.

Rock outcrops

Granitic outcrops occur on divides, ridges and in gullies where geological erosion is relatively active. They may occur as flat rock surfaces at ground level or as complex rounded tors with heights and diameters of 0.5–3.0 m. In the former sites, an argument for a lithosere interpretation could be made. However, in the latter sites, boulders are stranded in an environment of deeper soil. They show microseral and cyclic community changes and are not interpretable as part of a lithosere.

Fig. 83. Large rock outcrops of phenocryst granodiorite in the Plenty River rainforest with dense carpets of mesic bryophytes, ferns and herbs.

The boulders will remain for a very long time and communities on them change in response to the changes in the surrounding and overarching vegetation.

In *E. regnans* forest, any flat rock surfaces accumulate litter with humic gravel 1–3 cm deep. These sites may be colonised by scattered turfs of *Bryum billardieri* and mesic herbs such as *Stellaria flaccida*, *Australina muelleri*, *Urtica incisa* and *Hydrocotyle hirta*, either with or without ferns such as *Asplenium flabellifolium*, *Grammitis billardierei*, *Microsorium pustulatum* and *Rumohra adiantiforme* (Fig. 82). Where more than 2–3 cm of humic soil has developed, shrubs such as *Coprosma quadrifida* may establish. On the sides of tors where litter cannot lie, bryophytic mats of *Wijkia extenuta*, *Rhacomitrium crispulum*, *Rhacocarpus purpurascens* and *Lepidozia ulothrix* may be profuse and eventually slough-off in patches. In less dense areas or on near-vertical slopes where bryophytes do not easily remain for long, carpets of foliose lichens (*Parmelia conspersa*) may be present. In dense 25–30-year-old stands of *E. regnans* the somewhat drier microenvironment is reflected in the communities on the rock surfaces. Here, mats of *Rhacomitrium crispulum*, *Thuidium furfurosum*, *Hypnum cupressiforme* and *Cladia aggregata* occur with *Dicranoloma billardieri* on the more sheltered microenvironments.

In the very moist environment of rainforest gullies the profuse vegetation of rock surfaces may also include carpets of filmy ferns (*Hymenophyllum flabellatum*, *H. australe*, *H. cupressiforme*), large trailing, frondose or dendroid mosses (*Dicranoloma billardieri*, *Ptychomnion aciculare*, *Camptochaete ramululosum*, *Cyathophorum bulbosum*, *Hypnodendron arcuatum*) and liverworts (*Radula buccinifera*, *Umbraculum flabellatum*, *Tylimanthus tenellus*). Depending on the light intensity available, the humus on flat surfaces may support various fern species such as *Asplenium bulbiferum*, *Blechnum aggregatum*, *B. wattsii*, *Pellaea falcata* and *Microsorium pustulatum*, as well as establishing seedlings and saplings of wet sclerophyll shrubs and rainforest dominants (Fig. 83).

In the non-forest sites of open bracken, scrub and grassland, rock outcrops are subjected to strong insolation and are consequently frequently very dry. The flat surfaces contain very little plant debris and are colonised by crustose, foliose

Fig. 84. Flat rock outcrops of granodiorite at ground level in grassy bracken communities, Wallaby Creek valley.

(*Parmelia conspersa*, *P. pulla*) and fruticose lichens (*Cladia aggregata*, *Cladonia verticillata*), as well as isolated cushions of xerophytic *Grimmia pulvinata* (Fig. 84). Where soil accumulates to depths of 1–2 cm it is usually colonised by turfs of *Polytrichum juniperinum* and drought-resistant ferns (*Cheilanthes austrotenuifolia*, *Asplenium flabellifolium*) or drought-evading ephemerals such as *Crassula sieberiana* and *Aira caryophyllea*. Although shrubs such as *Cassinia aculeata*, *Olearia phlogopappa* and *Acacia dealbata* establish in rock cracks, they may die in dry years. In slightly more favourable sites in brackenland, bryophytic turfs (*Campylopus introflexus*, *Bryum billardieri*) and mats (*Breutelia affinis*, *Rhacomitrium crispulum*, *Hypnum cupressiforme*) commonly occur (Fig. 85). From the presence of large *E. regnans* stumps and logs and the remains of tree ferns, it is clear that these exposed sites were also once covered with dense forest and probably supported rock surface communities similar to those in forest areas today. Fire and consequent exposure and desiccation has caused the regression of these lithosere micro-communities to a more xeric stage. Complete reforestation and restoration of these areas may take a century or more.

In drier zones, such as low *E. obliqua–E. cypellocarpa* forests at Stokes Hill (Fig. 86), massive rock surface communities consist of *Bryum billardieri*, *Campylopus introflexus*, *Cladia aggregata* and *Cladonia verticillata* on the flatter surfaces, and *Hypnum cupressiforme*, *Lophocolea semiteres* and *Thuidium furfurosum* on the slopes, with eucalypts and shrubs in the major rock joints. The cryptogamic communities are thus somewhat similar to rock outcrop sites in the drier, open bracken areas of the *E. regnans* zone. A lithosere on a naturally exposed site occurs on the south side of the Wallaby Creek gorge at Nimmo Falls, where a large granitic rock face, above a quarry used in the 1860s, is exposed to the north-east, but is well clear of the *E. radiata*, *E. obliqua* and *E. cypellocarpa* forest to the south. The rock face slopes gently towards the gorge and displays a striking zonation of vegetation which is correlated with the depth of soil accumulated. Towards the edge of the rock slope a mosaic of bare rock, mats of *Parmelia* and cushions of *Grimmia* occur where erosion is continually taking place. Beyond this zone, dense carpets and turfs of the mosses, *Breutelia affinis*, *Campylopus introflexus*, *Rhacomitrium crispulum*, *Cladia aggregata* and

Fig. 85. Boulder of granodiorite in moist bracken with moss mats and fruticose lichens (*Cladia aggregata*).

Bryum billardieri occur for several metres. Commonly the dense moss mats advance over and suppress the foliose and crustose lichens unless swept from the rock surface by heavy rains (Ashton & Webb 1977). As in the sites in the bracken and grasslands, *Polytrichum juniperinum* forms a dense turf where soil is about 2 cm deep. It is associated with *Crassula sieberiana*, *Geranium potentilloides*, *Oxalis corniculata*, *Ophioglossum lusitanicum*, and introduced ephemerals such as *Aira caryophyllea*, *Vulpia bromoides*, *Anagallis arvensis*, *Centaurium erythraea* and *Cerastium glomeratum*. The ecotone between the rock outcrop vegetation and the forest is marked by a prominent band of *Lomandra longifolia* and associated ferns (*Cheilanthes austrotenuifolia*, *Asplenium flabelliforme*, *Adiantum aethiopicum*), where soils are up to 15 cm deep. A further zone of scrub 5–8 m wide, consists of *Cassinia aculeata*, *Goodia lotifolia*, *Acacia dealbata*, *A. obliquinervia* and *Poa* sp. (Fig. 87). The forest of *E. radiata* and *E. obliqua* contains most of the scrub species in the understorey, although the floor is dominated by various grasses amid a scattering of small, stranded boulders covered by mats of *Thuidium sparsum*. In the severe drought of 1976–78, much vascular vegetation died on shallow soils up to 10 m from the rock face. However, most of this had recovered by 1990 in spite of the drought and fire of the 1982–83 season. Perturbations such as these are natural events and clearly the species inhabiting these sites are resilient. Colonisation of broken granodiorite in the quarry has reached the *Parmelia* stage after 80 years (Fig. 88), indicating even in this moist climte, the very long period of early vegetation development.

CONCLUSIONS AND DISCUSSION

The *E. regnans* forests on the Hume Range are, for the most part, above the altitudinal level of the cold front cloud bases and therefore are considerably benefited by additional fog drip, as well as increased annual rainfall, resulting from increased altitude. At lower altitudes, *E. regnans* extends along gullies where it benefits from

Fig. 86. Massive rock outcrops of granodiorite at Stokes Hill with stunted *E. cypellocarpa* in major crevices associated with *Lomandra longifolia* and *Cheilanthes austrotenuifolia*.

increased moisture availability and protection from winds and fire by the surrounding topography. On parts of the plateau, thin soils and rocky knolls compensate for increased rainfall and permit *E. cypellocarpa* (eg. Yorktown Hill) and occasionally *E. obliqua* (eg. Stokes Hill) to compete with *E. regnans* and occupy the sites. On the south fall of the plateau where the climatic gradient is sharp, the boundary between *E. regnans* and *E. obliqua* is also sharp and may be associated with an increase in abundance of *E. cypellocarpa*. This behaviour has been suggested by Ashton (1981) to be related to the competitiveness between eucalypt species and relative tolerance to shade and drought. On the northern parts of the plateau where the climatic gradient is more gradual, *E. regnans* and *E. obliqua* may form mixed stands in a broad ecotone, which may be manifest as a mosaic of pure patches (Ashton & Martin 1996b).

The *E. obliqua–E. radiata* open-forests develop understoreys ranging from sclerophyll shrub, damp fern or light grassy-shrub types which are associated with both topography (and therefore climate and soil type) and geographic position on the the range.

The foothill forests and woodlands contain a relatively large number of eucalypts species complexly distributed according to subtleties of aspect, slope, soil depth and type. Their understoreys range from well-developed sclerophyll shrub strata to forb and tussock grass or sparse grasses and scattered shrubs. Such development may be due in part to soil nutrient status, soil moisture storage, the time since the last fire (Specht 1972) or the season of the fire (Baird 1977).

The boundaries of the overstorey eucalypts appear to be stable, however minor fluctuations occur between *E. regnans* and *E. obliqua* due to the height growth dominance displayed by the former species in post-fire ecotonal areas (Ashton 1981). In *E. obliqua–E. radiata* forests, the latter species is more predominant in the lower strata, which suggests that it may eventually dominate the mixture unless fire restores the balance of regenerating species. A similar situation occurs with *E. dives* in lower strata of dry sclerophyll forest of *E. macrorhyncha–E. goniocalyx–E. dives* (Ashton 2000b). These examples are, however, concerned with changing proportions of species in the stand and not overall boundary changes.

Fig. 87. Large rock ledge of granodiorite near the boundary of the batholith at Nimmo Falls (1968), showing zonation of lichens, mosses and mat rush (*Lomandra longifolia* with increasing soil depth).

The *E. regnans* zone has been severely damaged over much of the plateau by the plethora of fires over the last 100 years. These and some selective logging has resulted in a loss of the forest complement and its replacement by a mosaic of scrub, bracken and grassland where fire frequencies are shorter than the reproductive time of the species.

Cassinia scrub and brackenland are clearly seral over wide areas, but the denser *Pomaderris* scrub of drier sites is likely to be intractable and self perpetuating even in the absence of fire. Grassland has developed in suitable low-lying sites on the plateau in response to the accumulation of cold air and the death and regeneration failure of taller competitive plants. Such frost hollow communities are also seral due to the gradual encroachment of forest or scrub. This may be due to the reduction of cold air pooling as a consequence of the sinking and mixing of cooled air amongst the taller canopies of maturing *E. regnans* forest on the adjacent slopes.

Although the vast majority of regenerated *E. regnans* stands are fire induced, some patchy, relatively even-aged stands may have arisen following invasion of light scrub and bracken in interfire periods over 10–20 years.

The site quality for tree growth varies with topography, aspect, slope, soil moisture storage and to some extent soil parent material. Fifty-year-old stands initiated *c.* 1900 on poor sites may therefore be of equal or lesser stature than those initiated 25 years later on good sites.

The wet sclerophyll understorey component of the *E. regnans* forest in 1950 occurred through the southern part of the Wallaby Creek Catchment. It is thought that this boundary did not necessarily indicate a limiting climatic boundary but rather the effects of the past fire regimes. Small outliers of *Pomaderris aspera* scrub occurring on the Wallaby Creek–Silver Creek divide are probably relics of a former wider distribution. Today the wet sclerophyll elements have spread a kilometre or more northwards and, 70 years after the 1926 fire, appear to be reclaiming much of their original distribution in the *E. regnans* zone. These broad-leaved elements are also advancing up to 200–300 m into adjacent wet forests of *E. obliqua–E. cypellocarpa–E. radiata*, on the moister south and east slopes, particularly south of the Great Divide.

Fig. 88. Granodiorite rock chips in the aqueduct quarry at Nimmo Falls, showing foliose lichen stage of colonisation (*Parmelia conspersa*, *P. pulla*) over a period of 80 years.

It is possible that the shallower-rooted understorey species are responding to the seasonally more equable rainfalls in the south, whereas the deeper-rooted overstorey eucalypts are influenced more by water storage in the subsoil and accessable parent material.

Understoreys of *E. regnans* are variable and although the richness of vascular species may decrease with time since the last fire (Ashton & Martin 1996a, 1996b), the reverse may hold for bryophytes and lichens (Ashton 1986). The regimes of repeated fires of variable intensities has produced a wide range of understoreys which are gradually adjusting to their pre-fire condition. These seral stages may be arbitrarily divided into a number of classes depending on their duration: very short (3–5 years); short (20–40 years); long (80–120 years); and very long (300–500 years). In general the time scale is predicated by the longevity of the species, its regeneration capacity and its reaction to competition by taller growing, more vigorous associates. In the *E. regnans* zone very short stages include 'fire weeds' such as *Senecio quadridentatus* and *Dryopoa dives*, whilst short stages include *Cassinia aculeata*, *Prostanthera lasianthos* and *Pteridium esculentum*. The persistence of bracken is to some extent dependent on the development of patchiness and gap production which enables shrub and tree invasion to take place and eventually suppress the original community. Long term stages include *Pomaderris aspera* which may succumb to damage and infection and be unable to regenerate in the presence of vigorous ground-fern strata. Very long term stages may include lignotuberous species such as *Olearia argophylla* and *Bedfordia arborescens* (Mueck et al. 1996), the former of which is able to regenerate in shady conditions and may remain as a component of a 'climax' stand (Ashton 2000a). *E. regnans*, which is the most notable member of this group, will have largely died out after 500–600 years. In the Big Ash at Wallaby Creek, the increase in cover and luxuriance of ferns 100 years after the last fire suggests that the moisture status becomes more favourable as the tree and shrub strata of the understorey strata mature and thin out. This could be thought of as a compensating of resources within the stand. As one stratum declines in vigour and density, more resources are available to other more shade tolerant and persistent strata to develop. Whether or not such resources are fully utilised may well determine whether new species in the secondary succession can establish and whether certain species can regenerate. The increase in the cover of the fern strata has continued in spite of two very severe droughts (1967–68 and 1982–83), in which *B. wattsii* withered in many areas of plateau forest (Ashton 2000a).

The spontaneous appearance in the Big Ash of occasional seedlings of *Atherosperma moschatum* 0.5 km from the nearest gullies, testifies to its dispersal capacity, and suggests that it may eventually become established as a form of rainforest in this area, if no fires occur before the last old, seed-bearing *E. regnans* trees have died.

Rainforest vegetation on the Hume Range occurs typically in gullies where moisture is least variable and where steep topography creates 'fire-shadows' (Melick & Ashton 1991). In shallow gullies on the plateau, rainforest has been burnt out and replaced by wet sclerophyll scrub. This is now being slowly invaded by long distance dispersal of *Atherosperma moschatum*.

Similarly, tall, even-aged swamp scrub of *Leptospermum grandifolium* is, after 50–60 years, being invaded by young *Atherosperma moschatum*. In places this development is likely to result in a mixed rainforest community of these species and *Acacia melanoxylon*.

The potential longevity of the Big Ash forest has undoubtedly been reduced by the damage inflicted by surface fires which created butt scars that have allowed the entry of wood rots and termites. Trees have been weakened and crowns of old trees, once broken, are less easily repaired. Early observations by the early pioneers (Committee of the South Gippsland Pioneers' Association 1920) indicated that the Big Forest in that region consisted of a mosaic of various age classes including occasional old eucalypts of enormous dimensions. Understoreys likewise, showed great variability over short distances and were not necessarily replaced after the passage of fires—especially if soil seed had died out in long interfire periods.

The structure and composition of vegetation at any time is thus but a 'snap-shot' of its developmental sequence. Pollen analysis by Pittock (1989) of the peat in the Poley Creek swamp at 630 m a.s.l., indicated that grasses and *Tasmannia* were more common in the early Holocene than today, and thus the vegetation may have been similar to the present-day montane zone at or above 1000 m a.s.l. This observation is consistent with there being colder conditions in the early Holocene and suggests that a great deal of the present wet forest species have arrived here since that time (Pittock 1995).

The view that vegetation changes with time is not new but has been emphasised during the 51 years of this study. Not only have young stands developed and thinned out during that time, but unsuspected changes in the understoreys (such as the great proliferation of *Coprosma quadrifida*) have occurred, due both to the senescence of certain species as they reached their lifespan, and by invasion of others by normal dispersal vectors and chance events.

The Hume Range ecology is under the influence of a wide variety of factors, including climate and climatic changes, variation in topography, soils and fire regimes. Most importantly it shows the extent to which vegetation will change and eventually recover from serious disturbance.

Prediction of future changes can only be made from the experience and evidence from the past. Vegetation at various scales of pattern is frequently in a state of flux. Any management demands a detailed knowledge of synecology and autecology of the major species. Long term observations remain essential prerequisites for gaining ecological perspective. Adequate conservation not only requires that we know what we want to conserve but also where, how and why. To date, this task in many areas has only just begun.

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REFERENCES

Ashton, D. H., 1958. The ecology of *Eucalyptus regnans* F. Muell.: the species and its frost resistance. *Australian Journal of Botany* 6: 154–176.

Ashton, D. H., 1965. Regeneration pattern of *Poa foliosa* Hook f. on Macquarie Island. *Proceedings of the Royal Society of Victoria* 79: 215–233.

Ashton, D. H., 1975a. The seasonal growth of *Eucalyptus regnans* F. Muell. *Australian Journal of Botany* 23: 239–252.

Ashton, D. H., 1975b. Studies in litter in *Eucalyptus regnans* forests. *Australian Journal of Botany* 23: 413–433.

Ashton, D. H., 1975c. The root and shoot development of *Eucalyptus regnans* F. Muell. *Australian Journal of Botany* 23: 867–887.

Ashton, D. H., 1975d. Studies of flowering behaviour in *Eucalyptus regnans* F. Muell. *Australian Journal of Botany* 23: 399–411.

Ashton, D. H., 1976a. The development of even-aged stands of *Eucalyptus regnans* F. Muell. in central Victoria. *Australian Journal of Botany* 24: 397–414.

Ashton, D. H., 1976b. Studies on the mycorrhizae of *Eucalyptus regnans* F. Muell. *Australian Journal of Botany* 24: 723–741.

Ashton, D. H., 1979. Seed harvesting by ants in forests of *Eucalyptus regnans* F. Muell. *Australian Journal of Ecology* 4: 265–277.

Ashton, D. H., 1981a. The ecology of the boundary between *Eucalyptus regnans* F. Muell. and *E. obliqua* l'Herit. in Victoria. *Proceedings of the Ecological Society of Australia* 11: 75–94.

Ashton, D. H., 1981b. Fire in Tall Open Forests (Wet Sclerophyll Forests). In *Fire and the Australian Biota*, A. M. Gill, R. H. Groves & I. R. Noble, eds, Australian Academy of Science, Canberra.

Ashton, D. H., 1984. Artificial hybrids produced by the pollination of *Eucalyptus regnans* F. Muell. by *E. obiqua* l'Herit. and *E. baxteri* (Benth.) Maiden and Blakely at Foster North, Victoria. *Victorian Naturalist* 101: 193–198.

Ashton, D. H., 1986. Ecology of bryophytic communities in mature *Eucalyptus regnans* F. Muell. forest at Wallaby Creek, Victoria. *Australian Journal of Botany* 34: 107–129.

Ashton, D. H., 2000a. The Big Ash Forest, Wallaby Creek—changes in one lifetime. *Australian Journal of Botany* 48: 1–26.

Ashton, D. H., 2000b. Ecology of eucalypt regeneration. In *Diseases and Pathogens of Eucalypts*, P. J. Keane, G. A. Kile & B. N. Brown, eds, CSIRO Publishing, Melbourne.

Ashton, D. H. & Attiwill, P. M., 1994. Tall Open Forest. In *Australian Vegetation* 2nd edn, R. H. Groves, ed., The University Press, Cambridge, U.K., 157–196.

Ashton, D. H. & Bassett, O. D., 1997. The effects of foraging by the Superb Lyrebird (*Menura novae-hollandiae*) in *Eucalyptus regnans* forests at Beenak, Victoria. *Australian Journal af Ecolagy* 22: 383–394.

Ashton, D. H. & Chinner, J. H., 1999. Problems of regeneration of the mature *Eucalyptus regnans* F. Muell. (The Big Ash) forest in the absence of fire at Wallaby Creek, Victoria, Australia. *Australian Forestry* 62: 285–290.

Ashton, D. H. & Kelliher, K. J., 1996a. Effects of soil desiccation on the growth of *Eucalyptus regnans* F. Muell. seedlings. *Journal of Vegetation Science* 7: 487–496.

Ashton, D. H. & Kelliher, K. J., 1996b. The effect of soil desiccation on the nutrient status of *Eucalyptus regnans* seedlings. *Plant and Soil* 179: 45–56.

Ashton, D. H. & Martin, D. G., 1996a. Regeneration in a pole stage forest of *Eucalyptus regnans* subjected to different fire intensities in 1982. *Australian Journal of Botany* 44: 393–410.

ASHTON, D. H. & MARTIN, D. G., 1996b. Changes in a spar-stage ecotonal forest of *Eucalyptus regnans*, *Eucalyptus obliqua* and *Eucalyptus cypellocarpa* following a wildfire on the Hume Range in November 1982. *Australian Forestry* 59: 32–41.

ASHTON, D. H. & TURNER, J. S., 1979. Studies on the light compensation point of *Eucalyptus regnans* F. Muell. *Australian Journal of Botany* 27: 598–607.

ASHTON, D. H. & WEBB, R. N., 1977. The ecology of granite outcrops at Wilson's Promontory. *Australian Journal of Ecology* 2: 269–296.

ASHTON, D. H. & WILLIS, E. R., 1982. Antagonisms in the regeneration of *Eucalyptus regnans* in the mature forest. The plant community as a working mechanism. *Special publications series of the British Ecological Society* No. 1, E. I. Newman, ed., 113–128.

ATTIWILL, P. M & LEEPER, G. W., 1987. *Forest soils and nutrient cycles*. Melbourne University Press, Melbourne.

BAIRD, A. M., 1977. Regeneration after fire in King's Park, Perth, Western Australia. *Journal of the Royal Society of Western Australia* 60: 1–22.

BROOKES, J. D., 1950. The relation of vegetative cover to water yield in Victorian mountain watersheds. MSc Thesis, University of Melbourne (unpublished).

BROOKES, J. D. & TURNER, J. S., 1963. Hydrology and Australian Forest Catchments. in 'Water Resources —Use and Management', Proceedings of a symposium held at Canberra by the Australian Academy of Science, 9–13 September 1963. Melbourne University Press, Melbourne.

BUSBY, J. R. & BROWN, M. J., 1994. Southern Rainforests. In *Australian Vegetation*. 2nd edn, R. H. Groves, ed., The University Press. Cambridge, U.K., 131–156.

CHAMBERS D. & ATTIWILL, P. M., 1994. The ash-bed effect in *Eucalyptus regnans* forest: chemical, physical and microbiological changes in soil after heating or partial sterilisation. *Australian Journal of Botany* 42: 739–749.

CHESTERFIELD, E. A., 1996. Changes in a mixed forest after fire and clear felling silviculture in the Errinundra Plateau. *Flora and Fauna Technical Report* 142, Department of Conservation & Environment, Heidelberg, Victoria.

CLIFFORD, H. T., 1950. Plant ecology in the Dandenong Range with special reference to the *Eucalyptus* species. MSc Thesis, University of Melbourne (unpublished).

CLIFFORD, H. T., 1953. On the distribution of the species of *Eucalyptus* in the region of the Dandenong Range, Victoria. *Proceedings of the Royal Society of Victoria* 65: 30–55.

COMMITTEE OF THE SOUTH GIPPSLAND PIONEERS ASSOCIATION, 1920. *The Land of the Lyre Bird*, Gordon & Gotch, Melbourne.

FINCH, V. C. & TREWARTHA, G. T., 1942. *Elements of Geography. Physical and Cultural*, McGraw-Hill Book Co., New York.

FOLEY, J. C., 1945. *Frost in the Australian Region* Bulletin 32: Commonwealth Meteorological Bureau, Melbourne, 142 pp.

GILL, A. M. & ASHTON, D. H., 1968. The role of bark type in relative resistance to fire in three central Victorian eucalypts. *Australian Journal of Botany* 16: 491–498.

GRIFFIN, A. R., BURGESS, I. P., & WOLF, L., 1988. Pattern of natural and manipulated hybridisation in the genus *Eucalyptus* l'Herit.—a review. *Australian Journal of Botany* 36: 41–66.

HILLS, E. S., 1975. *Physiography of Victoria*. Whitcombe & Tombs, London.

HOLMES, L. C., LEEPER, G. W. & NICHOLLS, K. D., 1940. Soils and land utilisation around Berwick. *Proceedings of the Royal Society of Victoria* 52: 177–245.

HOVELL, W. H. & HUME, H., 1831. Journey of Discovery of Port Phillip, New South Wales in 1824 and 1825. W. Bland, ed., A. Hill. Sydney, i–viii, 1–87 +Appendix 5 pp.

KERSHAW, K. A., 1964. *Quantitative and Dynamic Ecology*. Edward Arnold, London.

LEEPER, G. W. & UREN, N. C., 1993. *Soil Science, An Introduction*, 5th edn. Melbourne University Press, Melbourne.

LEITCH, C. J., FLINN, D. W. & VAN DER GRAAF, R. H. M., 1983. Erosion and nutrient loss resulting from Ash Wednesday (February 1983) wildfires: a case study. *Australian Forestry* 46: 173–180.

MELBOURNE WATER, 1987. *Stony Creek reference area system management plan*. Unpublished report, Forestry & Land Management Section, Melbourne & Metropolitan Board of Works, Victoria.

MUECK, S. G., OUGH, K. & BANKS, J. C. G., 1996. How old are wet forest understoreys? *Australian Journal of Ecology* 21: 349–351.

NORTHCOTE, K. H., 1979. *A factual key for the recognition of Australian soils* 4th edn, Rellim Technical Publication, Adelaide, 123 pp.

NIKIVOROFF, C. C., 1948. Stony Soils—their classification. *Soil Science* 66: 347–363.

PATTON, R. T., 1933. Ecological studies in Victoria. The fern gully. *Proceedings of the Royal Society of Victoria* 42: 117–129.

PETRIE, A. H. K., JARRETT, P. H. & PATTON, R. T., 1929. Vegetation of the Blacks' Spur region, Pt 1 Pyric Succession. *Journal of Ecology* 17: 249–281.

PITTOCK, J., 1989. Palaeoenvironment of the Mt Disappointment plateau (Kinglake West, Victoria) from the late Pleistocene. BSc(Hons) Thesis, Monash University (unpublished).

RAAF, 1944. *Weather on the Australia Station*. Publication No. 252, Cover B, Pt 7, 116 pp.

ROSS, D., 1982. *TAXON Users Manual* Edn 3. Division of Computing Research, CSIRO, Canberra.

ROYAL COMMISSION, 1876. *Report from the Select Committee on the water reserve, Plenty Ranges*. Parliament of Victoria, Parliamentary Paper D11/1876: 733–755.

SCOTT, G. A. M. & STONE, I. G., 1976. *The Mosses of Southern Australia*. Academic Press, London.

SEEGER, R. C., 1948–49. The History of Melbourne's Water Supply Catchment Policy. *MMBW Federation Journal*, December 1948–June 1949, 21 pp.

SPECHT, R. L., 1972. *The Vegetation of South Australia* 2nd Edn. Government Printer, Adelaide.

THORNTHWAITE, C. W., 1931. The climates of North America according to a new classification. *Geography Reviews* 21: 633–655.

WALSH, N. G. & ENTWISTLE, T. J., 1994. *Flora of Victoria* Vol. 2: Ferns, allied plants, conifers and monocotyledons. Inkata Press, Melbourne, 946 pp.

WALSH, N. G. & ENTWISTLE, T. J., 1996. *Flora of Victoria* Vol. 3: Dicotyledons Winteraceae to Myrtaceae. Inkata Press, Melbourne, 1073 pp.

WALSH, N. G. & ENTWISTLE, T. J., 1999. *Flora of Victoria* Vol. 4: Dicotyledons Cornaceae to Asteraceae. Inkata Press, Melbourne, 1088 pp.

WATT, A. S., 1947. Pattern and process in the plant community. *Journal of Ecology* 35: 1–22.

WILLIAMS, G. E., 1964. The geology of the Kinglake district, central Victoria. *Proceedings of the Royal Society of Victoria* 77: 273–324.

Appendix 1. Chemical analysis of soils and litter from *E. regnans* zone. P (HCl extract) % ODW; pH 1 : 5 dilution; cations (ME%) ammonium acetate exchange. Number of replicates = 3 (except for Big Ash *Pomaderris*, where n = 5). Organic matter Walkley & Black values; %N as NH_3; trace elements ppm; %P as HCl extract; avail. P as 0.05 N H_2SO_4 extract as ppm.

Community: Profile		Soil component												
		pH	%OM	%P	(avail.)	%N	ME%Ca	ME%Mg	ME%K	Mn	Fe	Zn	Cu	Mo
Big Ash: Type A granite														
Litter		4.28	—	0.033		—	34.50	8.90	2.20	170.0	—	12.8	12.0	0.13
Soil (a)	0–7.5 cm	4.40	18.0	0.028	(7.2)	0.050	2.90	0.98	0.76	97.0	97.0	2.8	0.5	—
(b)	15.0–22.5	4.49	12.2	0.025	(1.8)	0.040	0.72	0.15	0.29	19.0	90.0	0.4	0.3	—
(c)	30.5–37.5	4.52	10.8	0.020	(1.6)	0.036	0.78	0.30	0.48	18.0	82.0	0.5	0.2	—
(d)	60.0–67.5	4.51	5.0	0.015		0.015	0.12	0.17	0.37	0.1	79.0	0.4	0.1	—
(e)	120.0–127.5	4.47	2.2	0.013	(0.8)	0.014	0.14	0.23	0.28	—	89.0	0.3	0.1	—
Big Ash: Type C granite														
Litter		4.40	—	0.037		—	32.60	9.50	2.77	122.0	—	21	6.7	0.13
(a)		5.10	17.7	0.031	(1.3)	0.049	4.66	2.03	1.05	42.0	57.0	2.2	0.5	—
(b)		5.03	13.0	0.027	(0.8)	0.038	1.33	0.43	0.61	17.3	63.0	0.2	0.3	—
(c)		4.92	11.0	0.023	(0.6)	0.029	0.57	0.22	0.40	17.3	57.0	0.2	0.1	—
(d)		4.96	4.3	0.016	(0.5)	0.011	0.10	0.22	0.33	5.0	70.0	0.2	—	—
Young Ash: *Pomaderris* hornfels														
Litter		4.27	—	0.037		—	36.33	7.83	1.53	167.0	—	12.0	8.0	0.05
(a)		4.77	25.0	0.035	(5.0)	0.054	7.27	2.27	0.92	83.0	43.0	1.9	0.6	—
(b)		4.92	15.3	0.028	(2.3)	0.040	0.87	0.23	0.53	20.0	48.0	0.3	0.3	—
(c)		4.92	11.0	0.024	(1.7)	0.032	0.20	0.06	0.41	12.0	43.0	0.2	0.2	—
(d)		4.87	5.7	0.020	(0.7)	0.013	0.13	0.05	0.27	3.0	60.0	0.2	0.1	—
Young Ash: *Pomaderris* granite														
Litter		4.13	—	0.023		—	24.17	7.68	1.53	188.0	—	11.3	5.7	0.07
(a)		4.63	16.0	0.020	(0.8)	0.043	1.80	0.51	0.51	30.0	97.0	1.9	0.3	—
(b)		4.73	11.3	0.017	(1.0)	0.023	0.40	0.16	0.38	8.0	80.0	0.5	0.1	—
(c)		4.80	8.3	0.015	(0.8)	0.013	0.20	0.12	0.34	3.0	72.0	0.2	0.1	—
(d)		4.77	4.0	0.013	(1.0)	0.007	0.10	0.10	0.23	—	80.0	—	—	—
Young Ash: *Cassinia* hornfels														
Litter		4.00	—	0.029		—	22.67	9.33	1.43	215.0	—	11.0	5.0	0.05
(a)		4.63	19.0	0.027	(2.3)	0.042	2.13	0.48	0.43	51.0	73.0	2.2	0.4	—
(b)		4.78	17.0	0.023	(1.3)	0.035	0.93	0.29	0.51	27.0	53.0	0.5	0.2	—
(c)		4.93	10.0	0.015	(0.5)	0.016	0.20	0.09	0.53	13.0	45.0	0.1	0.1	—
(d)		4.53	6.0	0.019	(0.5)	0.009	0.13	0.18	0.31	3.0	70.0	—	—	—

Appendix 1 continued next page

Community: Profile	pH	%OM	%P	(avail.)	%N	ME%Ca	ME%Mg	ME%K	Mn	Fe	Zn	Cu	Mo
						Soil component							
Scrub: Silver wattle *Pomaderris* hornfels													
Litter	5.00	—	0.047		—	59.33	15.00	2.63	170.0	—	19.0	13.0	0.07
(a)	4.60	24.0	0.027	(3.7)	0.059	7.03	1.32	1.01	32.0	43.0	2.7	0.5	—
(b)	4.62	15.3	0.022	(1.3)	0.035	0.77	0.29	0.46	32.0	38.0	0.3	0.2	—
(c)	4.57	8.7	0.017	(0.7)	0.015	0.10	0.08	0.39	10.0	38.0	0.2	0.1	—
(d)	4.60	6.7	0.016	(0.5)	0.016	0.10	0.21	0.44	7.0	45.0	0.2	0.1	—
Scrub: Silver wattle *Cassinia* granite													
Litter	4.73	—	0.071		—	26.83	15.50	3.33	168.0	—	38.0	15.0	0.23
(a)	4.60	17.3	0.042	(1.0)	0.046	4.73	2.21	0.94	30.0	27.0	1.4	0.5	—
(b)	4.72	14.3	0.030	(2.3)	0.034	0.47	0.36	0.38	28.0	38.0	0.4	0.2	—
(c)	4.67	11.3	0.025	(0.5)	0.027	0.37	0.07	0.30	12.0	35.0	0.3	0.1	—
(d)	4.67	5.7	0.020	(0.5)	0.014	0.23	0.09	0.15	5.0	42.0	0.2	0.1	—
Scrub: *Cassinia* granite													
Litter	4.77	—	0.071		—	26.83	15.50	3.33	168.0	—	38.0	15.0	0.23
(a)	5.07	17.3	0.042	(1.7)	0.046	4.73	2.21	0.94	30.0	27.0	1.4	0.5	—
(b)	4.78	14.3	0.030	(0.7)	0.034	0.47	0.36	0.38	28.0	38.0	0.4	0.2	—
(c)	4.82	11.3	0.025	(0.7)	0.027	0.37	0.07	0.30	12.0	35.0	0.3	0.1	—
(d)	4.83	5.7	0.020	(0.5)	0.014	0.23	0.09	0.15	5.0	42.0	0.2	0.1	—
Bracken: Hornfels													
Litter	4.77	—	0.047		—	22.50	12.17	2.63	228.0	—	20.0	4.0	0.12
(a)	5.08	20.7	0.031	(3.7)	0.047	5.69	3.10	0.86	53.0	27.0	2.2	0.4	—
(b)	4.97	16.3	0.027	(1.7)	0.041	1.47	0.27	0.93	37.0	23.0	0.1	0.2	—
(c)	4.83	10.7	0.020	(0.8)	0.031	0.23	0.10	0.44	11.0	27.0	0.1	0.1	—
(d)	4.70	5.7	0.017	(0.5)	0.014	0.17	0.08	0.27	2.0	47.0	—	0.1	—
Bracken: Granite													
Litter	4.53	—	0.057		—	22.00	12.00	1.73	92.0	—	17.0	4.0	0.12
(a)	5.35	17.3	0.040	(2.7)	0.045	5.93	2.87	0.81	30.0	18.0	2.2	0.4	—
(b)	5.23	13.0	0.026	(1.3)	0.034	1.80	0.37	0.61	30.0	28.0	0.2	0.3	—
(c)	5.17	9.3	0.021	(0.5)	0.026	0.87	0.11	0.27	15.0	38.0	0.1	0.2	—
(d)	4.97	4.3	0.016	(0.5)	0.012	1.17	0.50	0.49	3.0	55.0	0.1	0.1	—
Poa grassland: Hornfels													
Litter	4.23	—	0.064		—	10.67	3.50	2.30	82.0	—	22.0	6.0	0.18
(a)	5.15	16.3	0.035	(1.0)	0.047	4.90	1.70	1.33	32.0	30.0	1.6	0.4	—
(b)	5.07	12.0	0.023	(1.0)	0.034	1.93	0.67	0.86	23.0	35.0	0.3	0.2	—
(c)	4.98	8.0	0.019	(0.5)	0.024	1.00	0.39	0.63	20.0	40.0	0.2	0.1	—
(d)	4.83	3.3	0.017	(0.5)	0.010	0.50	0.37	0.55	13.0	45.0	0.3	—	—
Rainforest: Sassafras Creek													
Litter	4.43	—	0.052		—	22.67	9.17	4.03	260,0	—	14.0	7.0	0.01
(a)	4.38	16.7	0.029	(4.3)	0.045	1.50	0.21	0.39	25.0	77.0	24.0	0.3	—
(b)	4.53	12.0	0.020	(2.7)	0.032	0.30	0.04	0.19	7.0	92.0	0.8	0.2	—
(c)	4.69	10.0	0.018	(4.0)	0.029	0.40	0.13	0.13	3.0	72.0	0.5	0.3	—
(d)	4.75	6.0	0.019	(1.7)	0.014	0.10	0.02	0.11	—	100.0	0.5	0.1	—
Rainforest: Beech Plenty River													
Litter	4.47	—	0.048		—	20.50	7.83	3.20	260.0	—	15.0	7.0	0.12
(a)	4.40	18.7	0.027	(6.0)	0.039	1.70	0.25	0.43	45.0	72.0	2.9	0.7	—
(b)	4.38	10.7	0.021	(6.3)	0.031	0.60	0.06	0.26	55.0	70.0	2.0	0.4	—
(c)	4.55	9.0	0.018	(1.7)	0.022	0.33	0.04	0.12	—	120.0	0.8	0.6	—
(d)	4.82	5.0	0.028	(2.0)	0.014	0.60	0.12	0.23	20.0	87.0	1.9	0.6	—

Appendix 2. Vascular plants on the Hume Range, 1949–69 (includes catchments of Wallaby, Silver, Strath and Sunday creeks, and East Plenty and West Plenty rivers). Nomenclature following Walsh & Entwistle (1994–96). * = exotic species.

Pteridophyta
FILICINAE
Ophioglossaceae
Ophioglossum lusitanicum
Osmundiaceae
Todea barbara
Gleicheniaceae
Gleichenia microphylla
Sticherus flabellatus
Hymenophyllaceae
Hymenophyllum flabellatum
H. australe
H. cupressiforme
Polyphlebium venosum
Cyatheacae
Cyathea australis
Dicksoniaceae
Dicksonia antarctica
Dennstaediaceae
Pteridium esculentum
Calochlaena dubia
Hypolepis glandulifera
Histiopteris incisa
Lindsayaceae
Lindsaea linearis
Pteridaceae
Pteris tremula
Adiantaceae
Adiantum aethiopicum
Cheilanthes austrotenuifolia
Pellaea falcata
Grammitidaceae
Grammitis billardierei
Ctenopteris heterophylla
Polypodiaceae
Microsorium pustulatum
Aspleniaceae
Asplenium flabellifolim
A. bulbiferum
A. flaccidum
Athyriaceae
Allantodia australis
Dryopteridacae
Rumohra adiantifarmis
Polystichum proliferum
Lastreopsis acuminata
Blechnaceae
Blechnum wattsii
B. cartilagineum
B. nudum
B. chambersii
B. fluviatale
B. patersonii
B. minus
Culcitidaceae
Calochlaena dubia
Psilophytinae
Psilotaceae
Tmesipteris obliqua

Spermatophyta
GYMNOSPERMAE
Pinaceae
*Pinus radiata**
ANGIOSPERMAE
Monocotyledonae:
Typhaceae
Typha latifolia
Potamogetonaceae
Potamogeton ochreatus
Juncaginacae
Triglochin striatum
T. procerum
Poaceae
*Ehrharta erecta**
Microlaena stipoides
Tetrarrhena juncea
T. distichophylla
*Briza minor**
Poa ensiformis
P. labillardieri
P. helmsii
P. sieberiana
P. morrissii
P. tenera
*P. annua**
*Vulpia bromoides**
*Lolium perenne**
*Cynosurus cristatus**
Dryopoa dives
*Glyceria declinata**
*Bromus hordaceus**
*B. diandrus**
Elymus scaber
*Aira caryophyllea**
*A. praecox**
*Holcus lanatus**
*Anthoxanthum odoratum**
*Dactylis glomerata**
Dichelachne crinita
D. micrantha
Deyeuxia quadriseta
D. rodwayi
D. frigida
Agrostis avenacea
A. venusta
Echinopogon ovatus
Eragrostis brownii
Phragmites australis
Chionochloa pallida
Danthonia semiannularis
D. geniculata
D. penicillata
D. pilosa
D. racemosa
Stipa rudis
*Paspalum dilatatum**
Themeda triandra

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Cyperaceae
Cyperus brevifolius
C. lucidus
Isolepis inundata
I. fluitans
Eleocharis acuta
Schoenus maschalinus
S. apogon
S. lepidosperma
Baumea planifolia
Gahnia radula
G. sieberiana
G. clarkei
Lepidosperma elatius
L. laterale
L. semiteres
Gymnoschoenus sphaerocephalus
Uncinia tenella
Carex apressa
C. breviculmis
C. inversa
C. fascicularis
C. longibracteata
Restionaceae
Empodisma minus
Centrolepidaceae
Centrolepis fascicularis
Juncaceae
Luzula meridionalis
Juncus planifolius
J. pauciflorus
J. pallidus
J. subsecundus
J. holoschoenus
J. prismatocarpus
J. usitatus
Xanthorrhoeaceae
Xanthorrhoea australis
X. minor
Lomandra longifolia
L. filiformis
L. glauca
L. multiflora
Liliaceae (sens. lat.)
Caesia parviflora
Arthropodium strictum
A. milleflorum
Thysanotus tuberosus
T. patersonii
Trichoryne elatior
Drymophila cyanocarpa
Dianella tasmanica
D. revoluta
D. longifolia
Wurmbea dioica
Burchardia umbellata
Hypoxis glabella
Iridaceae
Romulea rosea
Burmanniaceae
Thismia rodwayi
Orchidaceae
Thelymitra aristata
T. media
T. ixioides
Diuris lanceolata
Microtis uniflora
Prasophyllum brevilabre
Chiloglottis valida
Acianthus exertus
Cyrtostylis reniforme
Caladenia carnea
C. hildae
C. dilatata
C. gracilis
Glossodia major
Corybas diemenicus
Cryptostylis leptochila
Pterostylis nutans
P. longifolia
P. pedunculata
P. alpina
P. parviflora
P. decurva
Gastrodia sesamoides
Dipodium punctatum
Dicotyledonae:
Fagaceae
Nothofagus cunninghamii
Urticacaeae
Australina muelleri Wedd.
Urtica incisa
Proteaceae
Grevillea alpina
G. repens
G. rosmarinifolia
Hakea sericea
H. ulicina
Lomatia ilicifolia
L. fraseri
Banksia marginata
B. spinulosa
Santalaceae
Exocarpos cupressiformis
Loranthaceae
Amyema pendula
Muellerina eucalyptoides
Polygonaceae
*Acetosella vulgaris**
*Rumex brownii**
Persicaria hydropiper
Amaranthaceae
Alternanthera denticulata
Caryophyllaceae
Stellaria flaccida
S. pungens
S. media
Cerastium glomeratum
Moenchia erecta
Sagina procumbens
S. apetala
Ranunculaceae
Ranunculus plebeius
R. lappaceus
Clematis aristata
C. microphylla

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Winteraceae
Tasmannia lanceolata
Monimiaceae
Hedycarya angustifolia
Atherosperma moschatum
Lauraceae
Cassytha pubescens
C. glabella
Brassicaceae
Rorippa dictyosperma
*Erophila verna**
Malvaceae
Gynatrix pulchella
Droseraceae
Drosera auriculata Backh. ex Planch.
D. peltata Sm. ex Willd.
D. whittakeri
D. binata
Crassulaceae
Crassula sieberiana
C. decumbens
Baueraceae
Bauera rubioides
Tremandraceae
Tetratheca ciliata
T. baurifolia
T. subaphylla
Pittosporaceae
Pittosporum bicolor
*P. undulatum**
Billardiera longifolia
B. scandens
Rhytidosparum pracumbens
Bursaria spinasa
Rosaceae
Rubus parvifolius
R. ulmifolius aff.*
Aphanes arvensis
Acaena novae-zelandiae
A. echinata
Mimosaceae
Acacia dealbata
A. mearnsii
A. melanoxylon
A. implexa
A. verniciflua
A. obliquinervia
A. pycnantha
A. paradoxa
A. gunnii
A. verticillata
A. oxycedrus
A. brownii
A. mucronata
A. genistifolia
A. aculeatissima
Fabaceae
Podolobium procumbens
Gompholobium huegellii
Daviesia ulicifolia
D. leptophylla
D. latifolia
Pultenaea muelleri
P. gunnii
P. mallis
P. scabra
Almaleea subumbellata
Dillwynia glaberrima
D. phylicoides
D. cinerascens
Platylobium formosum
Bossiaea prostrata
B. linearis
Goodia lotifolia
*Ulex europeaus**
*Trifalium repens**
*T. dubium**
*T. campestre**
*Lotus corniculatus**
Desmodium varians
Kennedia prostrata
Hardenbergia violacea
Glycine clandestina
Geraniaceae
Geranium potentilloides
G. solanderi
Pelargonium australe
Oxalidaceae
Oxalis corniculatus
Linaceae
Linum marginale
Rutaceae
Correa lawrenciana
C. reflexa
Boronia nana
Asterolasia astericophora
Polygalaceae
Comesperma volubile
C. ericinum
Euphorbiaceae
Poranthera microphylla
Amperea xiphoclada
Stackhousiaceae
Stackhousia monogyna
Sapindaceae
Dodonaea viscosa
Rhamnaceae
Pomaderris aspera
P. vacciniifolia
P. racemosa
P. elachophylla
Spyridium parvifolium
Dilleniaceae
Hibbertia aspera
H. riparia
H. acicularis
H. empetrifolia
Clusiaceae
Hypericum gramineum
H. japonicum
*H. perforatum**
Violaceae
Viola hederacea
V. betonicifolia

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V. sieberiana
Hymenanthera dentata
Thymeliaceae
Pimelea axiflora
P. humilis
P. linifolia
Myrtaceae
Eucalpytus regnans
E. obliqua
E. radiata
E. dives
E. macrorhyncha
E. baxteri
E. viminalis
E. cypellocarpa
E. goniocalyx
E. melliodora
E. ovata
*E. globulus**
E. polyanthemos
Leptospermum lanigerum
L. grandifolium
L. cantinentale
L. myrsinoides
Kunza ericoides
Baeckea ramossissima
B. utilis
Lythraceae
*Lythrum salicaria**
Onagraceae
Epilobium billardierianum
E. b. cinereum
Haloragidaceae
Gonocarpus tetragynus
G. humilis
G. micrantha
Myriophyllum propinquum
M. amphibium
Araliaceae
Polyscias sambucifolia
Asterotricha linearis agg.
*Hedera helix**
Apiaceae
Xanthosia dissecta
Hydrocotyle hirta
H. geraniifolia
H. laxifolia
H. verticillata
H. callicarpa
Centella cordifalia
Daucus glochidiatus
Epacridaceae
Epacris impressa
Acrotriche serrulata
A. prostrata
Astroloma humifusum
Monotoca scaparia
Leucopogon virgatus
Sprengelia incarnata
Primulaceae
*Anagallis arvensis**
Oleaceae
Notelaea ligustrina
Gentianaceae
*Centaurium erythraea**
*C. tenuiflorum**
*Sebaea ovata**
*Cicendia quadrangularis**
Apocynaceae
Parsonsia brownii
Boraginaceae
Austrocynaglossum latifolium
Myosotis australis
Solanaceae
Solanum aviculare
*S. nigrum**
Scropulariaceae
*Verbascum virgatum**
Grattiola peruviana
G. pedunculata
*Mimulus maschatus**
Euphrasia collina
Derwentia derwentiana
Veronica notabilis
V. calycina
V. gracilis
V. serpyllifolia
*V. arvensis**
*V. agrestis**
Verbenaceae
*Verbena bonariensis**
Lamiaceae
Ajuga australis
Prostanthera lasianthos
P. hirtula
P. melissifolia
Mentha laxiflora
*M. satureoides**
*M. pulegium**
Prunella vulgaris
Teucrium corymbosum
Callitrichacae
Callitriche stagnalis
Plantagiaceae
*Plantago lanceolatum**
P. varia
P. debilis
Rubiaceae
Coprasma quadrifida
C. hirtella
Asperula scoparia
Galium gaudichaudii
G. propinquum
Opercularia varia
Leptostigma reptans
Caprifoliaceae
Sambucus gaudichaudiana
Campanulaceae
Wahlenbergia gracilis
W. communis
W. gracilenta
Lobeliaceae
Lobelia gibbosa
Pratia pedunculata
Isotoma fluviatilis

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Goodeniaceae
Goodenia ovata
G. geniculata
G. elongata
Dampiera stricta
Brunoniaceae
Brunonia australis
Stylidiaceae
Stylidium graminifolium
Asteraceae
Lagenofera stipitata
Solenogyne gunnii
Brachyscome multifida
*Conyza bonariensis**
*C. canadensis**
Olearia argophylla
O. phlogopappa
O. lirata
O. erubescens
O. asterotricha
O. megalophylla
Stuartina muelleri
Euchiton gymnocephalus
E. involucratus
E. sphaericus
Pseudognaphalium luteoalbum
Leucochrysum albicans
Chrysocephalum apiculatum
C. semipapposum
Helichrysum scorpioides
H. leucopsideum
Triptilodiscus pygmaeus
Craspedia glauca agg.
Pycnosorus globosus
Cassinia aculeata
C. longifolia
C. arcuata
Ozothamnus ferrugineus
O. obcordatus
Sigesbeckia orientale
Leptinella filicula
Senecio linearifolius
S. vagus
S. minimus
S. quadridentatus
S. tenuiflorus
S. glomeratus
S. hispidulus
Bedfordia arborescens
Cymbonotus preissianus
*Arctotheca calendula**
*Sonchus oleraceus**
S. asper*
*Cirsium vulgare**
Microseris lanceolata agg.
*Hypochoeris radicata**
*H. glabra**
*Crepis capillaris**
*Leontodon taraxacoides**
Taraxacum officinale agg.*
*Helminotheca echioides**

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