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ON THE DISTRIBUTION OF THE SPECIES OF *EUCALYPTUS* IN THE REGION OF THE DANDENONG RANGE, VICTORIA

By H. T. CLIFFORD*

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Abstract

The distribution of the *Eucalyptus* species has been determined for an area of about 70 square miles, in the region of the Dandenong Range, Victoria. With a view to understanding this distribution, the climate, soils and geology of the area have also been investigated. Certain correlations between factors of the environment and the distribution of individual *Eucalyptus* species have been noted and tentative explanations have been suggested for them.

Introduction

Except for several general accounts, the most important being that of Patton (1930), little has been published on the ecological relationships of the Victorian species of *Eucalyptus*. A great deal of intensive work is required on the biology of the individual species, but it is believed that this will be facilitated if the distribution of species of the genus is studied in selected small areas of varied topography and soil type.

The area described in this report embraces about 70 square miles and is situated about 25 miles east of Melbourne (Fig. 1); the nearest mountainous region to the city, it is well served with public transport, and its character is now rapidly changing with settlement. The area was selected so as to include several geological formations and soil types and an altitudinal range from 250 to 2,000 feet. In the natural condition it was a completely forested region, but at the present time it is not suitable for the study of the primary features of the *Eucalyptus* communities as these have been largely modified by fire, clearing and settlement. It has now become difficult to determine the characteristics of the shrub and field layers in their virgin state, and even for the trees themselves the data for density, height and form of the individuals are those for secondary forests. Nevertheless, a great deal of the area is still forested, carrying nineteen species of *Eucalyptus* of which nine are of importance in the plant communities.

The evidence from surveyors' notes and from early published accounts (Walters 1853; V.F.N. 1884-) supports the view that the distribution of the tree species has not appreciably altered since settlement. This paper describes the results of a primary survey of the species of *Eucalyptus* and their distribution in relation to several environmental factors.

Geology and Topography

The area embraced by this survey is divisible into two topographically very different sections. The eastern section includes most of the Dandenong Range, and parts of the Lilydale and Beaconsfield Hills. The western section lies in the mature valleys of the Dandenong and Brushy Creeks.

*Botany School, University of Melbourne.

The Dandenong Range is a roughly triangular area of steep hills that rise abruptly from the surrounding countryside to a maximum elevation of about 2,000 feet. Three perennial streams rise in this Range—the Olinda, Monbulk and Dandenong Creeks. South of the Dandenong Range are the Beaconsfield Hills; they have an average elevation of about 700 feet, and are part of a peneplain which slopes gently to the south. The valleys in this area are shallow and are drained

LOCALITY MAP

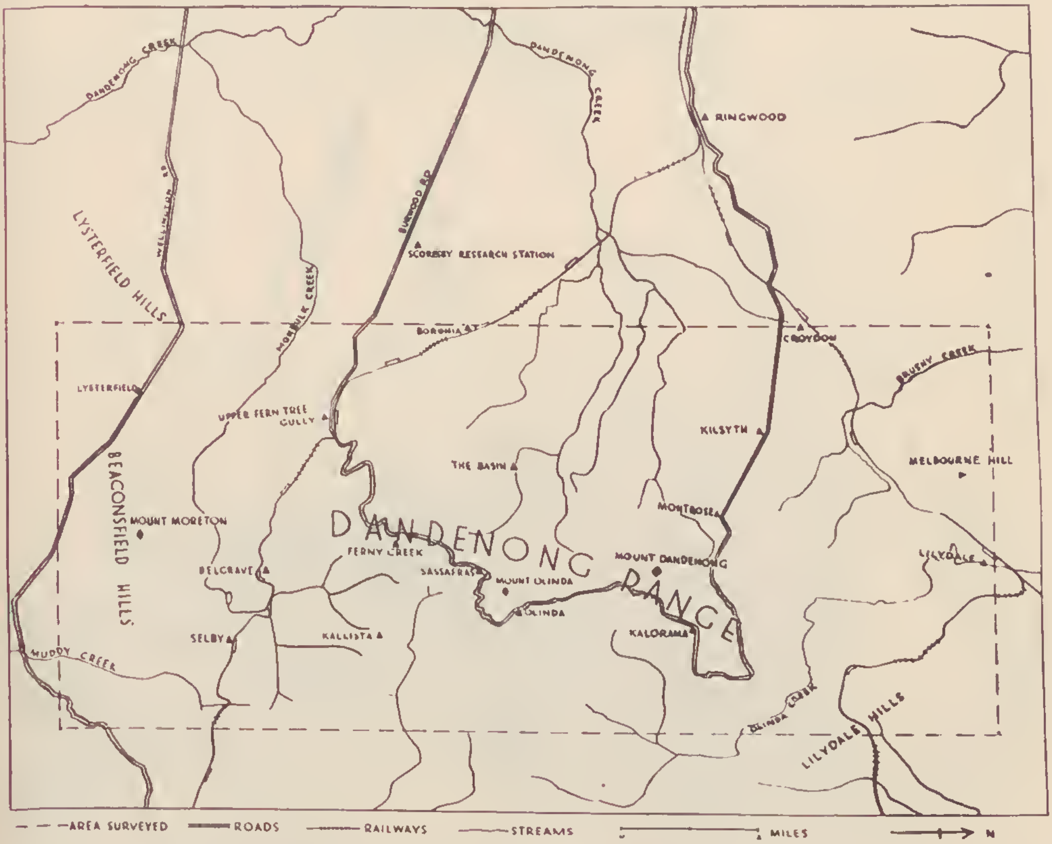

Fig. 1.—A map in the region of the Dandenong Range, showing the location of places mentioned in the text.

by ephemeral creeks. Forming a crescent about the northern end of the Dandenong Range are the Lilydale Hills, a group of steeply sloping hills with an average elevation of about 700 feet; the creeks draining these hills are mostly ephemeral.

West of the Dandenong Range are the broad mature valleys of the Dandenong and Brushy Creeks. Within both these valleys the topography is gently undulating and drainage is poor. Swamps, formerly extensive, have been reduced in size by the cutting of many drains. The Dandenong Creek rises on the western slopes of the Dandenong Range; Brushy Creek rises in its lower N.W. slopes, and receives a tributary from Melbourne Hill, a small hill west of Lilydale.

There is a close correlation between topography and the underlying rock types. The Beaconsfield Hills are granitic, the Lilydale Hills are composed of toscanites and dacites, and the Dandenong Range is principally dacite. Melbourne Hill is capped with basalt (Morris 1913). The Dandenong and Brushy Creek valleys are eroded into sedimentary rocks, mostly mudstones, and it is probable that differential erosion of these various rock types has resulted in the present topography (Hills, 1934).

The major geological features are illustrated in a map (Fig. 2) simplified with permission from one prepared by Dr. A. B. Edwards.

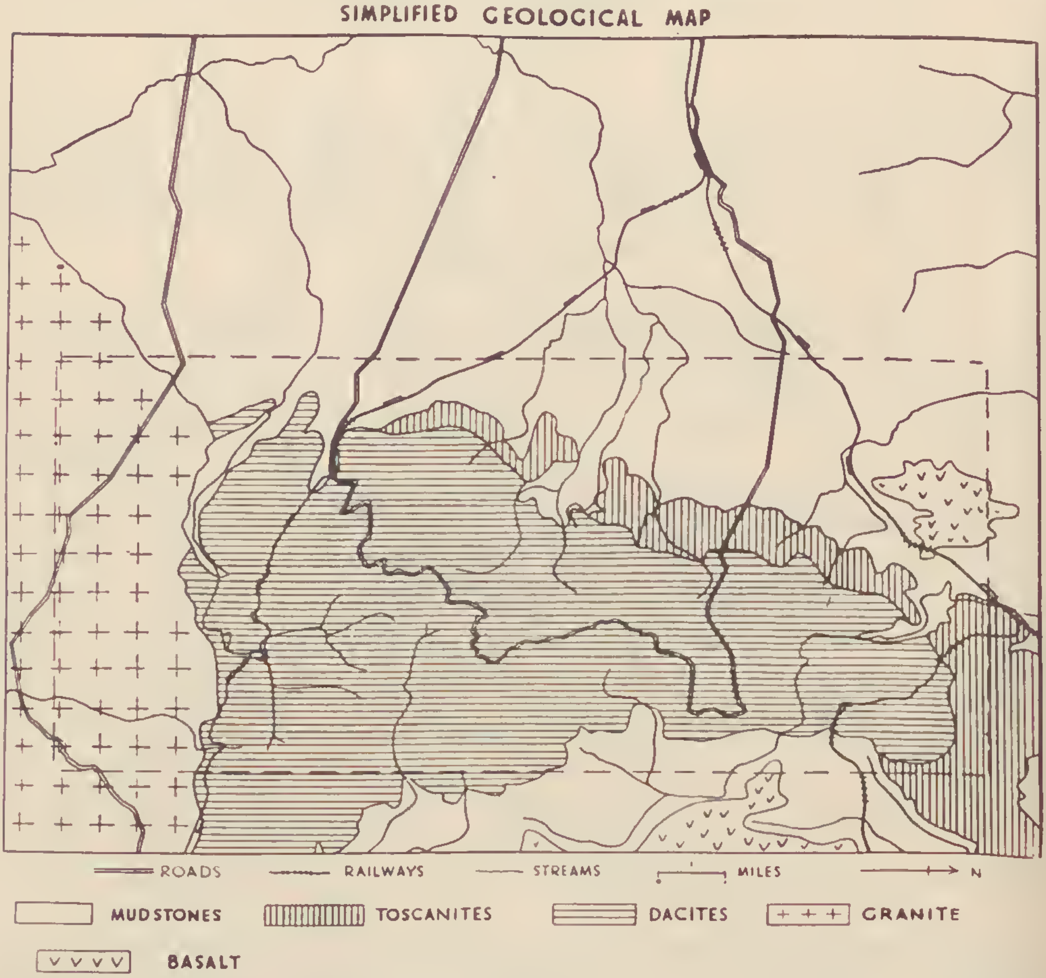

Fig. 2.—A simplified geological map in the region of the Dandenong Range. (Boundaries mainly after Dr. A. B. Edwards.)

Climate

From the available measurements of climatic elements a good impression can be obtained of the regional climate of the area, but the local and micro-climate, like the topography, is extremely varied. It is impossible to describe local climatic conditions accurately for, although rainfall data are extensive, temperature records are few and the evaporation has been measured at only one station.

The regional climate belongs to the Humid Mesothermal type of Köppen or the Subhumid Mesothermal type of Thornwaite (Trewartha, 1943). Conditions are mild with medium temperatures and high reliable rainfalls. Evaporation is low and the Transeau ratio (Precipitation divided by Evaporation) does not fall below 0·33 for more than 2-3 months per year. Droughts are uncommon. On the cleared areas ground frosts often occur from February to October, but only rarely beneath the trees.

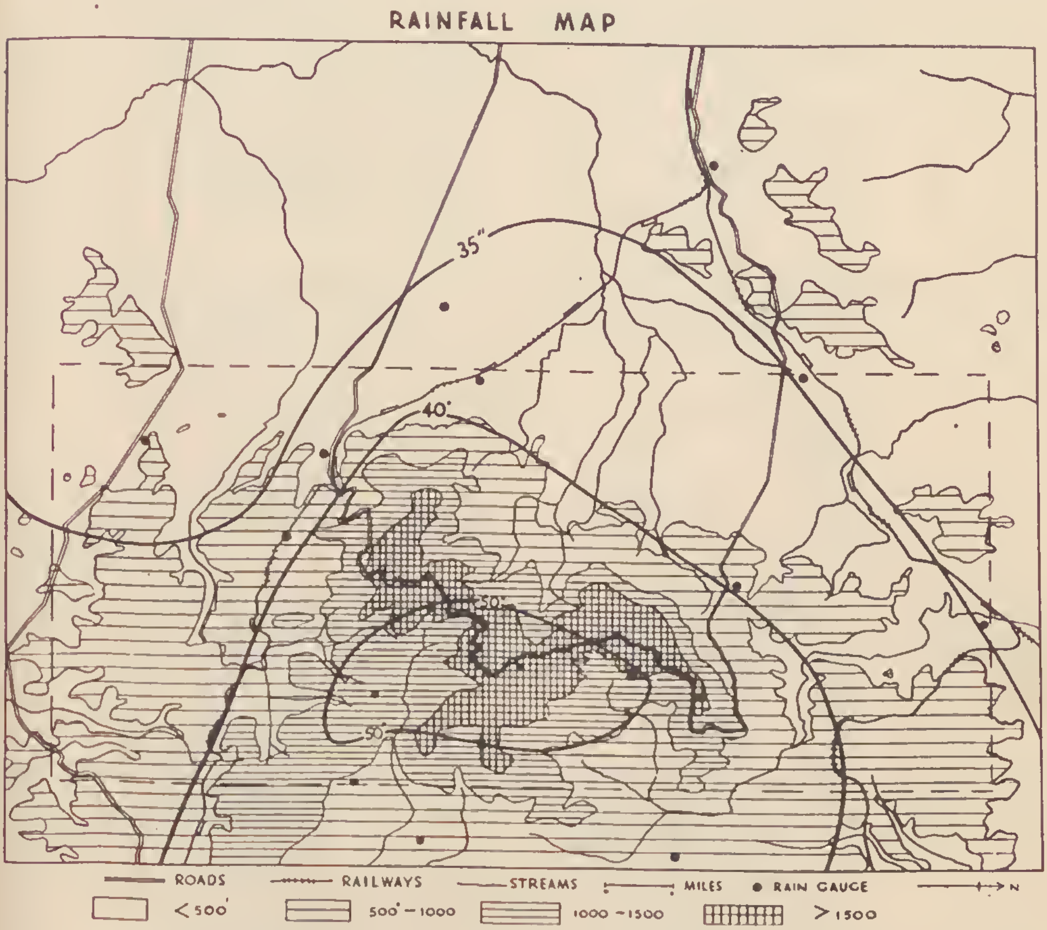

FIG. 3.—A map in the region of the Dandenong Range, showing the relation between altitude and annual rainfall.

Rainfall

Annual total rainfall ranges from 28 in. at Lysterfield to 51 in. at Olinda. The parallelism between contours and isohyets is shown in Fig. 3. Not only is the rainfall high but it is also very reliable. Some figures for variability are shown in Table 1. The variability is stated in the terms used by Taylor (1918), namely that the mean deviation from the mean is expressed as a percentage of the mean.

TABLE 1

Rainfall Variability Calculated from Monthly and Annual Figures for a Ten-Year Period

Town	J	F	M	A	M	J	J	A	S	O	N	D	Annual
Kallista . .	45	64	61	53	54	23	26	38	30	41	33	40	15·2
Lilydale . .	45	54	52	46	59	41	27	44	25	46	42	44	15·4
Boronia . .	41	60	42	47	64	35	31	46	18	42	41	42	16·4
Lysterfield . .	66	62	38	53	47	26	38	36	29	25	45	70	12·0

TABLE 2

The Seasonal Distribution of Rainfall at Stations on or near the Dandenong Range

Town	J	F	M	A	M	J	J	A	S	O	N	D	Annual
Boronia . .	2·72	3·20	2·19	3·94	3·27	3·81	2·96	2·89	3·14	3·30	2·78	2·39	36·6
Narre Warren N.	2·52	2·11	3·06	3·24	3·27	3·38	2·87	3·14	3·45	3·73	3·19	2·99	36·9
Fern Tree Gully	2·32	2·08	3·25	3·46	3·56	3·71	2·91	2·97	3·53	3·44	2·99	3·14	37·4
Lilydale . .	2·43	2·00	2·61	3·15	2·80	3·34	3·01	3·06	3·22	3·61	2·79	2·87	34·9
Kalorama . .	2·88	2·71	2·92	5·27	4·53	4·96	4·02	4·14	3·71	4·89	3·74	4·04	47·8
Sassafras . .	3·09	2·96	3·77	4·49	4·63	5·34	4·55	4·63	4·47	5·32	4·05	3·81	51·1

The low rainfall season is the summer, which is therefore an unfavourable period for the vegetation. The seasonal distribution of the rainfall for selected stations is shown in Table 2. Although the rainfall is reliable, occasional storms of great violence are reported (Anon. 1949), and both Kalorama and Olinda have had falls of more than 10 in. in 24 hours.

Snow

Snowfalls are reported for most of the area, but they are infrequent except on the higher peaks in the east of the Dandenong Range. Snow has been recorded during the period from May to October. Occasionally a heavy fall is experienced, as in the winter of 1951, when branches were snapped off and trees were uprooted.

Fog Drip.

Mists and fogs are common their frequency increases with altitude and they may be an important source of moisture on the Dandenong Range, the top of which is often shrouded in cloud.

Temperature

Local temperature records are scarce and have been measured for a short time only at Scoresby. The data for Scoresby and other stations near the area are shown in Table 3.

TABLE 3

Temperature Data for Stations near the Dandenong Range.

	Mean	Amplitude
Healesville	55·8 F	9·2 F
Berwick	61.3 F	13.5 F
Scoresby	56·3 F	9·3 F

Evaporation

The only evaporation data are for Scoresby, and they indicate that evaporation exceeds the precipitation for about six months of the year. However, if we assume that rainfalls which are effective for crops are also effective for natural vegetation,

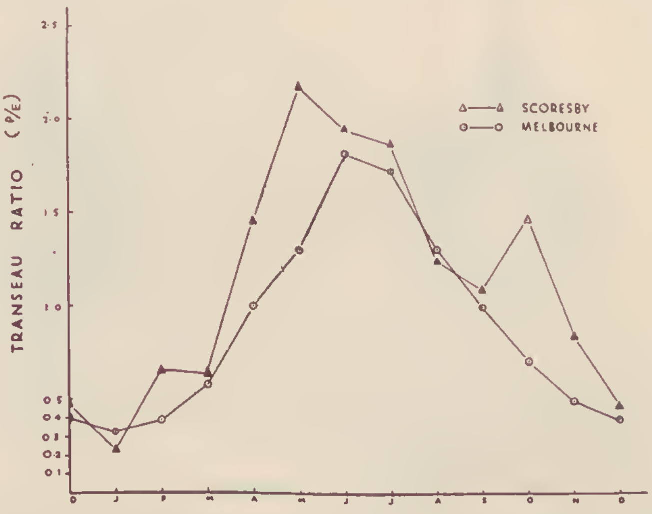

FIG. 4.—A diagram of the seasonal distribution of the Transeau Ratio at Melbourne and Scoresby.

then using Trumble's (1939) measure of effectiveness ($P/E > \frac{1}{3}$), the only period of water shortage will be during the summer. From the present data it appears that January is the only unfavourable month, but the data cover too short a period to be reliable and it is probable that both December and February are also unfavourable months. The monthly values of the ratio P/E for Melbourne and Scoresby are shown in Fig. 4.

Wind

Reliable wind data are not available for any station in the area and those for Melbourne have been assumed to apply. (Table 4.) Recent records from Scoresby Agricultural Research Station tend to confirm this assumption. In Fig. 5 the direction and frequency of the winds are shown. Those from the north and north-west are dry, hot in summer and cold in winter.

TABLE 4

The direction from which winds above 30 m.p.h. blow, expressed as a percentage of the total winds above 30 m.p.h. (Anon. 1944).

Altitude	N	N.E.	E	S.E.	S	S.W.	W	N.W.
0 ft.	65·7	—	—	—	4·3	14·3	4·3	11·4
1800 ft.	55·0	—	—	·1	3·2	4·4	12·0	25·3
3500 ft.	33·4	·4	·4	1·0	3·4	5·7	15·7	40·0

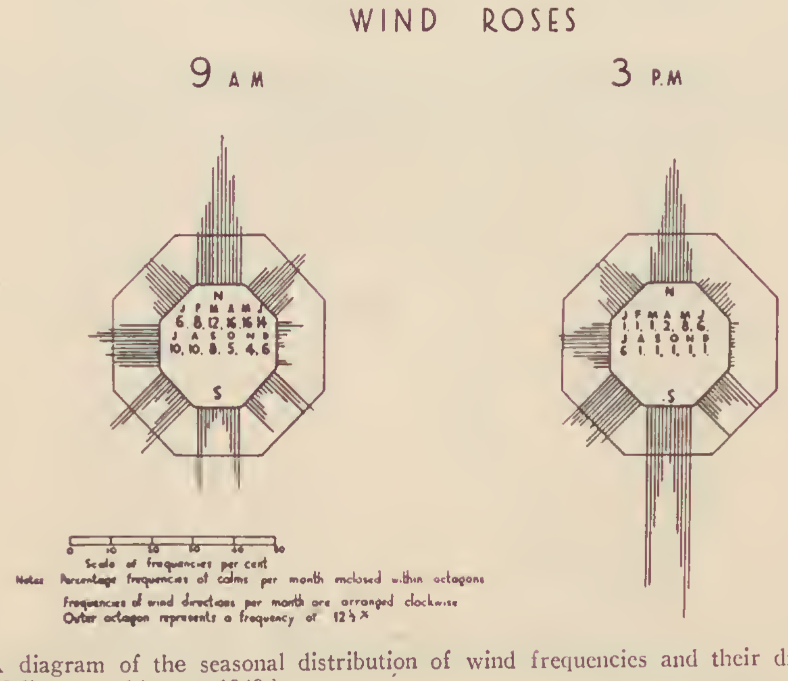

FIG. 5.—A diagram of the seasonal distribution of wind frequencies and their directions at Melbourne. (Anon., 1949.)

Soils

The soils have been studied from exposures in quarries and road cuttings and also from numerous auger borings. Typical samples were analysed in the laboratory by standard methods (Piper 1947, Leeper 1948, Wright 1934), and the results are tabled in the appendix.

The main soil types occurring in the aıea are:

1. Silty loam podzol. (Identical with the Hallam Loam, described by Holmes et al. 1940.)
2. Sandy Loam Podzol. (Identical with the Harkaway Sand, ibid.)
3. Krasnozem. (This soil, found on the dacites, mudstones, and basalt, is pedologically similar to the Basaltic Clay Loam, ibid.)
4. Embryonic or skeletal. (The stony soils of certain steep slopes.)
5. Alluvium.

The approximate distribution of the soils is shown in Fig. 6.

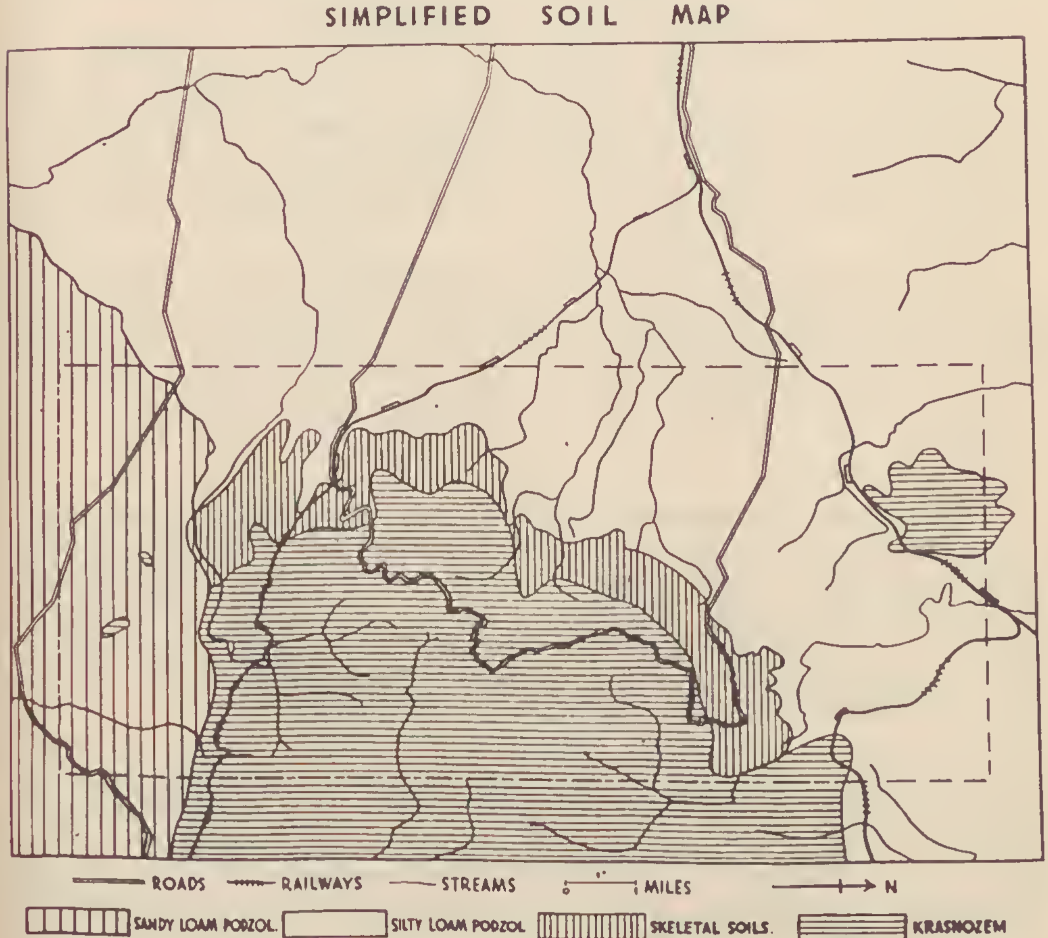

Fig. 6.—A simplified soil map in the region of the Dandenong Range.

Silty Loam Podzol

On gentle slopes (where the rainfall is less than about 45 in. per annum) a soil with well-marked profile is developed. It occurs on the toscanites, dacities and mudstones, but never on basalt. The A horizon is a silty loam or silty clay-loam from one to two feet in depth; beneath it and extending to variable depths is a clay B horizon. A layer of ironstone nodules is present along the junction of the two horizons (Fig. 7). Structure is poor throughout the profile, and on drying the surface becomes very hard and cemented together. When wetted again the surface is easily dispersed and very liable to erosion. The reaction is acid (pH 4·5 – 5·5).

Soils of this kind, widespread in Victoria, are not easily related to soils from other parts of the world. Although they are here regarded as podzolised, they show no accumulation of organic matter in the B horizon, and the silica-alumina ratio is similar in both A and B horizons. They agree most nearly with the grey-brown podzolic soils of the Americas (Lutz and Chandler 1949). The American soils are also acid, they show an abrupt change from the A to the B horizon and an accumulation of ironstone nodules at the junction between them.

In both the Silty Loam Podzol and the Hallam Loam, it is probable that the heaviness of the B horizon is due to the accumulation of clay, mobilized and washed out from the A horizon. The mobilization of the clay could be caused by the sodium ion, considerable amounts of which are present in the rain water. It is estimated (Holmes et al. 1940) that about 30 lb. per acre of this element are added to the soil per annum. If this ion has been responsible for the mobilization of the clay in this profile, then the soil is more akin to an immature solonetz than a podzol.

In the Lysterfield and Lilydale Hills the silty loam podzol is usually represented by a stony phase. This is equivalent to the "Silurian phase" of the Hallam Loam near Berwick (Holmes et al. 1940) and the "shaly phase" of the Hallam Loam near Whittlesea (Baldwin 1950). It differs from the typical silty loam podzol in possessing abundant fragments of primary rock in the profile.

Some profiles from this group are illustrated in Fig. 7.

Sandy Loam Podzol

The sandy loam podzol occurs in gently undulating country where the rainfall is less than about 45 in. per annum. It is developed principally on the granite but may also occur on the toscanites or dacites. The sandy loam podzol is pedologically similar to the silty loam podzol except that there is an abundance of coarse sand throughout the profile. Where this soil is developed on granite the coarse sand fraction is predominantly quartz, but on toscanites and dacites, it is of small pieces of rock. The profile is illustrated in Fig. 7.

Krasnozem

The krasnozem has developed on basalt, toscanite, dacite and mudstones, but not on the granite. Where the rainfall is less than 45 in. per annum, this soil is restricted to basalt. but under higher rainfalls it overlies several rock types. The absence of krasnozem on granite in this region may be related to the rainfall, which is less than 45 in. per annum in the granitic areas. Further east in Victoria, on granite, where rainfalls exceeding 45 in. are recorded, a soil is found which resembles the krasnozem but includes large amounts of coarse sand in the profile.

The krasnozem profile in contrast to that of the podzolic soils is not differentiated into horizons. The soil is a red-brown friable clay-loam which is particularly well known in the Melbourne district as "Mountain Soil". The name has arisen because this is the most extensive soil type in the Dandenong Range, being found

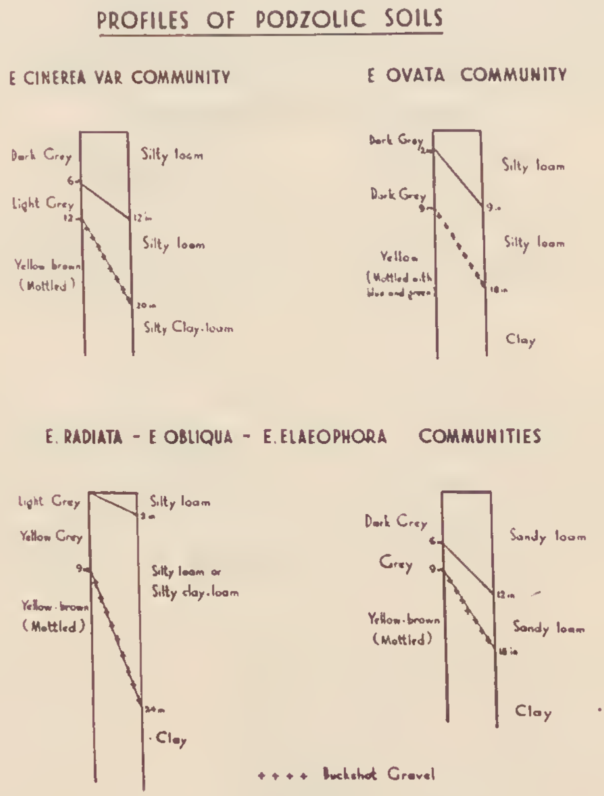

FIG. 7.—Profiles of typical soils of the silty loam and sandy loam podzolic types.

on all high slopes except some to the north and west. However, the name is not a good one because the soil occurs at quite low altitudes as at Berwick and Melbourne Hill near Lilydale.

The profile is little differentiated but there is a slight increase of clay content with depth. The soil possesses an excellent structure which is very stable. A wet sieve analysis of samples from a field cultivated for forty years yielded results similar to those for samples from a nearby forest stand. It is for its stable porous structure and not its fertility that this soil is esteemed. With the high rainfall and good drainage attendant upon good structure this soil has become deficient in nutrients, and possesses as little as 1 m.e. per cent of calcium at 2 feet. The soil has another undesirable feature in that it fixes phosphorus, as do similar soils in northern Tasmania (Stephens 1937). Phosphate fertilizers are much used on the cleared land of the Dandenong Range.

Soils similar to these are found in many localities in eastern Australia, and Bryan (1938) has suggested that they are fossil in origin. However, this is not so in the Dandenong Range, because there rock can be found in the profile in all stages of decomposition, from totally unweathered boulders down to soil particles. Nevertheless, the soil must have had a long history, because in many places it is very deep. Local tradition has it that a well was sunk to 80 feet at The Patch without striking bedrock. This would be exceptional, but there are many cuttings that expose 10-15 feet of soil-like material.

Several profiles of this group are illustrated in Fig. 8.

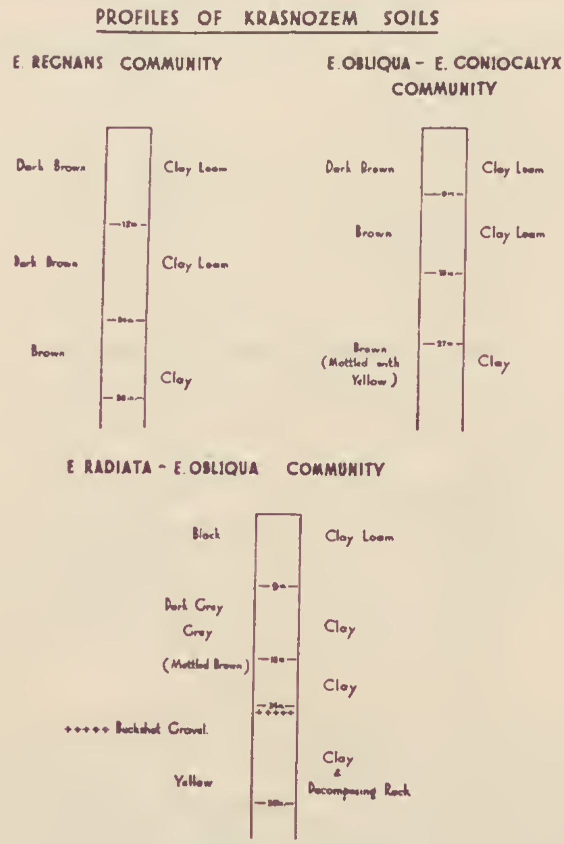

FIG. 8.—Profiles of typical soils of the krasnozem type.

Embryonic or Skeletal Soils

Along the western slopes of the Dandenong Range are extensive areas of stony soils. These soils have developed on dacite, under an annual rainfall of between 40-50 in., and are developed best on the spurs. In the deeper valleys the stony soils are replaced by the krasnozem. The prevalence of these stony soils on the spurs suggests that drainage and perhaps exposure have been responsible for their development. Steepness of slope alone has not been responsible, for the krasnozem may occur on equally steep slopes.

The depth of these stony soils is variable, and the soil may extend down for several feet between the boulders. They are pedologically closely related to the podzolic soils. The affinity is suggested by their yellow-grey colour and the sudden increase of clay content at about 18 in. depth.

The classification of stony soils is avoided by soil workers who usually place them in a "mountain complex". Nikiforoff (1948) has proposed a three-fold division of stony soils, and the Dandenong examples fit his group of *Embryonic* soils. The name is not very satisfactory as it suggests extreme youth. An *Embryonic* soil is not necessarily young, for the top soil may, on a steep slope, move over the more stable subsoil. With such movement each particle as it is displaced downward is replaced by one from further uphill, and so at any given place on the slope the depth and appearance of the profile remains constant.

Alluvial Soils

There are no extensive areas of alluvial soils, but small patches are fairly common, particularly where the perennial streams level out on leaving the Dandenong Range. The alluvial soils are usually very gritty or stony and are well drained. Except for an indefinite A_1 horizon, distinguished by its darker colour, these soils lack a differentiated profile.

Soil–Climate–Geology

A summary of the interrelations between the soil, geology and climate of the area studied is shown in Table 5. Small exceptions are ignored, thus the sandy loam podzol is shown as restricted to the granitic rock types, although it occurs as small patches where the bedrock is toscanite or dacite. Alluvial and embryonic soils have also been left out of the table because each is closely related to topography, which seems to be more important than climate in determining the development of these two soil types.

TABLE 5

The commonest soil types developed on different rocks under given rainfalls in the area studied

Annual Rainfall	Rock Type	Soil Type
Less than 45 in.	Basalt	Krasnozem
	Dacite	Silty Loam Podzol
	Toscanite	Silty Loam Podzol
	Mudstone	Silty Loam Podzol
	Granite	Sandy Loam Podzol
Greater than 45 in.	Basalt	———
	Dacite	Krasnozem
	Toscanite	———
	Mudstone	Krasnozem
	Granite	———

Distribution of the species of Eucalyptus

The species distribution has been mapped by traversing all the roads and tracks of the area on foot and entering records at each quarter-mile (or less when necessary) on a specially prepared field map on the scale of 4 in. to the mile. In addition numerous cross-country traverses were made where roads were obviously built on ridges and in valleys. Where clearing had removed the trees, the composition of the original forested area was estimated as far as possible from the remnants on roadsides and uncultivated areas, from adjacent uncleared

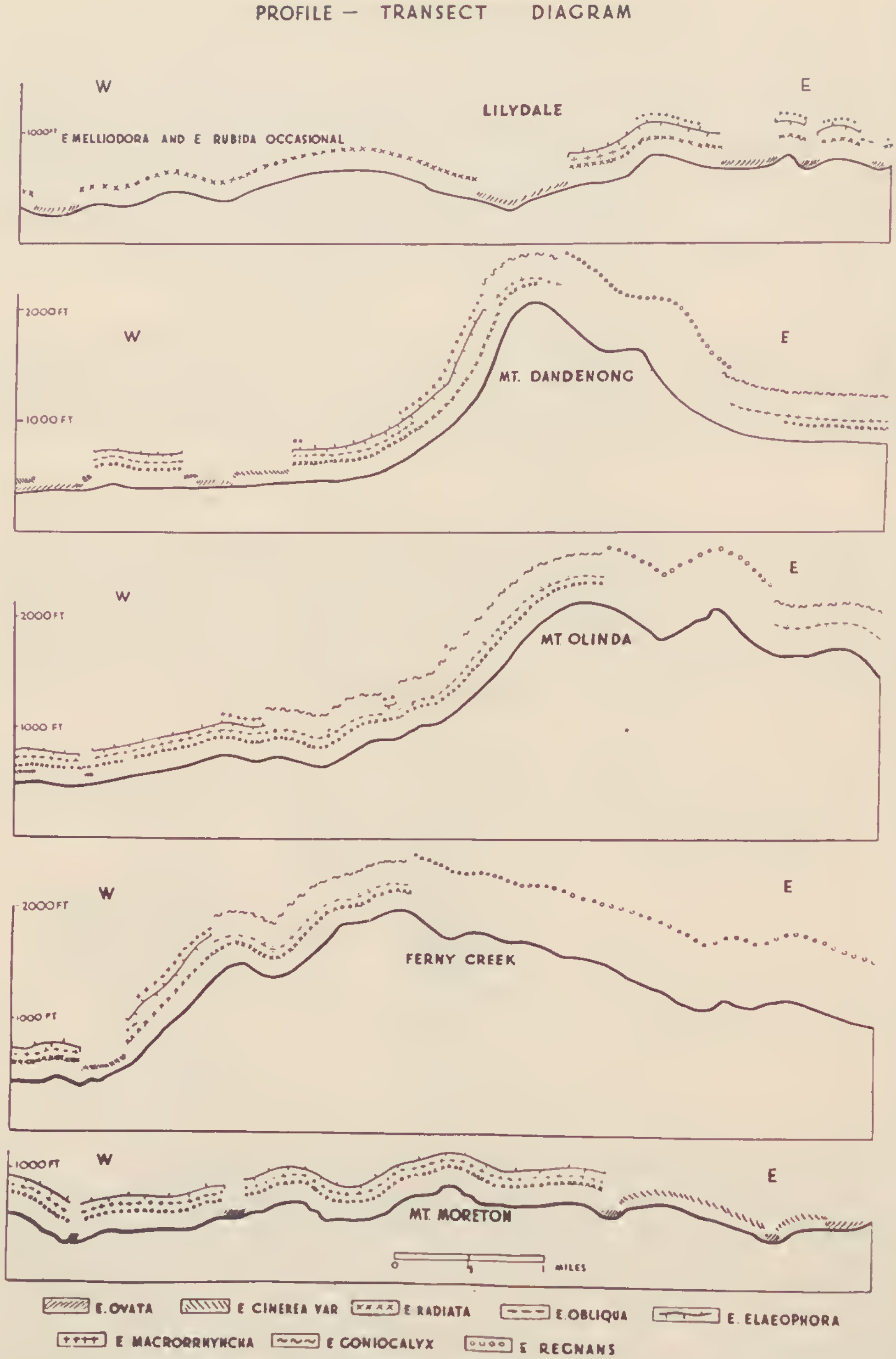

FIG. 9.—Transects along E-W lines across the area surveyed, showing the relation between the distribution of *Eucalyptus* species and the topography. The vertical order of the transects is from N (Lilydale) to S (Mt. Moreton).

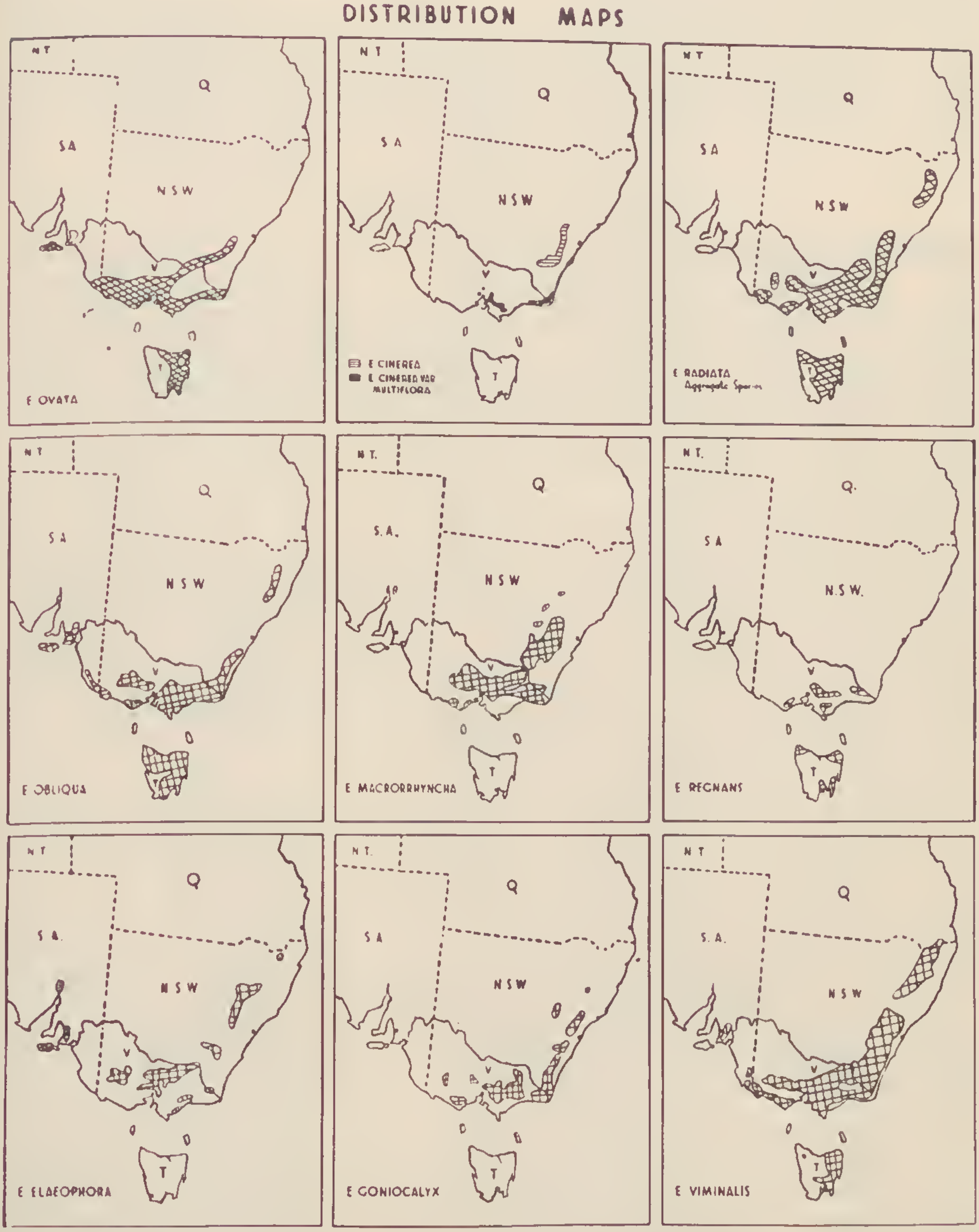

FIG. 10.—Maps of south-eastern Australia, showing the generalized distribution of the *Eucalyptus* species most commonly met with in the region of the Dandenong Range. Data principally from Carter (1945), Anon. (1948), Boomsma (1949).

sites of similar soil and aspect, and to some extent from historical accounts. Clearing has nowhere been so extensive as to make these estimates unreliable considering the scale of mapping.

The data are here summarized in a number of maps (Figs. 11, 12, 13, 14) and in several cross sections drawn from E to W across the area surveyed (Fig. 9). Each species will be discussed separately, this discussion being facilitated by the preparation of a relief map of the area on which the species distribution has been mapped.* In all these maps, cleared areas are not shown.

Species of Major Importance

Eucalyptus ovata Labill. Swamp Gum.

The nomenclature of this species has been quite stable. In Victoria, related species are *E. yarraensis* Maiden (Healesville, Vic.) and *E. studleyensis* Maiden (Kew, Vic.). Each of these has a very restricted distribution and may be of hybrid origin with *E. ovata* Labill. as one of the parents. Geographically *E. ovata* Labill. is widespread in south-eastern Australia (Fig. 10) and commonly grows in swampy soils at elevations up to about 2,500 feet. This species seldom grows where the annual rainfall is less than about 30 in., and is more abundant south of the Great Dividing Range.

Within the area surveyed *E. ovata* is widely distributed at low altitudes, west, north and south of the Dandenong Range. It usually grows in swampy places, along the banks of ephemeral streams and on flats bordering the larger creeks at elevations up to about 800 feet (Fig. 11). On these flats it is the dominant of a well-defined community. The trees here are 60-80 feet tall, with spreading habit but with the crowns not meeting to form a continuous canopy. Beneath them grows a dense thicket of *Melaleuca ericifolia* up to 15 feet tall. The ground flora is sparse, and the few etiolated herbs are almost smothered by the copious growth of the moss *Thuidium furfurosum.*

Usually *E. ovata* is restricted to sites that are badly drained, where the soil aeration is bad, as is evident from the gleying of the subsoil. Observation of several stands during the three year period, 1948-50, indicated that this species may grow where the surface soil is waterlogged for several months of the year. These conditions are often met with along the valley floors and there is a parallelism between the stream pattern and the distribution of this species. Although *E. ovata* is restricted to very wet soils, it does not favour any one soil type, and grows equally well on the krasnozem, silty loam podzol, sandy loam podzol and alluvium. These soils are derived from several different rock types, which suggests that the underlying geology does not affect the distribution of this species.

The highest altitude at which *E. ovata* has been seen growing in this area is about 800 feet, which is much lower than the maximum altitude to which this species extends (Ewart 1930). This low limit may be correlated with the rainfall. In other parts of Victoria *E. ovata* is uncommon where the annual rainfall is greater than 40 in., an amount usually exceeded in the area surveyed at altitudes above 800 feet.

*This relief map is available for inspection at the Botany School, University of Melbourne.

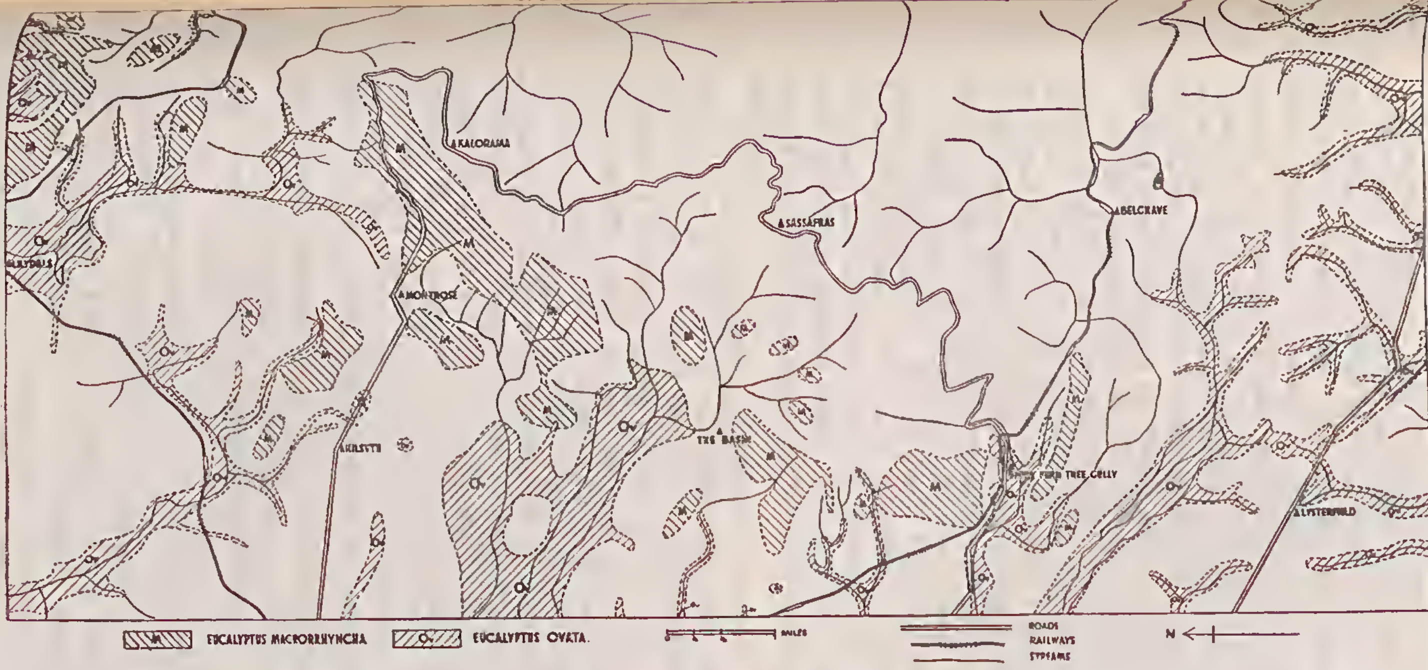

FIG. 11.—A map of the area surveyed showing the distribution of *E. ovata* and *E. macrorrhyncha*.

·SPECIES DISTRIBUTION MAP

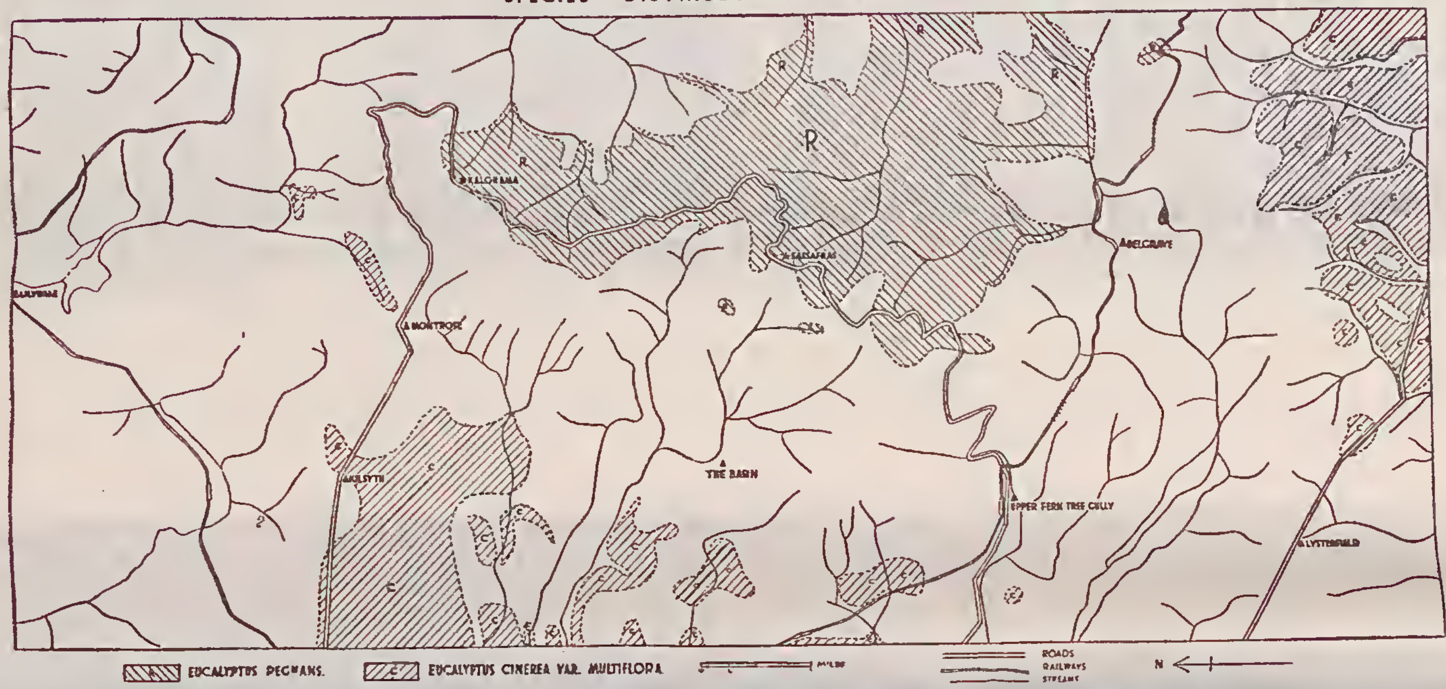

FIG. 12.—A map of the area surveyed showing the distribution of *E. cinerea var. multiflora* and *E. regnans*.

SPECIES DISTRIBUTION MAP

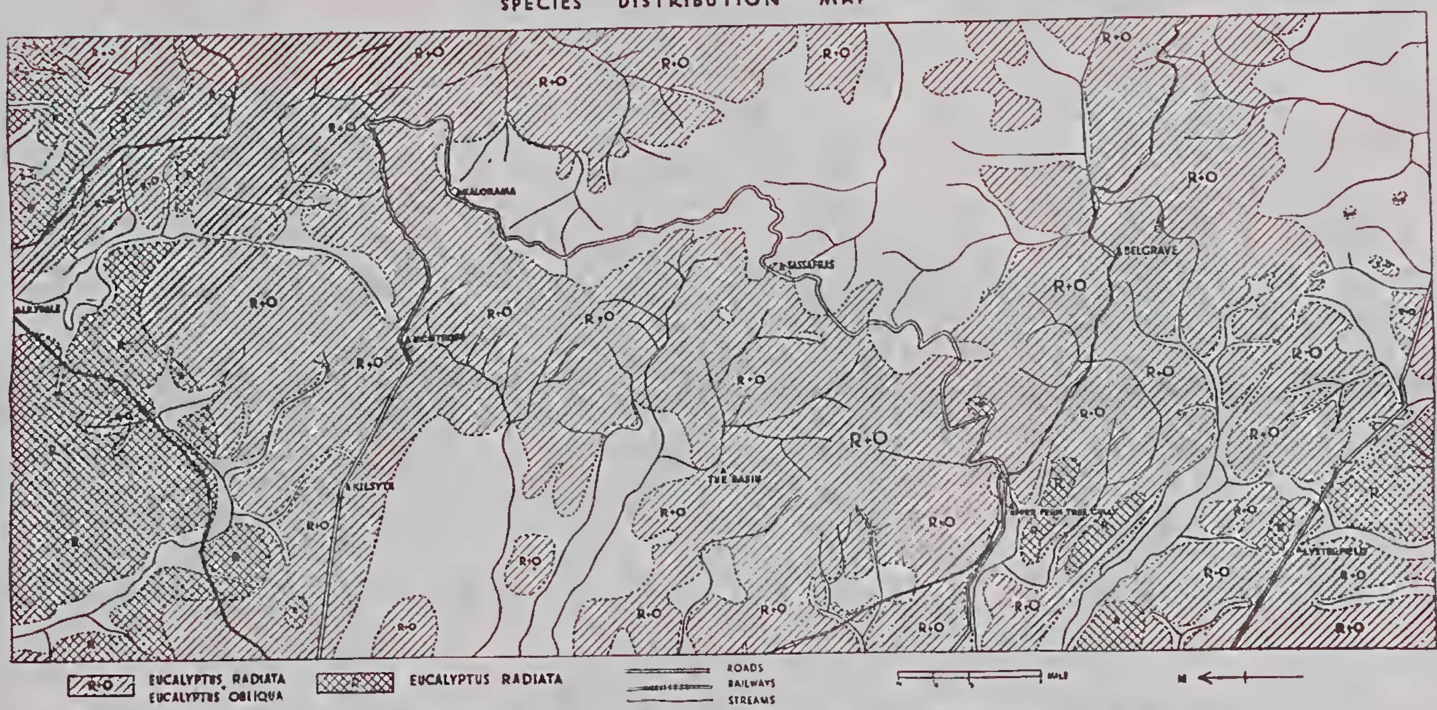

FIG. 13.—A map of the area surveyed showing the distribution of *E. radiata* and *E. obliqua*.

SPECIES DISTRIBUTION MAP

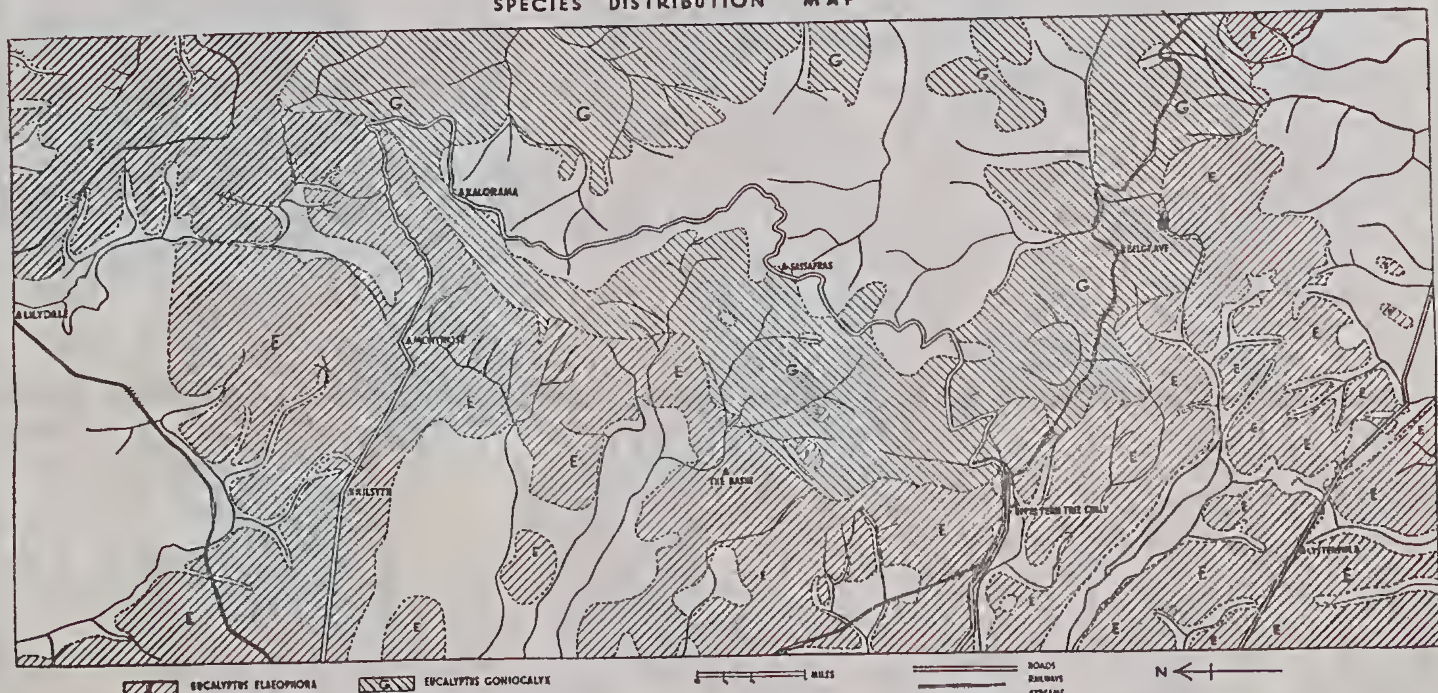

FIG. 14.—A map of the area surveyed showing the distribution of *E. elaeophora* and *E. goniocalyx*.

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Eucalyptus cinerea F. Muell. var. multiflora Maiden. Mealy-stringybark.

The taxonomy of this species has been much disputed. With the exception of the name *E. cephalocarpa* Blakely (Blakely 1934) the synonomy is discussed by Maiden (1917). The name accepted here is that recognized in the "Flora of Victoria" (Ewart 1930). The variety *multiflora* Maiden differs from the typical form of *E. cinerea* F. Muell. in several striking morphological features, and furthermore it occupies a different geographical region. The typical form of the species occurs in the foothills of the inland slopes of the Great Dividing Range (Fig. 10) from near Wangaratta in Victoria to about latitude 34° S. in New South Wales. The variety *multiflora* is restricted to the seaward side of the Great Divide and extends from just west of Melbourne to southern New South Wales.

In the area surveyed *E. cinerea var. multiflora* occurs most abundantly on the southern slopes of the Beaconsfield Hills, and in the triangle formed between Boronia, Montrose and Croydon (Fig. 12). Elsewhere the species may be locally abundant but does not grow in extensive pure stands. Usually it occurs in gently undulating country at elevations below about 800 feet and often forms a fringing forest about the *E. ovata* community. Where it grows in pure stands the trees are 40-50 feet tall with their crowns almost touching. Beneath the trees is a dense shrub stratum 4-5 feet high. Characteristic species of this stratum include *Epacris impressa, Viminaria denudata, Leptospermum scoparium, Sprengelia incarnata* and *Casuarina distyla.* Although the shrub stratum is dense there is a well developed ground flora. Species here include *Gahnia radula, Hypolaena lateriflora, Schoenus apogon, Xanthorrhea minor, Lindsaya linearis* and *Selaginella uliginosa.*

For the most part the habitats of *E. ovata* and *E. cinerea var. multiflora* are similar. Both species grow within the same range of altitudes and climates and upon the same soils and bedrock, but the tolerances of these two species towards conditions of waterlogging in the soil are quite different. Whereas *E. ovata* will grow on sites with the surface soil waterlogged for as long as six months per year, *E. cinerea var. multiflora* has not been observed growing where the surface soil is waterlogged for more than three months each year. Owing, however, to extensive draining and clearing of the area concerned over the last 50 years, it is difficult, if not impossible, to be certain that the water relations of the soils were originally the determining factors in the distribution of these species. *E. ovata* is usually more frequent near the creek beds, but a year's regular observation of soil moisture at depths of 1 and 2 feet has not revealed any striking differences between the areas bearing these two species. Experimental work is in progress on the seed- and seedling-tolerance to waterlogged soil.

Eucalyptus radiata Sieb. Narrow-Leaf Peppermint.

The nomenclature of this species is very confused. Following Cheel (1943) and Cameron (1946) the following alterations become necessary in the "Flora of Victoria" (Ewart 1930):—The name *E. radiata* Sieb. must be replaced by *E. Andreana* Naudin, and *E. australiana* Baker and Smith must be replaced by *E. radiata* Sieb. In this paper the revised nomenclature is used. Some of the confusion has resulted from inadequate type material, and its poor description and some from limited knowledge of the variability of the species in the field. Variation, particularly of the "juvenile leaves" in different localities, supports the suggestion that *E. radiata* Sieb. possesses several different races. Furthermore, it is probable that several of the species closely related to *E. radiata* would be better regarded as of less than specific rank, until they are more fully investigated. Accepting the species *E. radiata* - *E. robertsoni* - *E. salicifolia* as a species complex, it is seen from Fig. 10 that this group is widespreaed in south-eastern Australia and Tasmania.

In the area studied *E. radiata* Sieb. is widespread (Fig. 13) and it is phenotypically uniform. It is a common species of the hillsides and ridges, except in the wetter parts of the Dandenong Range between Kalorama, Kallista and Belgrave. Rarely does it grow in pure stands, annual rainfall probably determining the other *Eucalyptus* species with which it is associated. Where the rainfall is less than 35 in. per annum, *E. radiata* grows in mixed stands with *E. rubida* and *E. melliodora*. At localities where the annual rainfall is between about 35-45 in. the associated trees are *E. obliqua*, *E. elaeophora* and *E. macrorrhyncha*. Where the rainfall is higher than this, *E. radiata* grows with *E. obliqua* and *E. goniocalyx*. Towards the drier limit of its distribution *E. radiata* is a tree 50-60 feet tall and, at a wetter limit, it grows to twice this height.

It is certain that *E. radiata* is not a species of specialized habits. Growing in the region enclosed by the 30-50 in. isohyets, it shows no preference for particular soil types and grows on the krasnozem, silty loam podzol, sandy loam podzol, embryonic soils and occasionally on alluvium. Altitude does not limit the distribution of the species in this area for it grows at all altitudes from the summit of Mount Dandenong (2,070 feet) to North Croydon (250 feet).

This species and *E. obliqua* occur over a wide range of habitat conditions whereas the shrubs and herbs associated with them are more exacting. For this reason no attempt is made here to list these subsidiary species, either those of the understorey, or of the ground layer.

Eucalyptus obliqua LeHeret. Messmate.

There is no confusion about the nomenclature of *E. obliqua* LeHeret. A few varieties of this species have been described but none of these has been found in the area surveyed. The species is widespread in eastern Australia, particularly seaward of the Great Divide (Fig. 10).

Messmate is not very exacting as to habitat, and in the area studied it is common on well drained soils within the limits of the 35-50 in. isohyets (Fig. 13). In most respects the habitat of *E. obliqua* is similar to that of *E. radiata* and in this area the two species grow together for most of their range. Therefore, the description of the environment and associates of *E. radiata* will suffice for both species, with one amendment. Whereas *E. radiata* will grow where the annual rainfall is as low as 30 in., *E. obliqua* seldom grows where it is less than 35 in. About Lilydale, and in the Beaconsfield Hills where the annual rainfall is less than 35 in., *E. obliqua* is either absent or restricted to valley bottoms and southern slopes.

Eucalyptus macrorrhyncha F. Muell. Red Stringybark.

The nomenclature of *E. macrorrhyncha* F. Muell. has been quite stable. There are no synonyms and the species has only one described variety, and this is not present in the area surveyed. This species is limited to south-eastern Australia (Fig. 10), where it is common on the stony soils of the Great Dividing Range and the coastal ranges.

Within the area surveyed, *E. macrorrhyncha* grows on the well drained soils of hilltops and ridges in the Lilydale Hills, and on the steep western slopes of the Dandenong Range (Fig. 11), to an altitude of about 1,700 feet. The associated tree species are *E. elaeophora*, *E. radiata* and sometimes *E. melliodora* or *E. obliqua*.

The most obvious factors linked with the distribution of *E. macrorrhyncha* are topography and soil type. In the region surveyed it is found under annual rainfalls of from 35-48 in., almost always on well drained, steep slopes, ridges, or low hill tops. It is always associated therefore with embryonic soils and the more stony phases of the silty loam podzol; these are derived from toscanite, dacite and mudstones. The species is uncommon on the typical silty loam podzol and sandy loam podzol, and has not been observed growing on either the krasnozem or alluvium. Its absence from the basaltic and granitic areas may be due to the lack of embryonic soils there, but the same is not true of its limitation to elevations below about 1,700 feet. Above this altitude on Mount Dandenong embryonic soils extend up to about 2,000 feet. The absence of *E. macrorrhyncha* from the upper 300 feet may be associated with the clouds that frequently envelop the summit of the mountain and supplement the rainfall with fog-drip.

During the summer months, the northern and western slopes of the Dandenong Range are exposed to hot dry winds, and it is on these slopes that *E. macrorrhyncha* is most abundant. Yet even here this species is absent from places sheltered from the north and north-west winds. The sheltered localities support forests of *E. obliqua*, *E. radiata* and *E. goniocalyx* growing on krasnozem (not on embryonic soils) on the same bedrock. The interactions between soil, climate and vegetation make it impossible to decide, without experiment, the primary cause of the vegetation pattern, but the existence of *E. macrorrhyncha* on the lower hill tops in the Lilydale district suggests at least that soil type is a more important factor than exposure to dry winds.

Eucalyptus regnans. F. Muell. Mountain Ash.

This species was once regarded as a form of *E. radiata* Sieb. when that species was known as *E. amygdalina* Labill. The synonymy has been fully discussed by Maiden (1905). It is difficult to understand the source of this confusion, because *E. regnans* F. Muell. is an easily circumscribed species. With the possible exception of *Sequoia gigantea*, *E. regnans* is the tallest plant extant, often surpassing 300 feet. It is restricted to southern Victoria and Tasmania (Fig. 10), where it grows only on well drained soils in high rainfall areas below about 3,500 feet.

In the area surveyed, *E. regnans* is almost restricted to the eastern and southern fall of the Dandenong Range (Fig. 12) at all altitudes above about 750 feet. In this area the species may occur on any aspect. It grows only on the krasnozem and where the annual rainfall is above 45 in. it follows then, for this region, that it is restricted to dacites and mudstones.

The area once occupied by this species, almost certainly in pure stands, has been very extensively cleared and settled, first by farmers and nursery gardeners; more recently large blocks are being subdivided for housing. *E. regnans* still survives in one large reserve, Sherbrooke Forest, and bordering the creeks. Sufficient trees remain along roadsides to indicate clearly that the whole of the area indicated in Fig. 12 was once a continuous forest of *E. regnans*, and there is direct evidence from the older inhabitants to support this view. In many places within this area, *E. regnans* shows ready regeneration.

Typically *E. regnans* forms pure stands, sharply delimited from other forests and often of even age, owing to fires during the last century. Beneath it there is an understory of small trees (20-100 feet) including *Pomaderris apetala, Bedfordia salicina, Olearia argophylla, Prostanthera lasianthos, Acacia dealbata, Acacia melanoxylon* and the tree-ferns *Alsophila australis* and *Dicksonia antarctica*. The ground layer is rich in ferns, but poor in other species, and there is a dense litter of bark, twigs and leaves.

The areas carrying *E. regnans*, as well as slopes below them, are drained by numerous creeks that have cut deep valleys. The bottoms and lower slopes of these, adjoining the creeks, do not carry *E. regnans*, but are occupied by the very characteristic Victorian community described by Patton (1934) as the Fern Gully Association. Here the most frequent trees are the understory trees of the *E. regnans* forest together with *Atherosperma moschatum;* the two tree-ferns grow very luxuriantly and their trunks are clothed with mosses and filmy ferns. The typical fern gully occurs only within the *E. regnans* forest, although individual tree species from it may extend along the creeks to regions of low rainfall.

The soil of the fern gully is similar to the krasnozem, but contains much coarse sand, and is often waterlogged. This may account for the absence of *E. regnans* from the fern gully although the deep shade cast by the tree-ferns may prevent the establishment of this species.

Eucalyptus elaeophora F. Muell. Long Leaf Box.

Eucalyptus goniocalyx F. Muell. Mountain Grey Gum.

The two species *E. elaeophora* F. Muell. and *E. goniocalyx* F. Muell. as described in the "Flora of Victoria" (Ewart 1930) grade into one another in the area surveyed, making it impossible to define accurately the ecological requirements of either species.

However, for most part of their range (Fig. 14) the two species are not difficult of determination. *E. elaeophora* attains a height of 60-80 feet and has a rough flakey bark extending to all but the smallest branches. *E. goniocalyx* is a tall tree, up to 200 feet, with a smooth gum-bark throughout save for the first few feet of the bole. Except for the juvenile leaves, most of the usual botanical diagnostic features, such as buds and fruits, are not to be relied upon for the identification of these species. Their habitats are different (Table 6), but they are discussed together to emphasize this difference.

In the area surveyed *E. elaeophora* grows on the ridges and steeper slopes of the Lilydale and Beaconsfield Hills, and on the northern and western slopes of the Dandenong Range. It is particularly abundant along the roadside between Croydon and Montrose (Fig. 1). It is found at all altitudes up to about 1,700 feet, and in this region the annual rainfalls range from approximately 30 to 48 in. It grows on a variety of soil types and has been observed on the silty loam podzol, sandy loam podzol, krasnozem and skeletal soils, but not on the alluvium. It is more abundant on the stony phases of these soils and so the species is most common on the ridges. Its commonest associated tree species are *E. macrorrhyncha, E. radiata* and *E. obliqua*.

In the area surveyed, *E. goniocalyx* is almost restricted to the Dandenong Range where it is a common constituent of the forests of the eastern and southern slopes, and the sheltered parts of the western slopes between The Basin and Sassafras. This species is more exacting than *E. elaeophora*, although their habitat requirements overlap. *E. goniocalyx* grows at altitudes between about 600 to 2,000 feet, where the annual rainfall is about 40 to 50 in., and it has been observed growing only on the krasnozem and skeletal soils. The nature of the bedrock does not appear to determine the distribution because it grows on the dacite, toscanite, mudstone and granite. Its common associated trees are *E. radiata* and *E. obliqua*.

The intergradation of these two species may be due to their introgressing one into the other (Anderson 1949). Preliminary evidence of their ability to hybridize has been obtained by growing the seed of a suspected hybrid. The seedlings raised showed segregation of characters and several of the seedlings resembled one or other of their suggested parents. A more detailed account of the ecological and systematic relationships of these two species will be published elsewhere.

Eucalyptus viminalis Labill. Manna Gum.

This species is limited to south-eastern Australia and Tasmania (Fig. 10), and usually grows in riparian habitats. There are several varieties of *E. viminalis* Labill., and two of them grow in the area surveyed. They are the typical form and the variety *racemosa F. Muell. ex Maiden.* The former is a major species and the latter is discussed separately as a minor species.

Within the area surveyed, *E. viminalis* Labill. grows along the banks of creeks and occasionally forms small pure stands. The most extensive of these is along the Olinda Creek between Montrose and Lilydale; other stands occur along the Dandenong Creek near The Basin, and on the Monbulk Creek near the Belgrave reservoir. In pure stands the trees grow to 150 feet, and beneath them is a well developed shrub stratum up to 20 feet. The shrubs are similar to those of the forests dominated by *E. regnans.*

Neither altitude nor rainfall limit the distribution of *E. viminalis,* for it grows throughout the area surveyed. However, it is very specific as to the soil type on which it will grow, and rarely occurs except on alluvial soils. A very fine group of these trees grows high on the roadside on krasnozem soil adjoining Five Ways, Kalorama. The underlying bedrock does not limit its distribution for it grows on the mudstone, toscanite, dacite and granite. Its absence from the basalt may be correlated with the absence of permanent streams in those places where the bedrock is basalt.

Species of Minor Importance

Eucalyptus rubida Deane et Maiden. Candlebark.

Morphologically this species is similar to *E. viminalis* Labill. but differs from that species mainly in having orbicular instead of lanceolate juvenile leaves. The species *E. rubida* Deane et Maiden as described in the "Flora of Victoria" (Ewart 1930) probably contains several distinct races. Some of these are regarded as separate species by Blakely (1934) but his suggestions are not acceptable without extensive field and genetical investigation.

In the area surveyed, *E. rubida* is not a common species and is restricted to the Lilydale district. It grows on well drained soils and has been observed on the silty loam podzol and the krasnozem. It is rare where the annual rainfall is more than 40 in. The absence of *E. rubida* from the Beaconsfield Hills where the rainfall is similar to that about Lilydale, suggests that soil type or geology may be limiting the distribution of this species, for there the soil is a sandy loam podzol overlying granite.

Eucalyptus melliodora A. Cunn. Yellow Box.

This species is morphologically variable and has several described varieties, but none occur in the area surveyed. Geographically *E. melliodora* A. Cunn. is widespread in eastern Australia, and is more common on the inland than the seaward slopes of the Great Dividing Range.

In the area surveyed, *E. melliodora* is an uncommon species. It grows where the annual rainfall is less than about 40 in. and is restricted to the silty loam podzol. Soil type may be important in controlling the distribution of this species, because it does not grow on the sandy loam podzol, krasnozem, embryonic soil or alluvium, even when these occur where the rainfall is apparently suitable.

Eucalyptus capitellata Sm. Brown Stringybark.

The nomenclature of this species is very confused. The species *E. capitellata* Sm. as described by Ewart (loc. cit.) could be regarded as an aggregate species and indeed has been divided into several species, most of which are upheld by Blakely (1934). Since the segregate species are ill defined and their variability unknown they are not recognized here. According to Blakely's classification the plant that occurs in the area surveyed is *E. baxteri* (Benth.) Maiden *var. pedicellata* Maiden et Blakely.

In the field, *E. capitellata* Sm. is difficult to distinguish from *E. obliqua* LeHeret with which it is frequently associated. Its distribution was not accurately mapped although it is a frequent species on the northern slopes of the Dandenong Range and on the Lilydale Hills. It grows on the krasnozem, podzolic and embryonic soils where the annual rainfall is about 40-50 in.

Eucalyptus brevirostris Blakely.

One tree answering to the description of this species was found about one mile east of Lilydale, growing in the Lilydale Hills.

Eucalyptus dives Schauer. Broad Leaf Peppermint.

This species grows on the north and north-west slopes of the Dandenong Range at an altitude of about 800 feet. The trees are uncommon and appear to be interbreeding with *E. radiata* Sieb.

Eucalyptus globulus Labill. Blue Gum.

This species has been planted in fields as a shelter tree and occasionally it is left growing as an apparently indigenous tree.

Eucalyptus scabra Dum-Cours. White Stringybark.

A small clump of *E. scabra* Dum-Cours. was observed on a hillside about one mile north of Croydon. This species is recorded as *E. eugeniodes* Sieb. in the "Flora of Victoria".

Eucalyptus sieberiana F. Muell. Silvertop.

Several trees of this species are growing on a northern spur of the Dandenong Range.

Eucalyptus viminalis Labill. var. racemosa F. Muell. ex Maiden. Coastal Manna Gum.

A few trees conforming to the description of this species are growing on Melbourne Hill and the Beaconsfield Hills. Their determination is not entirely satisfactory. They may be the variety *racemosa* F. Muell. ex Maiden of *E. viminalis*

Labill., or as suggested to the writer by Mr. L. D. Pryor, Canberra, they could be hybrids, the parents being *E. viminalis* Labill. and *E. cinerea* F. Muell. *var. multiflora* Maiden.

Eucalyptus vitrea R. T. Baker. Gum-top Peppermint.

Two trees that possibly belong to this species have been observed in the area studied. One was at an altitude of about 1,600 feet on the western slope of Mount Dandenong, and the other was about one mile south of Selby.

TABLE 6

The habitats of the major species of Eucalyptus in the Region of the Dandenong Range.

Species	Status	Elevation	Rainfall in inches	Soil Type	Bedrock
E. radiata Sieb.	co-dominant	250–2000 ft.	30–50 p.a.	silty loam podzol sandy loam podzol embryonic krasnozem	mudstone granite toscanite dacite basalt
E. obliqua LeHeret	co-dominant	300–2000 ft.	35–50 p.a.	silty loam podzol sandy loam podzol embryonic krasnozem	mudstone granite toscanite dacite basalt
E. elaeophora F. Muell.	co-dominant	300–1700 ft.	30–48 p.a.	silty loam podzol sandy loam podzol embryonic krasnozem	mudstone granite toscanite dacite basalt
E. goniocalyx F. Muell.	co-dominant	600–2000 ft.	45–50 p.a.	embryonic krasnozem	mudstone toscanite dacite granite
E. regnans F. Muell.	dominant	750–2000 ft.	45–55 p.a.	krasnozem	mudstone dacite
E. macrorrhyncha F. Muell.	co-dominant	350–1700 ft.	35–48 p.a.	silty loam podzol sandy loam podzol embryonic	mudstone toscanite dacite
E. ovata Labill.	dominant	250–800 ft.	30–40 p.a.	silty loam podzol sandy loam podzol krasnozem alluvium	mudstone granite toscanite dacite basalt
E. cinerea F. Muell. var. multiflora Maid.	dominant	250–800 ft.	30–40 p.a.	silty loam podzol sandy loam podzol krasnozem alluvium	mudstone granite toscanite basalt
E. viminalis Labill.	dominant	250–1800 ft.	30–50 p.a.	alluvium	mudstone toscanite granite dacite

Discussion

The ideal potential environment of most plant species is much greater than that occupied under virgin conditions; probably the competition between species with different optimal requirements is the most likely cause of this restriction. For example, in the field *E. ovata* is usually restricted to badly drained soils near creeks, but it is occasionally found on sloping hillsides, and it may be successfully grown in well-drained garden soils. It follows that the explanation of the complex pattern of vegetation described above must await a most intensive study of the biology of each of the *Eucalyptus* species concerned. It does, however, seem worth while at this stage to note that the nine major species, each with a wide geographical range in southern Australia, differ markedly in their reaction to comparatively small environmental changes (Table 6). *E. radiata* and *E. obliqua* have a wide range even within the area studied, and may be regarded as relatively insensitive species. They grow in mixed *Eucalyptus* forest, with different co-dominants—*E. elaeophora, E. goniocalyx* and *E. macrorrhyncha*. These three are more sensitive to environmental factors, under competition, and are more limited in their distribution within the area. At the other end of the scale stand *E. regnans. E. ovata* and *E. cinerea var. multiflora*. These three species grow on well defined soil types, usually in pure communities. In particular, *E. regnans* may be regarded as a good indicator plant, being here restricted to the well-drained kraznosem soil in places where the high annual rainfall of 45 in. or more is supplemented by fog drip.

The analysis of the environment for each of the *Eucalyptus* species, in the area surveyed, indicates that climate and soil are the principal influences responsible for their distribution. Where the bedrock is apparently important, it is usually more satisfactory to interpret the distribution of a species in terms of either soil or climate. For example, although in this region *E. regnans* is limited to soils derived only from dacite or mudstone, this is almost certainly due to their being the only rock types within the 45 in. isohyet.

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