FOREST SUCCESSION IN THE FLORENTINE VALLEY, TASMANIA

By

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SUMMARY

The topography, geology, climate and soils of the middle Florentine (lat. 42° 30′ S., long. 146° 30′ E.) are described. The vegetation consists of temperate rainforest, mixed forest (eucalypts with an understorey of rainforest species), eucalypt forest and treeless areas.

Except perhaps on the poorest soils, the climax is temperate rainforest and should the site be undisturbed by man (fire or axe) the climax condition is reached with the death, from old age, of the current generation of eucalypts which germinated at the last disturbance of the site.

The large areas of mixed forest date from past widespread fires. The rainforest species regenerate immediately after fire, i.e., at the same time as the eucalypts, and do not have to invade from the edge of the burnt area. However, should fires occur several times per century, the rainforest species will be drastically reduced or even eliminated.

The mixed forest is a fire-climax occupying a broad zone between the eucalypt forests of areas of lower rainfall and the rainforest of areas of higher rainfall and lower fire frequency. In the absence of fire the areas now occupied by mixed forest would carry rainforest and the ecotone between rainforest and eucalypt forest would probably be very steep and along the boundaries of poor soil.

I. TOPOGRAPHY AND GEOLOGY

The Florentine Valley (latitude 42° 30′ S., longitude 146° 30′ E.) is approximately 48 miles N.N.W. from Hobart, the river flowing from the south to join the middle course of the Derwent. This paper deals particularly with 12 miles of the middle Florentine from Tim Shea to Dawson's Road (Figs. 1.1 and 1.2).

In this region the valley is broad and flat (Figs. 1.2 and 1.3), the river meandering along the western side of the valley floor which falls at a rate of about 1 in 250. By contrast, in the last six miles of its course to the Derwent River, the Florentine falls 525 feet (1 in 60).

Dominating the valley, is the group of mountains rising steeply on the eastern side. From north to south the main points on this range are: Misery (2,500-3,000 feet), Lord (3,900 feet), Field West (4,720 feet), Florentine (4,100 feet), and Wherretts (3,300 feet).

To the west are the moderately steep slopes of the Tiger Range (2.000-2,500 feet)—the watershed between the Florentine and Gordon. Northwards, this continues as the Gordon Range, which culminates in Wyld's Craig (4,388 feet).

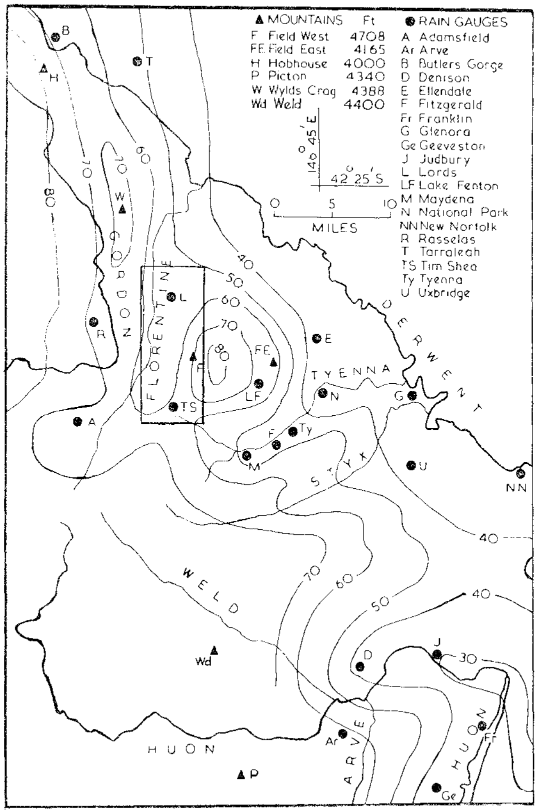

FIG. 1.1. Location of study area in Florentine Valley and annual rainfall (inches).

The Geology of the area has been described, as follows, by Banks (1957):—

"The Florentine Valley is the eastern limb of the syncline of which the Tiger and Gordon Ranges form the axis. At its southern end, at Tim Shea, there is exposed the core of an anticline which plunges northwards into the syncline. The core of this anticline consists of Owen Conglomerate which is overlain by Caroline Creek Sandstone and Florentine Valley Mudstone.

"The Florentine Valley Mudstone is overlain by Gordon Limestone, which forms the greater part of the floor of the valley. The limestone is cavernous. It is overlain in the Tiger and Gordon Ranges by quartizites and siltstones of the Eldon Group.

"Along the eastern face of the valley the Gordon Limestone is unconformably overlain by almost horizontal beds of Permian sandstones and mudstones. These beds are intruded by sheets of dolerite which now cap the ridges such as the Misery Range, Lords, Field West, Wherrett's Look-out (Wyld's Craig is also capped with dolerite). A series of faults along the western edge of the dolerite are down-thrown to the north-east.

"In the valley itself the Gordon Limestone generally dips steeply westward and in many places is overlain unconformably by unconsolidated, sub-horizontal beds of sand, gravel and cobbles. Near Lawrences Creek, these consist of fluvial gravels made up of rounded dolerite boulders. These may in part be fluvio-glacial as a small valley glacier occupied the head of the valley of the creek during part of the Pleistocene.

"Some beds of the Gordon Limestone have in places undergone selective silification and these beds are now represented by ridges covered with white angular fragments of cherty material containing silicified corals".

Throughout the floor of the valley and the lower slopes the surface drainage pattern is largely undifferentiated (subterranean drainage in limestone) and the surface is broken by local subsidences.

II. CLIMATE

1. General Pattern

Tasmania has a marine type of humid mesothermal climate (Cb of Trewartha—1954). The general weather pattern is imposed by Southern Ocean depressions. During the winter Tasmania is characteristically within the westerly air-stream with high pressure cells passing to the north of Bass Strait. Heavy rain may fall ahead of or along the cold fronts associated with the depressions, and showery weather continues often for several days with the strong westerly to south-westerly air-stream behind the front. If a depression causes an outburst of Antarctic air, snow falls.

In summer little rain falls ahead of the cold front. Should the depression be intense enough and have a trough extending into the Australian continent, hot, dry air of the Continental air-mass is brought in over the State. If forest fuels are already dry and these winds strong, any fires that occur will be severe (Gilbert, 1949). Such winds do not often blow for more than 24 hours.

Only scanty climatic information is available from the Florentine Valley itself and most of the records for nearby stations are for short terms.

2. Precipitation

The data in Table 1.1 indicate the monthly distribution of rainfall (for location of stations see Fig. 1.1.

TABLE 1.1.—MEAN MONTHLY RAINFALL IN POINTS.

Station: No. of Years:	Maydena. 5	Lake Fenton. 15	Tarraleah. 21
January	350	386	369
February	341	448	361
March	299	425	283
April	387	506	362
May	334	532	413
June	383	573	360
July	464	555	500
August	477	600	629
September	582	651	691
October	485	596	442
November	381	596	331
December	403	472	549
Year	4,886	6,340	5,290

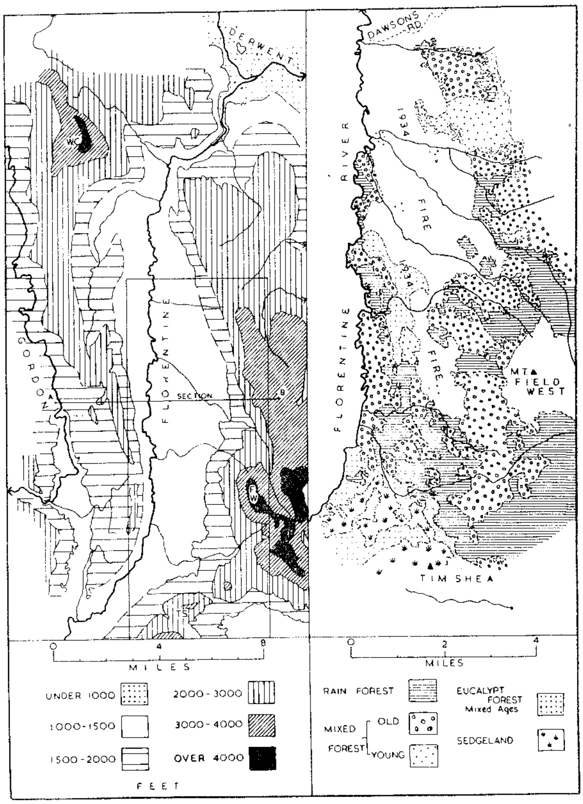

FIG. 1.2.—(a) Topography of Florentine Valley and surrounding districts. F.W.—Mt. Field West; T.S.—(Mt.) Tim Shea; W.C.—Wylds Craig.
(b) Distribution of forest types in middle of Florentine Valley. Complied from forest type map prepared by Tasmanian Forestry Commission.

Over three years (1955-57) the rainfall at Tim Shea averaged 59.97 inches and at Lords 47.27 inches for two years (1956-57). After considering data for long-term stations outside the Florentine (ratio of actual to mean catches for the years 1955, '56 and '57), the scanty information from the Florentine suggests that the mean annual rainfall at the southern end of the study area is 60-65 inches, and towards the northern end 50-55 inches.

In drawing the rainfall map (Fig. 1.1), some allowance has been made for the effect of topography and to some extent vegetation has been used as a guide. The 80" isohyet on the Field Range is justified by topography and by a comparison of the vegetation of the range with that near places such as the Cradle Valley, the Hartz-Adamson-La Perouse Range and the mountains near Lake St. Clair. Martin (1939) compared the development of the Austral-Montane shrubberies on several Tasmanian mountains and in particular referred to the relation between annual rainfall and the development of the dwarf endemic conifers. There are communities of *Diselma archeri, Pherosphaera hookeriana, Athrotaxis cupressoides* and *Microcachrys tetragona* on the Field West Range, which, following Martin, suggests that the annual rainfall is at least 80".

The seasonal distribution of rainfall for nearby stations is shown in Table 1.2.

TABLE 1.2.—SEASONAL DISTRIBUTION OF RAINFALL.

Station.	Elevation (feet).	Annual Rainfall (points).	% of Annual Rainfall. Jan.-Mar.	Apr.-Jun.	Jul.-Sep.	Oct.-Dec.
Maydena	870	4,886	21	22	31	26
L. Fenton	3,450	6,340	20	25	29	26
Tarraleah	2,050	5,290	19	22	34	25

The winter bias is not extreme and 20% of the annual rainfall occurs in the three months, January-March.

Snow is to be expected in all parts of the area each winter. On the floor of the valley snow rarely remains for more than 1-2 days . On the lee slopes (E.-N.E.) of the Field West Range snow drifts may persist into January. It would be unusual for snow to lie for more than a few weeks in the *Eucalyptus gigantea* forest below 3,000'.

Fogs.—Low-level fogs are very common during the winter months and often do not disperse from the flats until mid-day.

3. Temperature

Short-term records are available from Maydena and Tarraleah (Tables 1.3 and 1.4). Maydena is within the *Eucalyptus regnans* forest belt, but Tarraleah is at a higher elevation and in *Eucalyptus gigantea* forest. The figures for Tarraleah are indicative of temperatures just belond the range of *regnans*.

From the data of Table 1.4 it is clear that frosts may occur at Maydena in any month. In the Florentine frosts are usually widespread but only one uncertain case has been observed of frost-heave of young seedlings. Rime may form on the crowns of eucalypts, even when more than 200 feet high.

4. Wind

The general pattern of the westerlies of the southern hemisphere have been described by Trewartha (1954). One of their distinguishing characterestics is "spells" of weather, i.e., at times, and especially during the winter, the wind blows with gale force, while upon other occasions mild breezes prevail. Moderate to strong winds (Beaufort scale 3-7; 8-38 m.p.h.) are most numerous, with strong winds (B. scale 8-12; 39-71 plus m.p.h.) more prevalent than weak winds (B. scale 1-2; 1-7 h.p.h.). Calms are infrequent. The westerlies are more boisterous on the average than the Trades.

In the Florentine Valley, winds are generally light from all quarters except N.W.-S.W. Precise information is not available from nearby weather stations, but some data for Hobart is representative except that the position of Mt. Wellington and the Derwent Estuary turn the W.-S.W. stream winds to N.W.

TABLE 1.3.—MONTHLY MEAN MAXIMUM AND MEAN MINIMUM SCREEN TEMPERATURES.

Station	No. of Years.		°F. J.	F.	M.	A.	M.	J.	J.	A.	S.	O.	N.	D.	Yr.
Maydena	4	Mean:													
		Max.	72	71	67	59	54	49	49	51	56	58	61	67	60
		Min.	46	47	43	42	38	35	33	35	36	38	41	44	40
Tarraleah	*	Mean:													
		Max.	65	68	64	58	52	46	46	49	53	57	61	75	57
		Min.	44	44	42	41	34	31	31	33	34	36	40	42	38

* Unofficial station: basisfor means uncertain.

TABLE 1.4.—ABSOLUTE MAXIMUM AND MINIMUM SCREEN TEMPERATURES AT MAYDENA, 1952-57.

Month:	J.	F.	M.	A.	M.	J.	J.	A.	S.	O.	N.	D.	Yr.
Maximum	91	90	87	76	68	66	58	64	72	71	86	92	92
Minimum	34	31	30	30	28	22	20	22	23	26	32	38	20

For the period 1930-1947 the annual wind-gust maxima were distributed as follows:—

Wind Speed, m.p.h.

51-55	56-60	61-65	66-70	71-75	86-90
4	1	4	5	3	1

The lowest maximum was 54 m.p.h. in 1931, the highest 87 in 1946.

For the 34-year period (1922-56) the frequencies of the direction of the annual wind-gust maxima were: North 1, North-west 22, West 10, South 1.

Over the periods 1841-79 and 1882-1943 the mean number of days per month with gales were as follows:—

July	less than 1
October	2
All other months	1

(A gale is said to occur when for any occasion of about 10 minutes the average wind is 39 m.p.h. or more. Gusts could be expected to reach a wind speed of at least 50% above that for the mean of a 10-minute period.)

III. SOILS

The soils of the area have been described by Nicolls (1958) as follows:—

" The leaching potential of the climate is high so that soils, other than young ones, are highly leached.

" On the broad limestone floor of the valley a deep yellow podsolic soil has developed. The accumulation of soil is due to the fact that the limestone is very impure. The classical soils of limestone—Terra Rossas and Rendzinas—apparently do not occur in the Florentine, presumably because of the wet environment. pH varies from 5.3 to 5.7.

" The soils developed on the highly siliceous rocks on Tim Shea and on the low ridges of silicified limestones (see I. Topography and Geology) are typical of those on similar parent materials elsewhere in Tasmania. They are sandy and gravelly, highly acid (ph 4.1-4.4), and have considerable accumulation of organic matter in the A and B horizons. The soils developed on the silicified limestone have yellow clay at a depth of several feet.

" There are large areas of young soils because of the presence of recent deposits. The two important ones are:—

(1) The Lawrence's Creek fluvio-glacial deposits, which fan out on the floor of the valley. These deposits were probably laid down during the late Pleistocene.

(2) The mantle of solifluction debris which presumably dates from the concluding stages of the late Pleistocene glaciation. This type of material is common in central and eastern Tasmania above 2,000 feet, but occasionally it may descend in ribbons to as low as 1,000 feet (Davies, 1958).

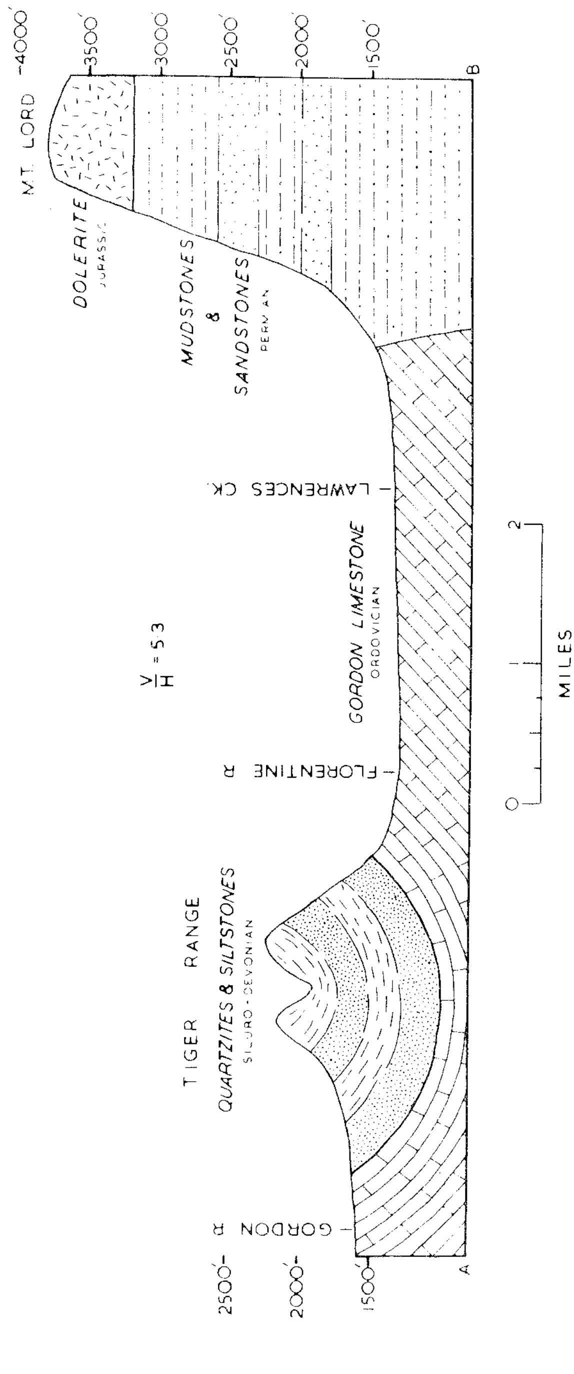

FIG. 1.3. Geological cross-section on an E.W. line from Gordon River to Mt. Lord. Location of section shown in Fig. 1.2 (*a*).

" On the fluvio-glacial deposits a brown loam has been developed which has an apparently uniform profile to a depth of 3-4 feet and overlies dolerite gravels. Internal drainage is free. Over wide area the solifluction deposits overlie the Permian mudstones and sandstones (Fig. 1.3) and essentially consist of unsorted dolerite boulders of all sizes in an earthy matrix. There is little differentiation in the soil profile, apparently due to limited downward movement of iron and clay. The solifluction deposits are probably important in that they bring weathering dolerite on to the rather sterile Permian sediments ".

Sedgeland, wet scrub or poor-quality eucalypt forest occur on the soils derived from siliceous rocks or silicified limestone. The other soils support a forest of good quality.

In unburnt forest there is an accumulation of organic matter at the base of large *Nothofagus* and *Eucalyptus*, to a depth of 1-2 feet. This material is in the form of a cone and within a few yards the layer may be less than an inch thick. Beneath *Atherosperma* the litter layer is virtually absent, even at the base of the trees.

IV. FOREST TYPES

1. Nomenclature

(*a*) *Taxonomic.*

As the latest complete Tasmanian flora was compiled more than fifty years ago (Rodway, 1903), the names used have been taken from several sources.

(1) *Gymnosperms* and the *Polypetalae* (of Bentham & Hooker), except *Eucalyptus,* from Curtis (1956).

(2) *Eucalyptus*—Blakely, (1934).

(3) *Ferns*—Wakefield, (1957).

(4) *Other Tasmanian plants* — Rodway, (1903).

(5) For plants not covered above, the author's names are given in an appendix. As a general rule, eucalypts are referred to by their specific names only.

(*b*) *Ecological.*

The classification proposed by Beadle and Costin (1952) is used to the extent to which it is applicable. The eucalypt-rainforest mixtures would be called " wet sclerophyll forest " but in reality they do not conform to the definition of this type in several important respects, e.g., the scattered eucalypts which occur above the understory of rainforest sepcies do not have densely interlaced crowns. Accordingly, this type is labelled " Mixed Forest ". Jacobs (1936) has suggested that the tender naked buds make interlacing impossible. Eucalypt crowns never interlace in the way that many other trees do. For want of a better term, all stands of eucalypts, other than those with a well developed understory of rainforest species, have been called " Eucalypt Forest ". The term " sedgeland " (Jackson, 1958) is used for the more or less treeless vegetation which is found on shallow acid soils. It consists of a mixture of low shrubs of the families *Myrtaceae, Epacridaceae* and *Proteaceae* and sedge-like plants of the *Cyperaceae* and *Restionaceae.*

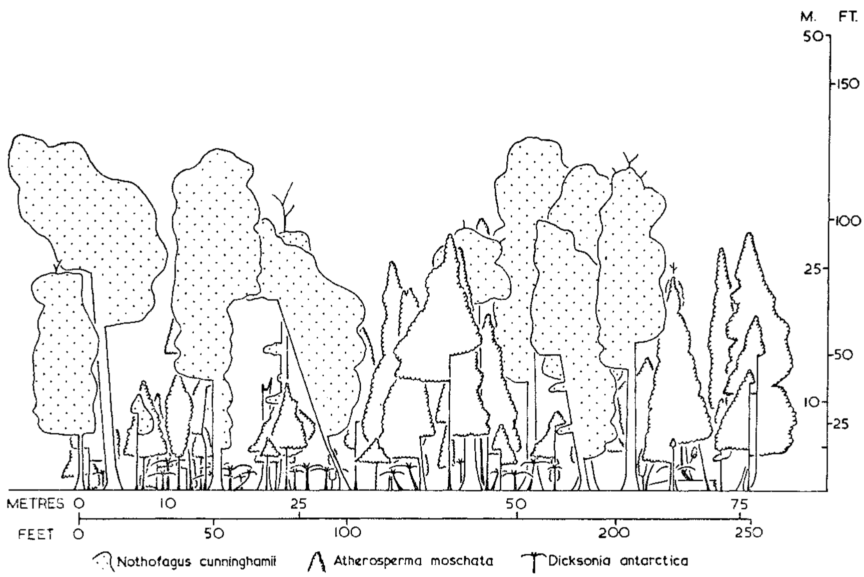

FIG. 1.4. Profile diagram of transect in temperate rainforest, Road 7, Florentine Valley. Transect 50 feet wide but *Dicksonia* shown for central 32 feet only.

2. Preliminary Note

Jackson (1958) has suggested that for S.E. Australia generally, rainfall requirements for the development of temperate rainforest are an annual fall of at least 50″ with a minimum of 2″ in each of the months of January, February and March. Other estimates of minimum annual rainfall for rainforest in Tasmania have been 50″ by Curtis and Somerville (1949) and nearly 60″ by Gilbert (1949). Fires have upset ecological succession in the region but it is apparent that at Maydena (49″) and Tarraleah (53″) a lowered fire-frequency would have allowed rainforest to have developed fairly generally.

In the central Florentine Valley the climax is temperate rainforest, except on some very acid soils of low fertility where the climax would be eucalypt forest or sedgeland.

Fire has been the major factor preventing the general attainment of climax vegetation. On soils of moderate to high fertility the particular frequency of fires has determined the point reached in the succession towards the climax. Thus:—

1. If an area remains unburnt for a single period of 350-400 years (life span of the main forest eucalypts) the climax condition is achieved.

2. If an area is burnt infrequently but with an interval between fires of less than 350 years, it remains under mixed forest. The forest is destroyed by each fire but the species present in the fully developed mixed forest regenerate immediately after the fire.

3. With a fire frequency of once or twice per century the mixed forest is replaced by eucalypt forest with an understory characterised by *Pomaderris*, *Olearia* and *Acacia* instead of climax rainforest species.

4. Still more frequent fires, perhaps at ten to twenty year intervals, will not only prevent eucalypt forest progressing to mixed forest but will maintain *obliqua* and *gigantea* at the expense of the much more fire-sensitive *regnans*.

5. There is evidence that very frequent fires were responsible in part for the maintenance of savannah-like conditions in the middle Florentine until perhaps 100-200 years ago.

On the soils of low fertility, much sedgeland would have progressed to wet scrub if not low eucalypt forest but for frequent fires. These are possible because of the inflammable nature of the vegetation and have occurred because the open sedgelands were routes of travel of the aboriginals and, later, white man.

With all forest types, freedom from fire—which means progression towards the climax—leads to floristic simplification. The ultimate in simplification is temperate rainforest, a condition unlikely to be attained on very poor soils. As soils improve, two main changes take place:—

1. Tree height increases; and
2. The floristics become simplified.

Neither aspect nor drainage are generally decisive in determining the distribution of forest types, although the development of sedgeland is favoured by impeded drainage on poor soils. Except on small flats along the Florentine River, drainage is good on the limestone floor of the valley.

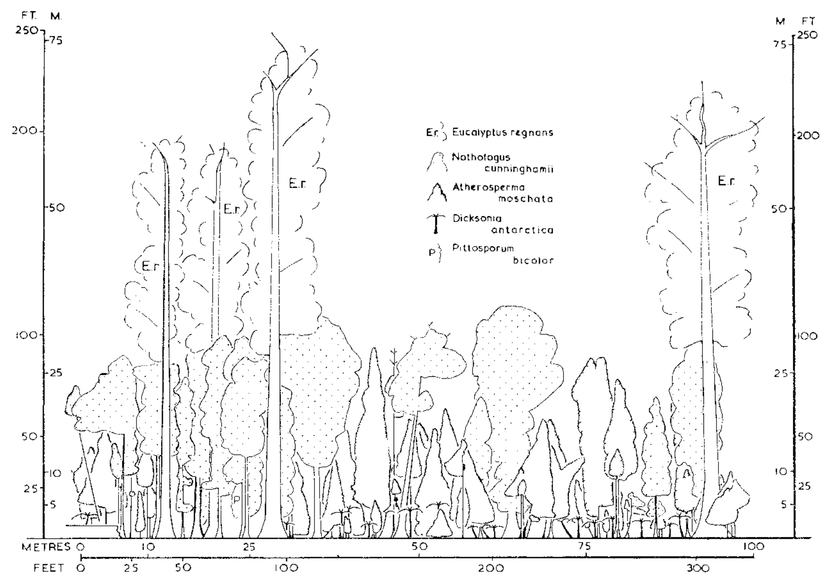

FIG. 1.9. Profile diagram of old mixed forest, Road 10, Florentine Valley. Transect 50 feet wide but *Dicksonia* shown for central 32 feet only.

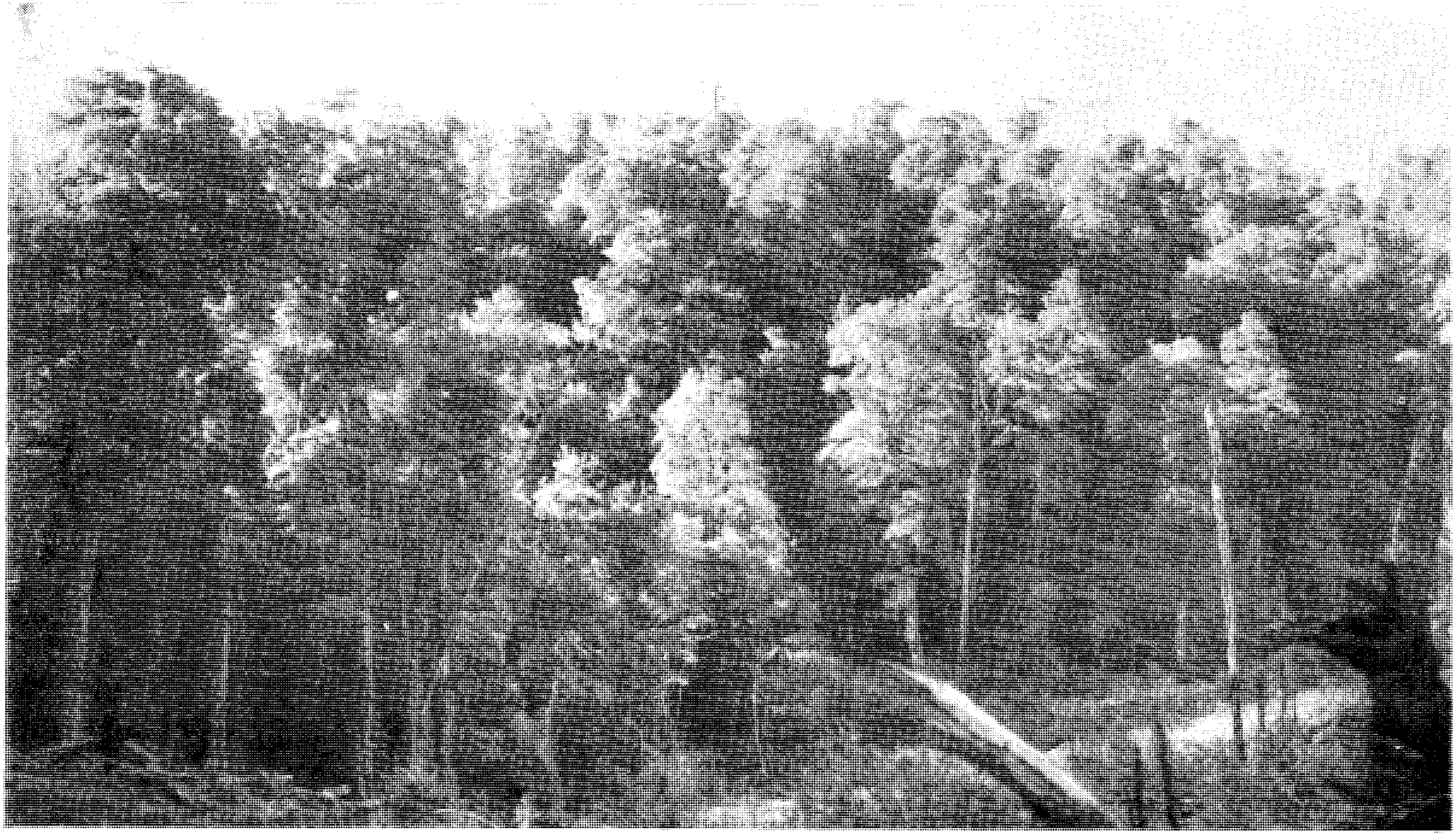

FIG. 1.5 Temperate rainforest near Companion River, N.W. Tasmania. **Principally** *Nothofagus cunninghamii* with *Atherosperma moschata*.

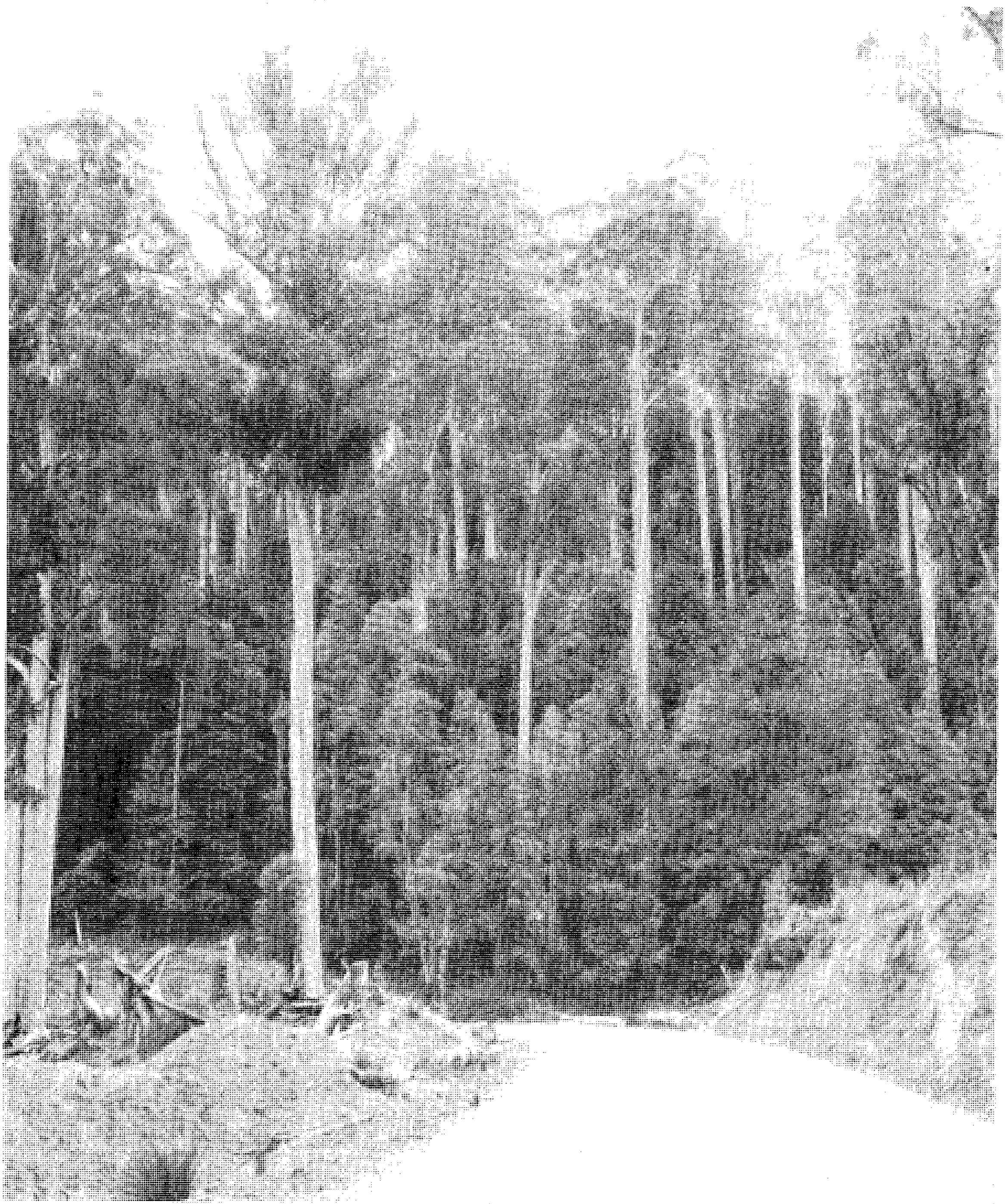

FIG. 1.10. Mixed forest, Florentine Road, upper Tyenna Valley. *Eucalyptus obliqua* with some *E. gigantea*. Understorey of *Nothofagus cunninghamii* and *Atherosperma moschata* (light coloured crowns).

Aspect has little direct influence in the distribution of the forest types. Rainforest and old mixed forest cover most of the westerly and north-westerly slopes of the Field West Range from Field West to Tim Shea because the middle Florentine is protected from fires from the west and north-west by the Tiger and Gordon Ranges. The main source of past fires has been in the vicinity of Dawson's Road and further north.

Elevation sets limits to the distribution of species but not to vegetation types. Thus *regnans* is not found above 2,000 feet, but mixed forest is common and dwarf rainforest is occasionally found to the limits of eucalypts at 4,000-4,200 feet.

3. Forest Types

The following forest types will be considered:—

(*a*) *Temperate Rainforest.*

This is an association of *Nothofagus cunninghamii* and *Atherosperma moschata*, in which other flowering plants are of rare occurrence except under special circumstances.

(*b*) *Mixed Forest.*

The mixed forest consists of eucalypts with an understory of rainforest species. In old stands the understory is not essentially different in structure or floristics from that of pure rainforest. In any one stand the eucalypts are of the same age (" even-aged ").

(*c*) *Eucalypt Forest.*

(i) *On soils of moderate to high fertility.*

In these forests *Nothofagus* and *Atherosperma* play a minor role at present. The eucalypt forest will be dealt with as follows:—

(1) Areas affected by the 1934 or later fires;
(2) Areas which, until recently, carried savanah woodlands;
(3) Areas burnt probably 3-4 times in the last 200 years by fires of low intensity.

These are shown together as a blank area in Fig. 1.2 (*b*), marked " 1934 fire ". Within this area there is great variation in the eucalypt stands.

(2) *On soils of low fertility.*

Fairly extensive areas of poor eucalypt forest occur on siliceous soils on Tim Shea, and in the floor of the valley on the low ridges formed from silicified bands of limestone. These are indicated in Fig. 1.2 (*b*) as " Eucalypt forest—mixed ages ".

(*d*) *Non-forested.*

The principal non-forested areas are found on the slopes of Tim Shea on conglomerate and quartzite—shown as " sedgeland " in Fig 1.2 (*b*). In addition, some very small treeless areas occur as remnants of the savannah of the middle Florentine.

A. Temperate Rainforest.

(*a*) *General.*

Temperate rainforest occupies large areas of the floor of the Florentine Valley to the north of Tim Shea and extends on to the steep slopes of the Field West Range from Wherrett's Look-out to Mt. Field West.

A feature of the forest, particularly on the lower slopes, is the small number of species present. Except for *Nothofagus* and *Atherosperma*, the counts of Spermatophytes are shown in Table 1.5 for five transects.

Table 1.5.—*Counts of Spermatophytes, Other than Nothofagus and Atherosperma on Transects in the Maydena District.*

Location	Size of Transect (ft.).	Species	No.
Road 7, Florentine	900 x 33	....	
Road 7, Florentine	250 x 30	....	
Road 10, Florentine	320 x 50	Pittosporum bicolor	1
5½m., Florentine Rd.	345 x 50	Pittosporum bicolor	1
Styx Valley	660 x 33	Olearia argophylla	1

In the above table the last three transects were in old mixed forests where the change to rainforest on the death of the eucalypts from old age, would not introduce new species. The transects may exaggerate the general position but it is clear that species other than *Nothofagus* and *Atherosperma* are not common. On good soils, species occasionally found are *Pittosporum bicolor, Coprosma billardieri, Clematis aristata* and *Aristotelia peduncularis.* Where the canopy of *Nothofagus* and *Atherosperma* is broken as is usually the case on poor soils, *Eucryphia lucida, Anodopetalum biglandulosum* and *Phyllocladus asplenifolius* (trees), together with *Anopterus glandulosus* and *Cenarrhenes nitida* (shrubs), may be locally frequent. An increase in the frequency of these species is fairly common on steep slopes at elevations above 1,500-2,000 feet. *Olearia argophylla* is not commonly found in rainforest or mixed forest. *Lyonsia straminea* has not been observed, the only liane found being an occasional *Clematis.*

(*b*) *Description of Transect.*

The profile of a transect in rainforest is given in Fig. 1.4. Although some trees on the 50-ft. wide transect could not be shown the only important omission is a dead *Nothofagus* 85 feet high and 15 feet in girth.

The upper stratum consists of *Nothofagus* which, in spite of deep, dense crowns, have a general appearance of senility. Some have dead tops with *Phymatodes diversifolium* growing on the main limbs and there are two standing dead trees. The *Nothofagus* canopy is not complete (Fig. 1.5), for large gaps occur. It is in the gaps that *Atherosperma* reaches its maximum development. The dimensions of the five largest *Nothofagus* were:—

	G.B.H.	Height.	Crown Spread.	Crown Depth.
Mean	16.5	125	40	80
Maximum	10	130	58	85

(Measurements in feet.)

Atherosperma has a total height of 80-100 feet, but does not develop a broad-topped crown as does *Nothofagus*. Also, the crown is more open and persists to lower levels. Small *Athersperma* occur throughout the transect in numbers far exceeding those of *Nothofagus*, which suggests that it is the more shade-tolerant species. Large numbers of *Nothofagus* seed germinate but few seedlings survive beyond the cotyledonary stage. On nearby roadside clearings well established *Nothofagus* seedlings are present in large numbers.

The tree-fern *Dicksonia antarctica* forms a broken stratum at 8′-10′. Many of the plants are showing the effects of low light intensities (c. 1/100 of that in the open)—mature fronds are often only three feet long and the tops of the trunks are sharply tapered. The forest is very open near ground level.

There are few logs on the ground. *Atherosperma* is not durable and many *Nothofagus* die "on their feet" and rot away while still standing. Logs, fallen limbs and the ground (except under mature *Nothofagus*) are more or less completely covered with a layer of liverworts, mosses and lichens. The Bryophytes also grow on most of the tree and fern trunks, and commonly reach a height of 80′-90′. Of the epiphytic ferns, *Grammitis billardieri* occurs here and there on logs and trunks (sometimes to 80 feet), members of the *Hymenophyllaceae* occur on lower trunks, and *Phymatodes diversi folium* is found at high levels in the crowns of dead and dying *Nothofagus*.

In Table 1.6 is shown the distribution by girth-classes of the trees depicted in Fig. 1.4 (transect A) and those on a nearby transect (B).

(*c*) *Regeneration in the Virgin Forest.*

The distribution of the two species over the range of girth-classes is markedly different. For *Atherosperma* it shows that a state of continuous regeneration has existed in the past. Ring counts confirm that the small trees are young. Recruits to the upper girth-classes are available in numbers which would allow considerable losses to occur among the lower classes without causing a significant fall in numbers in the upper.

Large numbers of *Atherosperma* are not of seedling origin. Dozens of small shoots may come from low on the trunk of a single tree; many of these shoots will grow to more than 4′ 3″ high and a few will grow to maturity (usually only one, sometimes two or three from one parent). It is not uncommon for one or two of these shoots to have grown to 6-9 inches in diameter and 50-60 feet high before the parent stem dies.

Although adventitious shoots are quite common on the lower trunks of old *Nothofagus* they have not been seen to persist.

In Transect A there are fewer *Nothofagus* below than above 2 feet G.B.H. and there are no trees in the range 2-6 feet G.B.H. All the *Nothofagus* above 6 feet G.B.H. are old trees and most would be dead before any of those below 2 feet girth had reached maturity. In Transect B much the same position is revealed. There is only one *Nothofagus* between four feet and eight feet girth, and to replace the 24 decadent trees above 8 feet G.B.H. some recruits would have to come from trees less than 1 foot G.B.H. Gaps in the present *Nothofagus* canopy are occupied by *Atherosperma* and additional gaps will develop as the large *Nothofagus* die (probably in 50-100 years). Because of its advantage in numbers and distribution of young trees, *Atherosperma* is likely to occupy more and more of the site to the exclusion of *Nothofagus*.

But this may be only part of a cycle of varying success in the establishment of regeneration. From ring counts made in nearby areas, it seems probable that in this case the absence of the middle girth-classes of *Nothofagus* represents a gap of 200 years in successful regeneration. Jones (1956) reports a paucity of middle sizes in most of the emergent species in tropical rainforests in Southern Nigeria. The trees below 4 feet girth on transects A and B look young—this is indicated by the character of the fissuring of the bark, the amount of moss on the trunks and limbs, and the shape of the crown. By contrast the trees in the upper-girth classes look very old and some are nearly dead. On the basis of ring-counts made on nearby areas it is considered that the stand is at least 500 years old.

(*d*) *Age Determination.*

The age determinations of *Nothofagus* on nearby areas were made from counts of annual rings on stumps and logs of trees felled for saw logs. The older trees were very rotten at stump height (4-6 feet), but at 15 feet or so from the ground were generally sound enough for complete counts to be made. Radial increments were found to be very low, particularly during the last 100-200 years of the life of the tree. The mean number of rings per inch was 15.6 for all sections counted. Averages of 20 rings per inch were noted over the last 100-200 years of the life of some trees and many old trees had 40 rings per inch. Such trees have very rotten butts and their crowns contain some dead limbs. It is doubtful that they would live for more than another 50 years. Yet many such trees yield logs sound enough for milling.

TABLE 1.6.—*Number of Trees per Acre, by Girth-Classes on Two Transects in Temperate Rainforest Road 7, Florentine Valley.*

Transect.	Species.	Seedlings. 1′-4′ 3″	Girth Breast-High—Feet										Total.
			0-0.5	0.5-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	>8	>1′ G.B.H.
A 250′ x 50′	*Nothofagus*	6	17	....	3	....	....	....	....	3	3	23	32
	Atherosperma	404	106	43	57	23	11	6	11	6	....	....	114
B 900′ x 33′	*Nothofagus*	49	55		10	3	4	....	1	....	....	24	42
	Atherosperma	?	592		85	33	21	16	9	....	3	....	167

The highest count gave an age of 450 years and several gave about 400 years. Field counts are made with difficulty but it is clear from the age of old eucalypts still growing in some of the stands where the counts were made, that the ages of the *Nothofagus* are of the right order of magnitude. The relation between the age of the eucalypts and rainforest species in mixed forests will be discussed later. Although the greatest age attained by *Nothofagus* has not been established with certainty it is reasonable to assume that it is 450-500 years.

Atherosperma reaches little more than half the age of *Nothofagus*. Mr. A. B. Mount, of the Tasmanian Forestry Commission has informed me of a count of 250 years in the Styx Valley. In the Florentine, where the *Nothofagus* counts mentioned above were made, nine trees of *Atherosperma*, ranging in G.B.H. from 4′ 6″ to 7′ 5″, had counts of 180-240 years. No other trees were seen that were larger than seven feet G.B.H. but it would be surprising if there were not some older ones. However, it is certain that the *Atherosperma* which germinated at the same time as the old *Nothofagus* have died and rotted away and that *Atherosperma* has been in a continuous process of regeneration and death. Once decadent, *Atherosperma* dies quickly and rapidly rots so that few dead and dying trees remain in the stand. One *Atherosperma* felled for saw logs was typical. The tree was six feet in girth and 102 feet high. Foliose and bearded lichens, mosses and ferns, grew on the branches and trunk in great abundance, even more than 80 feet above the ground. The centre of the stump was rotten for a radius of three inches and outside this 180 rings could be counted so that the tree was about 225 years old and would probably have deteriorated rapidly in the next 25 years. At 3′ 6″ from the ground a side shoot with a diameter of 7.5 inches was found to be 100-110 years old. When this shoot first appeared the parent tree must have been 80 feet or so high.

From measurements made in several of the Florentine it appears that *Nothofagus* does not often exceed 120-130 feet in height, even though a height of 115-120 feet may be reached in less than 150 years. Thereafter the crown spreads and becomes more dense. *Atherosperma* can reach 100 feet in height in 150 years.

(*e*) *Litter Layer.*

Near old trees of *Nothofagus* the mineral soil may be covered with litter to a depth of a foot or so, although usually this layer thins to 1-3 inches within a few yards of the tree. When the stand consists mainly of *Atherosperma* the litter layers are very thin and the mineral soil can be exposed with a rake of the fingers. Quite often the litter layer is virtually absent. This is remarkable under conditions of full canopy, cool temperature and moderately heavy rainfall. It is one of several features of *Atherosperma* worthy of investigation.

Fairly extensive stands of *Atherosperma* occur in which*Dicksonia* is often the only other plant besides liverworts, mosses and lichens. These relatively pure stands exhibit some peculiar features which will be discussed later (see V. Development of the Climax Types).

B. MIXED FOREST.

In order of decreasing abundance, the ecualypt species are *regnans, gigantea, obliqua, viminalis* and *ovata*. As is usual in Tasmania, *gigantea* is the most important forest tree above 1,800-2,000 feet, but in the Florentine it is also not uncommon on the floor of the valley (below 1,500 feet). Below 2,000 feet the relative ecological position of *regnans, obliqua* and *gigantea* requires considerable investigation. In general, the forest consists of a series of fairly extensive even-aged stands. The distribution of ages is quite irregular, there being large areas of the following (as in 1957)—23, 120, 150, 205, 315 and 400 plus years. Other ages have been reported but they probably occupy small areas. As will be discussed later, the large even-aged areas must have arisen from past fires, for with a fire-tender species like *regnans*, survival, even of adult trees, is unusual except at the dying margin of a fire. With more fire-resistant eucalypts such as *obliqua* many trees may recover after fires so that there is often an intimate mixture of many ages, particularly on poor sites.

(*a*) *Mixed Forests* (175-400 *years*). Fig. 1.2.

This forest consists of very large eucalypts (*regnans, obliqua,* or *gigantea*) with a mean density often less than five trees per acre, growing over a fully-developed understory of rainforest species. The structure of the understory differs little from that of pure rainforest. At ground level the light intensity is as low as in rainforest—c. 1/100 of that in the open.

Measurements have been made on three transects.

Transect 1, *Road* 10, *Florentine Valley* (Fig. 1.9).

Comparing the appearance of the eucalypts with stands of known age, it was estimated that this stand was over 300 pears old. All the eucalypts were apparently of the same age.

The number of *regnans* (11 per acre) is high for old mixed forest.

The four *regnans* on the transect had the following dimensions:—

	Mean.	Maximum.
Girth-breast-high	29.5′	42.0′
Total height	220′	250′
Crown spread	40′	55′
Crown depth	145′	180′

Crowns are stag-headed.

As in all mixed forests, eucalypt seedlings, saplings, or poles are absent.

The dominant trees of the understory are *Nothofagus*. In Table 1.7 the five largest *Nothofagus* and *Atherosperma* on this transect are compared with those on the transect described in rainforest.

TABLE 1.7.—*Comparison of the Five Largest Nothofagus and Atherosperma in Rainforest and Mixed Forest. Measurements in Feet.*

Species.	Transect.	G.B.H. Mean.	G.B.H. Max.	Total Height. Mean.	Total Height. Max.	Crown Spread. Mean.	Crown Spread. Max.	Crown Depth. Mean.	Crown Depth. Max.
Nothofagus—									
	Rainforest	16.5	19.0	125	130	40	58	80	85
	Mixed Forest	12.5	21.0	100	115	35	50	75	100
Atherosperma—									
	Rainforest	5.7	6.5	95	100	30	35	75	80
	Mixed Forest	5.5	8 75	90	95	25	25	70	80

On the basis of the five largest trees (rate 14 per acre) the pure rainforest is not markedly different from the understory in the old mixed forest except that the trees of *Nothofagus* in the mixed forest are smaller. As the samples are small and the site differences potentially so large, these size differences need not be significant.

The distribution of the trees by girth-classes is shown in Table 1.8.

Compared with the transect in pure rainforest (Table 1.6) the mixed forest carries many more *Nothofagus* over one foot G.B.H. (with the increase in numbers mainly in the smaller girth-classes). Furthermore. there is some representation in all classes. The contrast between *Nothofagus* and *Atherosperma* in the distribution of stems by girth-classes is of the same pattern in both cases, *Atherosperma* exhibiting a relative predominance of seedlings, *Nothofagus* of adults.

Transect 2, Styx Valley.

The result of an assessment, on a 10 chain x ½ chain transect in old mixed forests in the Styx Valley is shown in Table 1.9.

The age of the forest is not known but, although the eucalypts were smaller (mean G.B.H. 20 feet), they were probably about the same age as those of the Road 10 transect—over 300 years. The site of the Styx transect was not ideal for *regnans*, being on a steep ridge which would probably carry *obliqua* if the rainfall were somewhat lower.

Bearing in mind that the sample is small (½ acre), the figures suggest that successful regeneration of *Nothofagus* has not been continuous. The future status of *Atherosperma* is clear enough but this is not the case with *Nothofagus*.

Transect 3, Upper Tyenna Valley (5½ Mile, Florentine Road). (Figs. 1.10 and 1.11.)

The site of this transect was at first considered to be poorer than Road 10 for the following reasons:—

1. *regnans* is replaced by *gigantea* and *obliqua*, the latter being considered to indicate poorer sites.
2. The canopy of the understory here is much more broken than in Road 10.

TABLE 1.8.—*Number of Trees per Acre, by Girth-Classes on Transect in Old Mixed Forest, Road 10, Florentine Valley. Transect 320 x 50 feet.*

Species.	Seedlings.	Girth Breast High—Feet.										Total.
	1′-4′ 3″	0-0.5	0.5-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	>8	>1′ G.B.H.
E. regnans	....	....	....	....	....	....	....	....	....	....	11	11
Nothofagus	22	71	8	24	3	11	3	3	5	3	14	66
Atherosperma	327	193	120	57	24	22	8	3	....	....	3	117
Pittosporum	....	....	....	3	....	....	....	....	....	....	....	3

TABLE 1.9.—*Number of Trees per Acre, by Girth-Classes, on Transect in Old Mixed Forest. Styx Valley. Transect 660 x 33 feet.*

Species.	Seedlings.	Girth Breast High—Feet.										Total.
	1′-4′ 3″	0-0.5	0.5-1	1-2	2-3	3-4	4-5	5-6	6-7	718	>8	>1′ G.B.H.
E. regnans	....	....	....	....	....	....	....	....	....	....	6	6
Nothofagus	6	106	20	16	....	....	8	2	4	2	8	40
Atherosperma	176	720	164	114	50	28	10	6	....	....	....	208
Olearia	....	....	....	2	....	....	....	....	....	....	....	2

3. *Eucryphia* and *Anodopetalum* are common in the vicinity but just failed to get within the limits of the transect. These are two of several species usually regarded as indicative of fairly poor sites.

However, tree height is recognized as a good index of site quality, which basically is the capacity of the site to produce wood. In this case the eucalypts have grown to 250 feet and *Nothofagus* to 130 feet. Such heights indicate a site of high quality, and are of the same order as those of the Road 10 area. It must be concluded that the broken canopy of the *Nothofagus* on the transect in the Tyenna Valley had resulted from an initially poor stocking rather than from a poor site.

The number of trees per acre is shown in Table 1.10.

presumably because of competition for room in the stand. Understory trees of *Nothofagus* and *Atherosperma* occur throughout such stands and, where the eucalypts are locally less dense, may reach heights of 120 and 100 feet respectively in 150 years. The canopy of the understory is not complete, with the crowns of *Nothofagus* just becoming flat-topped but still relatively narrow. During the next 50 years, as a few eucalypts die, the understory will gradually assume the appearance of a rainforest with eucalypts towering above it.

As with the older mixed forests, the eucalypts are in even-aged stands, i.e., there is a complete absence of eucalypt seedlings and saplings.

C. EUCALYPT FOREST.

This includes all stands of eucalypts in which rainforest species at present play a minor role.

TABLE 1.10.—*Number of Trees per Acre, by Girth-Classes, on Transect in Old Mixed Forest, Tyenna Valley,* 5½ *Mile, Florentine Road. Transect* 345 x 50 *feet.*

Species.	Seedlings.	Girth Breast High—Feet.										Total.
	1′-4′ 3″	0-0.5	0.5-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	>8	>1′ G.B.H.
Nothofagus	....	....	....	....	....	....	....	....	....	....	13	13
Atherosperma	33	28	10	3	3	....	3	3	....	....	15	30
Pittosporum	397	126	28	45	15	20	25	5	3	....	....	113
*E. obliqua**	....	....	....	3	....	....	....	....	....	....	....	3

* Fallen twigs indicate that some of the trees were *gigantea*, but the standing trees could not be separately identified.

The number of eucalypts was above average for the surrounding forest, for which 5-10 per acre is a reasonable estimate.

Compared with Road 10 there are only half as many *Nothofagus* above one foot G.B.H. and far fewer small trees and seedlings. The 33 seedlings of *Nothofagus* shown in Table 1.10 were not dispersed throughout the transect but on the soil among the roots of one fallen dead tree, and almost all the small *Atherosperma* were suckers on the butts of standing trees. The broken canopy of the understory had enabled *Dicksonia* and other ferns to grow vigorously and conditions approached those to be found in a fern gully where seedlings of tree species became established only with difficulty (Fig. 1.12).

(*b*) *Young Mixed Forests.*

Young mixed forests (age 100-150 years) occur principally towards the northern end of the study area (Fig. 1.2 (*b*)) and to the north and north-west of it. Those within the study area generally comprise *regnans* (height 250 feet) with an understory of *Nothofagus* (to 120 feet), *Athersperma* (to 100 feet) and very occasional *Acacia melanoxylon* and *Pittosporum*. *Comprosma billardieri* and *Clematis* are occasionally found.

Officers of the Forestry Commission and Australian Newsprint Mills have made counts of the number of live eucalypts on several one-acre assessment plots in young mixed forest. Thirty *regnans* constitute full-stocking in 150-year-old stands. Such fully-stocked stands contain some eucalypts which have recently died or are about to die

(*a*) *Stands on Soils of Moderate to High Fertility.*

(i) Mixed Forest Affected by the 1934 or Later Fires.

From counts of annual rings it appears that no widespread fires occurred between the 1840's and 1934, when a fire spread from the vicinity of Dawsons Road southwards for eight miles. Its southward spread was obviously assisted by the presence of large areas on the floor of the valley which had recently been savannah and by inflammable vegetation on the series of low ridges of silicified limestone. Fires which burn through mixed forest usually kill all the eucalypts, particularly where the eucalypt component is the fire-sensitive *regnans*. Although a few eucalypts may survive, trees of the understory rarely escape destruction. The general pattern of fire behaviour will be discussed in a later section (V. The role of fire in forest succession).

Mixed Forest Completely Destroyed by the 1934 *Fire.*

The resultant stand could be classified as young mixed forest for the essential components are present, both eucalypt and rainforest species. However, the rainforest species are of little significance in the present stand (just over 20 years old) and several seral species are present: *Acacia dealbata, Olearia argophylla,* perhaps a few *Pomaderris apetala* and the last traces of fireweed species such as *Senecio australis* and *Erechthites prenathoides*. Small trees and shrubs, which are rare in mixed forest, are not uncommon, *e.g., Coprosma billardieri, Pittosporum bicolor, Clematis aristata.* Depending on the density of the eucalypt regeneration and the locality, a fern stratum 3-4 feet high and of greatly varying density and continuity is usually present. The most common species are *Histiop teris incisa, Polystichum proliferum, Hypolepis rugosula* and *Blechnum procerum*. This fern stratum will practically disappear if the canopy of rainforest species becomes more or less complete or the stratum will become fairly general, with locally dense patches, if this canopy remains broken.

Few measurement have been made in the stands of eucalypt regrowth resulting from destruction of mixed forest by the 1934 fire. Early growth of *Nothofagus* and more particularly *Atherosperma* may be so slow (often 2-6 inches in height in three years) that ring counts may falsely indicate that the rainforest species are younger than the eucalypts. Thus in a 22-year-old stand of *regnans, Nothofagus* gave counts of 18-20 years. In a stand of *gigantea*, ring-counts of *gigantea* and *Nothofagus* were the same—22 years. The mean dominant heights in the 22-year-old stad were *regnans* 80 feet, *Nothofagus* 25-30 feet and *Atherosperma* smaller.

Mixed Forest Destroyed by Fire since 1934.

The areas included here are those logged by Australian Newsprint Mills since about 1950 and on which logging slash has been burnt. Conditions are somewhat artificial, but in many small patches only slightly so. Large numbers of quadrats have been examined and the general rule is that there is fairly immediate and coincident germination of all species which are likely to be present from year 1 to year 400 or so when the last eucalypts die of old age and the site is left occupied by rainforest.

Mixed Forest Burnt in 1934 *and again in* 1948.

By fire or axe man can put the succession back to year 1 but, should a second disturbance come before all the tree-species are producing seed, a different successional pattern would follow.

An area of mixed forest which was burnt in 1934 was burnt over again in 1948. The second fire killed the rainforest species—the incipient understory—so that now there is only a fern stratum.

In places the 1948 fire was hot enough to kill all the 14-year-old eucalypts, and scattered regeneration followed the fire. The only survivors of the pre-1948 understory are coppice shoots of *Nothofagus* and *Atherosperma*, with the latter far more abundant.

The second fire has drastically reduced the stocking of tree-species and allowed the development of the dense fern stratum, about four feet in height. Tree seedlings growing below the level of this stratum will emerge slowly and suffer heavy losses. In their present condition ferns allow few new seedlings to become established and are likely to do so for many decades where tree-species are entirely absent. As tree seedlings develop, modification of the fern stratum will allow new shade-tolerant seedlings to become established and progression to more normal forest conditions would then proceed at a much faster rate.

(ii) Areas Recently Occupied by Tree and Shrub Savannah.

The occurrence in the recent past of tree and shrub savannah over several hundred acres in the central Florentine was first reported by Jackson (1956). Only a brief description can be given here of the eucalypt stands on these areas.

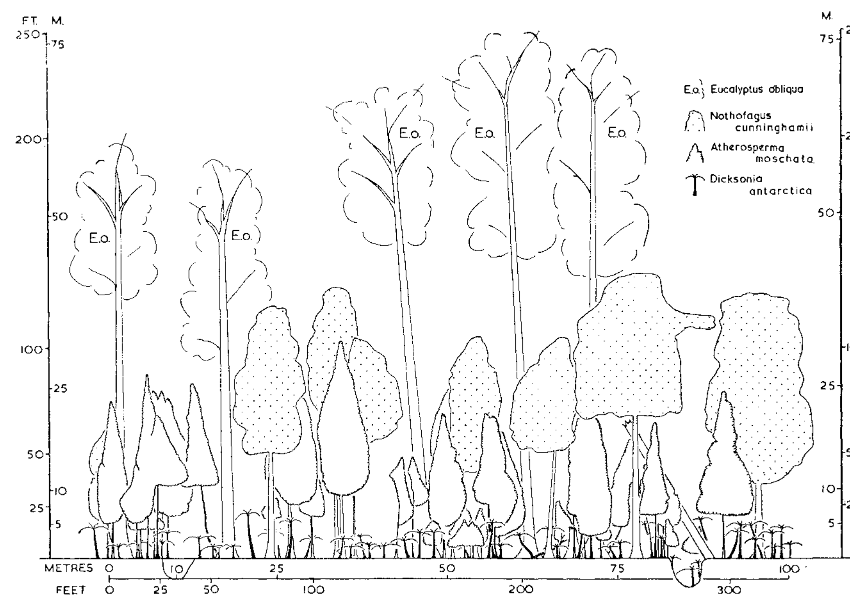

FIG. 1.11. Profile diagram of transect in mixed forest, 5½ m., Florentine Road, upper Tyenna Valley. Transect 50 feet wide but *Dicksonia* shown for ectnral 32 feet only.

It is probable that the savannah was made up of two sub-associations:

1. *Drimys aromatica—Hakea microcarpa*: *Poa caespitosa* shrub savannah; and
2. *E. ovata—E. viminalis—Acacia dealbata*: *Poa caespitosa* tree savannah.

It appears that physiography and climate would have allowed the area to be occupied by mixed forest or rainforest. Two factors which may have been responsible for the maintenance until recent times of savannah conditions are as follows:—

1. Repeated burning. Although the savannah is now rapidly progressing towards closed forest, the area is still attractive to wallabies and other marsupials. Under savannah conditions native animals would have been even more plentiful and the area attractive to the aboriginals who used fire freely both to hunt game and to attract it to the fresh plant-shoots which follow fires.

2. Most of the area appears to be associated with the deepest sheets of the unconsolidated material referred to under " Geology ". Water does not lie in the bottom of pits opened in these deposits for road-surfacing material and the deposits overlie cavernous limestone. It is probable that the water-holding capacity of the material is very poor.

The replacement of the savannah by eucalypt forest is probably the result of an increase in rainfall with an attendant decrease in fire frequency. The disappearance of the aboriginals 130 years ago may have resulted in a lower frequency of fires but, as many of the eucalypts are more than 200 years old, the change to eucalypt forest commenced before white man settled in Tasmania. A few small treeless patches are all that remain of the shrub savannah, *Hakea microcarpa* surviving with difficulty, whilst most other plants are smothered by bracken. Only a few tussocks of *Poa* and Cyperaceous species have survived except in a few small areas where the winter water-table is at ground level. Here *Poa caespitosa* is present as large hummocks.

In the succession to mixed forest, the order of appearance of the eucalypts is *ovata*, *viminalis* and *regnans*, with *Acacia dealbata* present throughout the succession, and sometimes the pioneer tree-species ahead of *ovata*. The species of the shrub-savannah do not survive for very long in the eucalypt forest with the exception of *Drimys*, which may build up to a continuous stratum, 15-20 feet high in the *ovata-viminalis* association. Thereafter it diminishes in frequency to become rare in mixed forest.

Acacia melanoxylon, *Olearia argophylla*, *Pomaderis apetala*, *Pittosporum bicolor*, *Coprosma billardieri* and *Phyllocladus asplenifolius* reach their peak frequency with the advent of *regnans*, but they are usually scattered trees of park-like habit, i.e., they have deep, very wide crowns. A few *Atherosperma* appear but *Nothofagus* is rare.

In the *regnans-viminalis* association the *viminalis* are very large trees of good form. Without disturbance of the site it is assumed that this association would change to pure *regnans*, because *regnans* with its faster rate of growth would suppress *viminalis* in most spots suitable for regeneration. It is possible that the understory will develop quickly enough to prevent eucalypt regeneration. However, part of the *regnans-viminalis* association was partially burnt by the 1934 fire and many more *regnans* than *viminalis* were killed. The resulting eucalypt regeneration consists of 50-feet saplings of *regnans* with 6-feet *viminalis* as part of a discontinuous stratum of shrubs. The shrub layer is quite different from that in mixed forest burnt in 1934, *Nothofagus* and *Atherosperma* being viraually absent. The commonest shrubs and tree seedlings of this forest are rare in mixed forest. They are *Drimys*, *Acacia dealbata*, *Acacia melanoxylon*, *Phyllocladus*, *Coprosma*, *Zieria arborescens*, *Olearia argophylla* and *Pomaderris*. Several Epacridaceous species are present and one, *Astroloma humifusum* is quite alien to forests.

The area once covered by savannah has been important because it provided an easy path for fires along the floor of the valley.

(iii) Areas Burnt Three to Four Times in the Last One Hundred Yearss by Fires of Low Intensity.

The stands on these areas have arisen because of the abortive effort at agriculture at Dawson's Road (" The Settlement "). Dawson's Road was built in 1847 as the beginning of a road link (uncompleted) to the West Coast. The first blocks of The Settlement were selected in 1904 and a start made in the following year to clear several hundred acres of mixed forest by felling, ringbarking and burning. By the early 1930's much of the cleared land was being overrun by bracken and scrub and attempts were made to halt this invasion with fire. Many fires spread into adjoining mixed-forest and greatly modified it. The eucalypt component became of mixed age and the simple *Nothofagus-Atherosperma* understory was largely replaced by *Acacia dealbata*, *Olearia argophylla* and *Pomaderris* with a few *Acacia melanoxylon*. Regeneration of *Atherosperma* occurred but, except for occasional trees, not of *Nothofagus*.

Even though *Atherosperma* occurs through the whole stand, and is not confined to gullies, the structure and floristics in these areas resemble that of wet sclerophyll forest in the 40-50″ rainfall zone. It is similar to much *regnans* forest in Victoria. At Wallaby Creek, Ashton (1956—unpublished thesis) found the understory of *Pomaderris*, *Olearia* and *Acacia* (dealbata) was commonly 40 years of age and he had to search carefully to find one that was older (80 years). Unless further fires occur it seems that no further regeneration of eucalypts will occur in the Dawson's Road stands and that the sub-climax would be temperate rainforest with a broken canopy in which there would be a marked increase in the frequency of usually occasional species such as *Acacia melanoxylon*, *Pittosporum* and *Olearia argophylla* and a fairly complete stratum of tree-ferns (*Dicksonia*).

(*b*) *Stands on Soils of Low Fertility* (Fig. 1.2 (*b*)—Eucalypt forest of mixed age.)

Geographically there are two main areas, the more extensive at Tim Shea on conglomerates and quartzites and the other in the floor of the valley on low quartzitic ridges running parallel to the Florentine River on its eastern side. The soils are shallow and very acid.

Eucalyptus simmondsii as on similar soils elsewhere in Tasmania where the rainfall exceeds 60 inches or so, occurs in fairly open stands with a relatively rich small tree and shrub stratum in which the families *Myrtaceae, Epacridaceae* and *Proteaceae* are strongly represented. The mature height of *simmondsii* may be as low as 40 feet.

The stands have been greatly modified by frequent fires. There is an intimate mixture of eucalypts of many ages and the shrub layer is usually young and, depending on the time since the last fire, also dense.

With an increase in soil fertility, *obliqua* and *gigantea* may occur with *simmondsii*. Tree height increases and understory trees are more numerous. With a further increase in soil fertility, shrubs are generally mesomorphic instead of generally xeromorphic and *simmondsii* goes out and *regnans* comes in.

D. Treeless Areas.

Except for a few small remnants of shrub savannah in the middle Florentine, together with rock and scree slopes of the Field West Range, treeless areas are confined to fairly extensive areas of poor, acid soils developed on the conglomerates and quartzites of Tim Shea ("Sedgeland"—Fig. 1.2 (*b*)). Around the foot of the mountain a few, very poorly drained flats probably constitute the only edaphic climax for *Mesomelaena* sedgeland. Elsewhere sedgeland and wet scrub have been maintained by frequent burning.

On the West Coast, freedom from fires would allow such areas of wet scrub to proceed through the stages of eucalypt forest and mixed forest to rainforest (Jackson, 1958), but on Tim Shea it is doubtful whether the succession would go beyond the mixed-forest stage, even if fires were excluded, because the rainfall is probably too low (just above 60 inches) for the maintenance of rainforest on such poor, shallow soils.

E. Summary.

The changes in plant association and floristics with changes in soil fertility and fire frequency are summarised in Table 1.11. The table has been divided into four fertility-gradings x four fire-frequencies, in order to illustrate the changes more clearly. The cells are certainly not of equal "dimensions," neither are the trends in ordered lines.

Eucryphia is included with caution. It is fairly common in the upper Tyenna Valley but not in the Florentnie Valley below 2,000 feet. The genera are arranged in a subjective order of importance.

Shrub and tree savannah are essentially of the past. Fire frequency would have to alter radically to enable eucalypt forest to develop on Tim Shea on soils derived from conglomerates and quartzites. For this reason the forest type to be found on soils of very low soil-fertility, given very low fire-frequency, is labelled "Future" in the table.

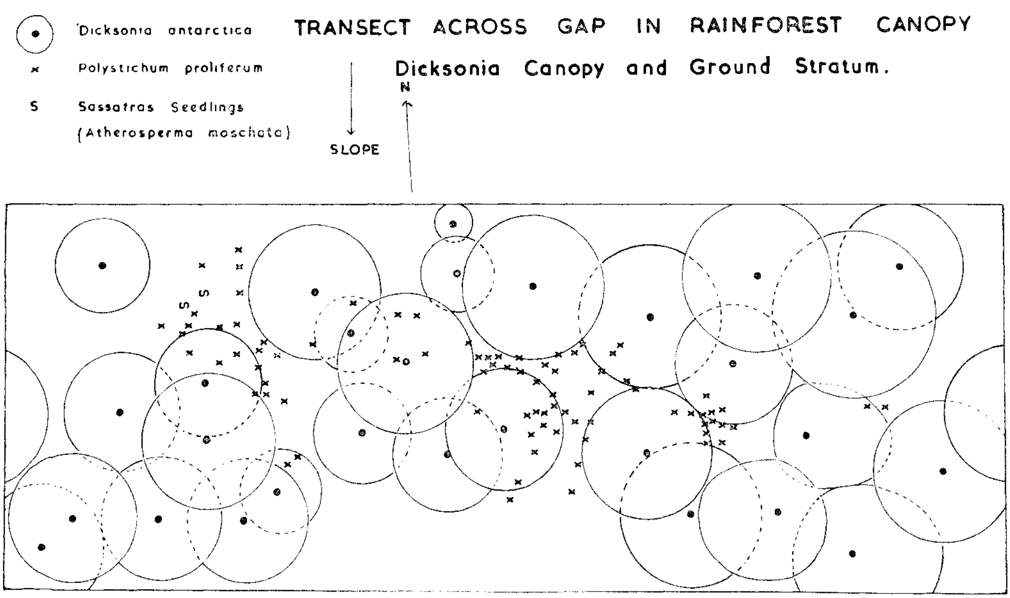

Fig. 1.12. Transect in forest depicted in Fig. 1.11. Plot 32 feet x 81 feet.

TABLE 1.11.—*Changes in Plant Associations and Floristics according to Changes in Soil Fertility and Fire Frequency in the Florentine Valley.*

Fire Frequency.	Soil Fertility. High ——> Low			
Low	Rainforest *Nothofagus* *Atherosperma* *Dicksonia*	Rainforest *Nothofagus* *Atherosperma* *Pittosporum* (*Eucryphia*) *Aristotelia* *Clematis* *Dicksonia*	Rainforest *Nothofagus* *Atherosperma* *Phyllocladus* *Anodopetalum* (*Eucryphia*) *Anopterus* *Cenarrhenes*	(Future) Mixed Forest. *Eucalyptus simmondsii* *Nothofagus* *Phyllocladus* *Leptospermum* *Anodopetalum* *Atherosperma* *Agastachys* *Cenarrhenes*
Increasing	Mixed Forest. *Eucalyptus*— *regnans* *obliqua* *gigantea* *Nothofagus* *Atherosperma* *Dicksonia*	Mixed Forest. *Eucalyptus*— *obliqua* *gigantea* *regnans* *Nothofagus* *Atherosperma* *Acacia melanoxylon* *Pittosporum* (*Eucryphia*) *Aristotelia* *Clematis* *Dicksonia*	Mixed Forest. *Eucalyptus*— *obliqua* *gigantea* *simmondsii* *Nothofagus* *Phyllocladus* *Anodopetalum* *Leptospermum* *Atherosperma* *Cenarrhenes* *Anopterus*	Eucalypt Forest. *Eucalyptus simmondsii* *Nothofagus* *Phyllocladus* *Anodopetalum* *Cenarrhenes* *Anopterus* *Leptospermum* *Monotoca* *Bauera*
	Eucalypt Forest. *Eucalyptus*— *obliqua* *gigantea* *regnans* *Pomaderris* *Olearia* *Acacia*— *dealbata* *melanoxylon* *Atherosperma* *Nothofagus* *Dicksonia*	Eucalypt Forest. *Eucalyptus*— *obliqua* *gigantea* *Pomaderris* *Olearia* *Acacia dealbata* *Phebalium*	Eucalypt Forest. *Eucalyptus*— *obliqua* *gigantea* *simmondsii* *Acacia*— *dealbata* *mucronata* *Leptospermum* *Banksia* *Gahnia* *Bauera*	Eucalypt Forest or Wet Scrub. *Eucalyptus simmondsii* *Acacia mucronata* *Leptospermum* *Melaleuca* *Banksia* *Agastachys* *Sprengelia* *Monotoca*
High	(Past) Tree Savannah. *Eucalyptus*— *ovata* *viminalis* *Drimys* *Hakea* *Acacia dealbata* *Coprosma* *Epacridaceae* *Poa*	(Past) Shrub Savannah. *Drimys* *Hakea* *Coprosma* *Epacridaceae* *Poa* *Eucalyptus ovata* (scattered)	Wet Scrub. *Leptospermum* *Melaleuca* *Banksia* *Acacia mucronata* *Agastachys* *Gahnia* *Bauera* *Eucalyptus simmondsii* (scattered)	Sedgeland or Wet Scrub. *Mesomelaena* *Melaleuca* *Leptospermum* *Restionaceae* *Sprengelia* *Banksia* *Agastachys* *Eucalyptus simmondsii* (scattered)

V. The Role of Fire in Forest Succession.

1. *Evidence of Fires.*

The presence of areas of several thousand acres of even-aged eucalypt forest is in itself strong and perhaps sufficient evidence that widespread fires have occurred in the Florentine during recent centuries. In Tasmania the general windthrow of trees in a stand is rare except over very small areas. It is thus hard to conceive of any agent other than fire being responsible for the large areas of even-aged forest. Over several thousand acres the eucalypts and the largest trees of the understorey species are all 150 years old. Similarly, there are stands of 400 plus, 315, 205, 120 and 23 years old (in 1957). The 23-year-old stands are widespread in western and southern Tasmania and arose from the devastating fires of January-February, 1934.

In all stands charcoal is readily found on the surface of the mineral soil after removal of the litter layer. Charcoal is usually absent on the trunks of fire-killed trees of species such as *regnans*. Few *regnans* survive a fire, so that burnt-out butts with a lining of charcoal are not preduced. The cambium of *regnans* is killed but the bark is rarely burnt from the tree, so that when the bark is shed a clean skeleton remains.

2. *Cause of Fires.*

The Tasmanian aboriginal used fire freely (Jackson, 1958) and there is ample evidence that in his nomadic existence he moved inland from the coast in the summertime. Stone implements have been found on the mountain country to the east of the Field West Range. As lightning-storms in Tasmania are usually wet, there are few authentic records that lightning has caused forest fires (Gilbert, 1949), although single trees may be set alight. In over 20 years association with forest fire-control in Tasmania, I know of only two cases of forest fires spreading from lightning strikes. One was in the Florentine Valley!

Only under conditions of high fire-danger can a fire burn over several thousand acres of virgin forest of the type found in the Florentine Valley. The pre-requisites are a period of several weeks with little rain culminating in one or two days of high temperature, low atmospheric humidity and strong wind. Before 1800 the aboriginal probably started most of the fires. Since 1800, white man has been responsible. Mixed forest will be perpetuated if burnt before the eucalypts die of old age, i.e., if burnt at least once in 350-400 years. Difficult as it may be to burn mixed forest, it is reasonable to assume that during a period of 350 years, fire conditions will arise which are at least as severe as white man has experienced during the last 150 years.

3. *Creation by Wild Fire of Conditions Favourable for Eucalypt Regeneration.*

From investigations made into the factors affecting eucalypt regeneration in areas of high rainfall in Tasmania, it is clear that wild fire creates a situation in virgin, mixed forests which is favourable to eucalypt regeneration. The favourable circumstances would appear to be:—

(*a*) The understorey is destroyed.
(*b*) The forest floor becomes fully lit.
(*c*) The litter layer is destroyed.
(*d*) Some eucalypt seed is destroyed but large numbers of capsules survive on the trees and there is a heavy fall of seed soon after the fire.
(*e*) There is a reduction in the number of insects which harvest eucalypt seed.
(*f*) Extreme fire-danger develops under the influence of intense Southern Ocean depressions, and good rains usually fall with the passage of the cold front associated with these depressions.
(*g*) Browsing marsupials (principally wallabies) destroy large numbers of eucalypt seedlings and cause a growth check to many more. Openings in the forest are attractive to browsing marsupials but a very large opening created by wild fire would be favourable to seedlings, particularly as the density of the population of browsing animals is low in the surrounding virgin forest. The eucalypt seedlings gain an advantage by weight of numbers and area.

4. *Fire Behaviour.*

Eucalyptus regnans, *Nothofagus*, and *Atherosperma* are not fire resistant, so that fires usually kill all the trees and another even-aged stand develops. However, along fire edges and also scattered within the burn, two-aged stands may occur. The old stand is represented only by eucalypts. Unless conditions are exceptional, forest fires do most of their damage between mid-morning and dark. Between midnight and dawn fires advance slowly and sometimes stop running. During the period between late evening to mid-morning the rainforest understory may be killed, but under these conditions only a few of the much taller, relatively more fire-resistant *regnans*. The same thing occurs where fires die out as rain sets in or in places protected by their topographic position.

5. *Regeneration of Eucalypts in the Absence of Fires.*

Many reports have been investigated of eucalypt stands of mixed ages in the Florentine and Styx Valleys which have not been caused by fire, i.e., cases where eucalypt regeneration was believed to have become established in mixed forest without disturbance of the stand by fire. In all cases except one it was possible to demonstrate that the younger age-class had resulted from fire. The exception is worth recording because it depended on a set of circumstanuces likely to recur only very occasionally and so of no importance in the maintenance of eucalypts in mixed forests. A large *regnans* had fallen across a steep slope and then skidded sideways down a log lying on the ground so that about a tenth of an acre was cleared and in the clearing there was a dense 3-4 feet layer of ferns, three *Acacia dealbata* saplings and one *regnans* sapling.

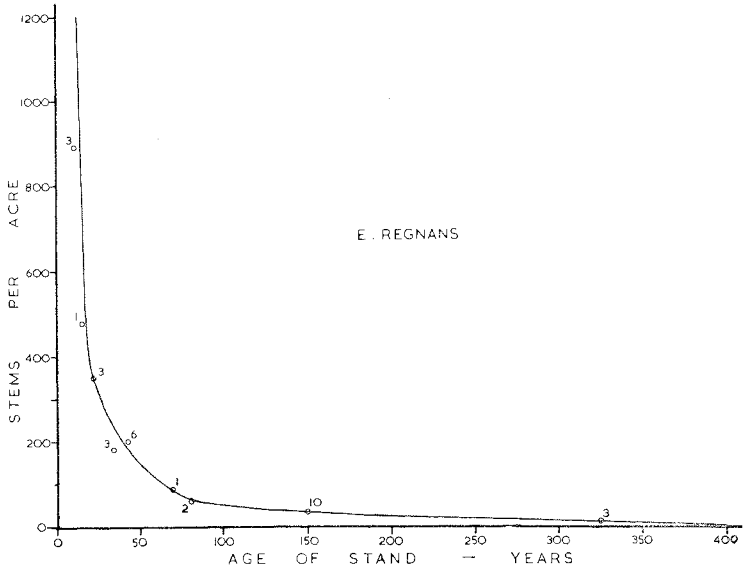

FIG. 1.15. Age—number of stems relationship for *E. regnans*. Information from plots established by Forestry and Timber Bureau (3), Forestry Commission (26), and Gilbert (3), in central and S. Tasmania. Plot sizes varied from ¼ acre for young stand to 1 acre for old stands. In three youngest plots, stems (numerous) less than 2½-in. diameter not included; on next oldest, stems (many) less than 12-in. girth, not included.

Fire is not essential for the re-establishment of eucalypts in all circumstances. Jarrett and Petrie (1929), in dealing with "Pyric Succession" in the Black Spur region of Victoria, stated that some *Eucalyptus* seed, on the ground before the fire, will escape destruction and that the fire or ashes from the fire stimulates germination or else "removes some previously operating inhibiting agent". Observations and sowing-trials in the Florentine do not support these conclusions. Eucalypt seed will germinate beneath the canopy of an undisturbed rainforest understory and if the litter layer is removed germination is improved. There is, however, no survival beyond the cotyledon stage.

Disturbance of the understory is an absolute essential for the successful establishment of eucalypt regeneration. However, removal of the understory and many other physical effects of fire can be achieved without fire. Regeneration is usually dense along the sides of roads in a forest. Clearing for road construction removes the understory and bares the mineral soil. Adequate seed is usually available from nearby standing trees. If all the eucalypts are felled on a logged area, regeneration is usually successful if the slash is not burnt, but unsuccessful if the slash, which contains the immediately available seed, is burnt. Replicated sowing trials on various types of seed-bed (in the forest) at various times and with various amounts of seed suggest that the physical effects of the removal of the understory by fire, of the destruction of deep litter and the sudden release of large amounts of seed from standing trees are the factors which cause the usually prolific crops of seedlings which follow fires.

Wild fires have been responsible for the continued existence of *Eucalyptus* in large areas of mixed forests. It is clear that fires of similar intensity and extent cannot form part of a planned system of regeneration of *Eucalyptus*. Apart from the risks involved, conditions on a cut-over area are markedly different from those in virgin forest. The logging slash provides fuel for an intense ground fire which destroys the seed in or shed from the capsules on the heads of the felled trees. In virgin forest these capsules would be on standing trees and much seed in them would survive fire.

Similar conclusions have been drawn elsewhere. Thus many of the stands of Douglas fir (*Pseudotsuga taxifolia*) on the Pacific Coast of North America owe their continued existence to past fires (Hansen, 1950; Allen, 1954). However, as Allen points out, it is "fallacious to claim that fire should be used in regeneration treatments just because wild fires have helped to maintain Douglas fir in the coast region".

VI. Development of the Climax Types.

1. *The Pattern of Fires.*

Table 1.11 shows the general level of the development of forest types according to soil fertility and the frequency of fires over the last few centuries. Given a low frquency of fires, temperate rainforest would be the climax on all but soils of very low fertility, where is would probably give way to mixed forest. But mixed forest cannot develop on the very poor soils with the present fire frequency and so in Table 1.11 mixed forest is labelled as "future" where there is a combination of very poor soil and low fire-frequency. Fires prevent the development of the climax type (rainforest) and the stage reached (fire-climax) is determined by the frequency of fire. Fires tend to be more frequent on areas of low soil-fertility because poor soils carry large proportions of highly inflammable species from families such as *Myrtaceae* and *Epacridaceae*.

Because of the frequency with which they can be burnt, the areas of low soil-fertility are the sources of fires which may damage the adjoining forest. It is often difficult to start fires in closed forest and most destruction has come from fires invading from areas of poor-quality forest. In the last century white man has changed this to some extent by making agricultural activities the principal source of forest fires. However, the main pattern of the forest in the Florentine Valley was established before white man arrived in Tasmania; his principal contribution being the 1934 fire and even the course of this fire was largely determined by what had happened before his arrival.

The winds which are associated with severe fire weather are from the north to north-west. Fig 1.2 (*a*) suggests that, owing to topographic protection on the west, fire sources in the Florentine Valley are the important one for the valley itself. There are two main sources. The first is on Tim Shea and the second near Dawson's Road. The sedgeland and eucalypt forest of mixed ages on Tim Shea occupy most of the area of very poor soil derived from conglomerate and quartzite. The plant communities have been repeatedly burnt. The fires have burnt uphill to the south and south-east (with the "fire" winds) and have not spread to the rainforest and old mixed forests on the slopes of the range running from Tim Shea to Mt. Field West. It could be argued that the aboriginal did not visit Tim Shea but white man has done so repeatedly as explorer, prospector, and hunter and his frequent fires have not travelled to the east.

The Dawson's Road area has been the most important source of fires. Small *Poa* plains and adjoining savannahs made the area attractive to the aboriginals. White man, coming from the Derwent Valley, thought the valley to be a good, large-scale agricultural proposition. Most of the young mixed forest shown in Fig. 1.2 (*b*) is 150 years old. This would have resulted from an aboriginal fire as white man did not settle Tasmania until 1801 and certainly up to 1807 (the year of the fire) was not pushing into areas such as the Florentine . The stand which originated after the 1807 fire is only partly intact, as much of it was burnt in the 1934 fire; but it can be traced as fire-killed spars. It is obvious that the 1807 and 1934 fires followed the same path. With topography, fire source and the direction of the fire wind the same, this is to be expected. It is reasonable to assume that the fires which regenerated the old mixed forests also came from the lower Florentine but spread further up the valley. Distance and direction from the fire-sourse is then seen as an important factor in determining the probability of the attainment of climax status. Jackson (1958) has demonstrated this for the Pieman-Waratah region. The presence of rainforest on the steep, west to north-west facing slopes of the Tim Shea-Field West Range is made possible because of low fire-frequency due to the long distance from the fire source.

2. Fire Climax Mixed Forests.

(*a*) *Floristic Changes after Fire.*

Repeated fires (say three or four times per century) produce a forest stand in which there is so much floristic variability in space and time that the term fire-climax cannot be applied to them. Such stands have been described under "Eucalypt Forest" and it is evident that the future cource of their development depends almost entirely on the future history of fires.

In the Florentine Valley, and the areas of Tasmania receiving more than 50 inches of rainfall annually, fire is a complicating factor, structurally and floristically. On all but poor soils, freedom from fire leads to temperate rainforest, the simple nature of which has already been described. Fire will cause simplification only if so frequent that regeneration of the forest species is prevented because the source of seed becomes completly depleted. If some of the species are highly fire-resistant, as for example on the central coast of N.S.W., there may be an elimination of only a proportion of the species by repeated fires (Pidgeon, 1938). Jarrett and Petrie (1929) regarded the forest fire "as a great simplifying factor in the development of these communities" (*regnans* forest) and as "leading to increased purity". In such cases the degree of purification is more apparent than real when a detailed examination is made of the species present.

The destruction of mixed forest (eucalypt plus temperate rainforest) by fire arrests the progress to climax rainforest and starts the forest once again on a course of secondary succession, from relatively many to relatively few species. Thus there is an immediate regeneration of all the species present in the previous stand, some in vastly increased numbers, and the appearance of a few short-lived species.

The most common firewood species is *Erechthites prenathoides* with *Senecio australis* far less common than in areas of lower rainfall. Scattered *Erechthites* become established in the first season and seed profusely. In the second season there is a dense growth of new seedlings with the first year plants growing again in the second year to produce plants 6 feet high. *Urtica incisa, Cirsium vulgare* and *Epilobium* show a similar build up in numbers in the second year and ferns (*Histiopteris Polystichum* and *Hypolepis*) may form dense patches. *Eucalyptus, Nothofagus* and *Atherosperma* appear in large numbers and species which are rare in the virgin forest become common, *e.g.*, *Clematis, Pittosporum, Coprosma;* and *Acacia dealbata,* not present in mature mixed forest, appear in very large numbers.

(*b*) *The Development of the Eucalypts.*

Depending on the speed of the development of the more ephemeral fireweed species and the effect of browsing by marsupials, the eucalypt seedlings may grow vigorously from the time of germination or take 3-4 years to get above the competing fire-weeds and to recover from browsing. Browsing also reduces the number of seedlings. Wild fires in virgin forest usually result in dense stands of eucalypt seedlings and counts of over 200,000 seedlings per acre have been made on millacre quadrats. This is exceptionally high but would be rapidly reduced in five years to numbers not differing from regeneration which originated at the rate of a few tens of thousands per acre. Enough information is available to form a reasonable picture of the reduction in seedling numbers (Fig. 1.15), which is extremely rapid for the first 10 years and very slow from 150 years to 350-400 years when the last eucalypt would be expected to die of old age if the site were not disturbed.

Doubt has been expressed as to the correctness of the statement that fire has perpetuated the eucalypts in the mixed forest. It has been suggested that as the eucalypts become decadent they will fall and eucalypt seedlings become established in the breaks made in the canopy. The one known case has been mentioned. It is clear that there has been a great deal of time for such pockets of seedlings to become established. Until the stand is 200 years old (or younger) reduction in the number of eucalypts per acre is mainly due to competition between the eucalypts for room and new eucalypts could not become successfully established even if understory competition were absent. Thereafter there is room for regeneration to become established, if the eucalypts alone were considered, and this condition applies until the last eucalypts die of old age when the stand is c. 400 years old. For about 200 years there is an opportunity for the eucalypts to regenerate if suitable gaps appear in the canopy of the understory.

(*c*) *Regeneration in Gaps in the Understorey.*

Large gaps in the canopy of the understory are not common in the Florentine. Such gaps as occur are usually caused by single stems of *Eucalyptus* which fall after their butts have decayed. The dead trees have usually lost most of their crown before they fall. The gaps are generally occupied by *Atherosperma* which is present as seedlings, saplings or small trees before the gaps appear. An example is shown between the 200 and 300 feet marks on the transect in Fig 1.9. Generally, the effective size of gaps is so small that groups of saplings of the understorey species do not occur and such gaps have not been and are not likely to be favourable for the establishment of eucalypts. For eucalypts—

1. The gaps are too small;
2. Undisturbed Aoo and Ao horizons are not good seed-beds;
3. There is not likely to be any seed, as many gaps are caused by the falling of dead trees which have long since shed their last crop of seed and it is very unlikely that eucalypt seed is stored in the surface soil in small gaps for more than a few months.

Holloway (1954) describes forests in the South Island of New Zealand which contain very old matai (*Podocarpus spicatus*). He is of the opinion that the failure of matai to regenerate is due to an adverse climatic change during the life of the ancient matai. This is not the case with eucalypts in mixed forests of the high rainfall areas of Tasmania, as eucalypt regeneration can be obtained naturally or artificially on areas which carry scattered ancient eucalypts provided the canopy of the understory is sufficiently disturbed.

(*d*) *Longevity of Seed of Acacia dealbata.*

When mixed forest is disturbed *Acacia dealbata* seedlings appear in large numbers. Numerous observations and ring counts have shown that the species does not survive beyond the generation which appears after disturbance of the site and that few trees live for more than 70 years. In forest which has not been disturbed for 350-500 years, *Acacia dealbata* seedlings appear as soon as the stand is opened up and the appearance is so immediate and general over large areas that the only reasonable explanation is that the seed has remained viable in or on the surface soil for 300-400 years. It appears unlikely that birds, &c., could carry sufficient seed in.

It is to be noted that burning is not essential for regeneration of *Acacia dealbata*, as seedlings appear on all roadsides and logging tracks in mixed forest whether the surrounding forest is burnt or not. Only a minor disturbance of the site is needed to allow the seed to germinate, seedlings appearing in the disturbed soil around the butts of single upturned trees in virgin forest. However, such seedlings soon die. Rotten eucalypt logs can be found in some of the temperate rainforest in the Florentine estimated not to have been burnt for 500 years, yet *Acacia* seedlings appear when such stands are disturbed; however, in very low numbers compared with mixed forest. The rate of seed-depletion and the limits of viability are not known.

3. Climax:—Temperate Rainforest.

(*a*) *Attainment of Climax.*

The climax condition is reached on the death from old age of the generation of eucalypts which arose from the last disturbance of the site. In the past this has meant freedom from fires during the life of the eucalypts. Logging operations now constitute a significant factor of disturbance but, as already noted, differ in important respects from disturbance by wild fire.

In some areas of rainforest no signs of eucalypts could be found despite a search which included digging into long mounds suggestive of the presence of ancient logs. It could not be deduced whether these areas were likely to have carried eucalypts in the last few thousand years.

(*b*) *Effect of Fire in Rainforest.*

In mixed forest eucalypt seed is not stored on the soil surface for more than a few months, so once the climax condition is reached on more than a few acres the area, if disturbed, will revert to mixed forest only on its margins, i.e., within the range of eucalypt seed-throw. This is uncertain beyond a distance equal to the height of the seed trees (Jacobs, 1955; Gilbert, unpublished thesis). Rainforest species germinate freely immediately after fire and do not need a canopy of *Eucalyptus* or *Acacia* for protection during their early growth. The seedlings grow slowly and at the end of the second year only a few are more than a few inches high, with large numbers ¼ to ½ inch high. It is inevitable that fireweed species will overtop such slow growing plants. There is no evidence that the fireweeds are needed as a nurse. *Nothofagus* and *Atherosperma* grow faster on open roadsides and on the large bare areas at log marshalling and loading points than in competition with fireweeds. *Nothofagus cunninghamii* is not a " tender " species as it grows on a wide range of sites in Tasmania from near sea level to 4,000 feet, where it is subjected to heavy snow. In the higher rainfall areas of Western Tasmania it will grow on shallow, siliceous soils irrespective of aspect (Jackson, 1958).

Frazer and Vickery (1938) reported that when the *Eucalyptus* seed-trees were removed from around small patches of sub-tropical rainforest in the Barrington Tops district and the small patches later burnt there was immediate regeneration to rainforest. Normally, destruction of tropical and sub-tropical forest is followed by a sere from which the climax forest-species are at first absent. There are no comparable seral stages for temperate rainforest in Tasmania. There may be an early development of an apparently unispecific stage but close observation shows that generally all the rainforest species are present.

(*c*) *Ecological Status of Atherosperma.*

The ecological status of *Athersperma* is not clear. In most rainforest and mixed stands it is associated with *Nothofagus* and on good sites grows to 90-100 feet compared with 110-120 feet for *Nothofagus*. *Atherosperma* undergoes continuous regeneration by seedlings as well as vegetatively and in terms of recruits to the uper-size classes is usually at a marked advantage compared with *Nothofagus*. It is more tolerant of low light intensities, has a much wider range of seed dispersal (the seeds float like thistle down) and from general observation would appear to tolerate much wetter conditions in the cotyledon and small seedling stage.

Outside the study area there are fairly extensive areas of mixed forest (with *regnans*) in which the understory is essentially pure *Atherosperma*, while there are smaller areas where the species forms pure stands. Occasionally very large *Acacia dealbata* occur in association with *Atherosperma* in these areas, indicating that poor drainage is not the factor which has favoured the formation of the pure stands. Such pure stands are neither particularly sheltered nor excessively exposed and at the same time the macroscpoic features of the soil-profile match those in the adjoining mixed forest.

The course of the development of fairly extensive areas of mixed forest having an understory of pure *Atherosperma* (which, if there were no disturbance of the site, could lead to areas of pure *Atherosperma*) is not known. It was once thought that, given a long period without disturbance, its compartively superior capacity to regenerate would allow *Atherosperma* to capture rainforest sites from *Nothofagus*. However, the frequent association of *regnans* with pure *Atherosperma* shows that disturbances which have been frequent enough to perpetuate *regnans* have not prevented the development of an understory of pure *Atherosperma*.

Atherosperma has a far greater range of seed-dispersal than *Nothofagus*, so should seed of *Nothofagus* not be available in a burnt area, *Atherosperma* is at a marked advantage (as when, for example, all seed is destroyed, there is a poor seed crop, or a second fire occurs before the regeneration from the first has produced seed). A stand of *Nothofagus* probably produces a reasonable quantity of seed each year; the seed begins to be shed early in February, is shed in large quantities until the end of April, in smaller quantities until about the middle of September and then in very small amounts until the following February. Poole (1950) has reported that the seed of New Zealand species of *Nothofagus* is ripe during the winter after flowering and is nearly all shed from the cupule shortly afterwards.

The rate of spread of rainforest has not been studied.

The presence of *Acacia dealbata* in mixed forest is indicative of a disturbance of the canopy of the understory during the previous 50-70 years, and if the forest has not been logged this usually means disturbance by fire. In the areas of pure *Atherosperma* a few very large *Acacia dealbata* are to be found, associated with small patches in which *Atherosperma* died out through failure to regenerate. In spite of the large quantities of seed which have been shed into these gaps each year, seedlings (even at cotylendon stage) can usually be found only on a few *Dicksonia* trunks. There is virtually no litter on the ground and there are no traces of recent fire. In pure stands the ground is partly covered with a mat of *Atherosperma* roots, while the canopy may become so complete that many *Dicksonia* die because of the small amount of light getting through.

Toxic material leached from the leaves or exuded from the roots of *Atherosperma* may be a factor which gives *Atherosperma* an advantage over other understory species. In addition, in pure stands such toxicity could be involved in the apparent instability of *Atherosperma*. In the Derwent and Huon River systems *Atherosperma* generally shows a regenerative advantage over *Nothofagus* and yet understories or stands of pure *Atherosperma* are much less common than stands of mixed *Nothofagus-Atherosperma*. Experimental evidence is required on these points.

VII. Comparisons with Other Forests.

1. *Temperate Rainforest and Mixed Forest with an Understory of Temperate Rainforest Species.*

(*a*) Tasmania.

Mixed forest is common in Tasmania where the annual rainfall is more than 50 inches. On good soils the eucalypts in the mixture are *regnans*, *obliqua* and *gigantea* but, as rainfall increases, *simmondsii* and *ovata* may occur instead, because rainforest species can spread on to the poorer soils occupied by these two species. At elevation above 2,500 feet, *coccifera*, *urnigera*, *gunnii* and *subcrenulata* may be components of mixed forest. *Gigantea* is present on stabilized talus slopes in western mountains where the rainfall may eceed 80 inches per annum.

As a general statement it can be said that in mied forests in Tasmania the eucalypts in any one stand are even-aged and that their continued existence has depended upon periodic destruction of the stand by fire. Eucalypt regeneration cannot become established unless the understory is more or less completely removed.

Some areas of mixed forest in the Arve Valley (for location see Fig. 1) show much more disturbance of the canopy of the understory of rainforest species than is the case in the Florentine. Gaps caused by falling eucalypts are more numerous and larger, and as a consequence groups of poles of the rainforest species are common. Eucalypt regeneration is absent.

In Tasmania, as mean annual rainfall increases, fire frequency decreases. Towards the West Coast, rainforest is able to spread on to poorer soils, although the trend is halted in many places where large areas of inflammable sedgeland occur on very infertile, acid soils (Jackson, 1958).

In areas receiving less than 50-55 inches of rainfall annually, rainforest tends to be confined to gullies and S.E.-facing slopes. Below 35-40 inches, rainforest is rarely found outside steep-sided gullies facing S.E. and in these cases it is doubtful whether the rainforest would spread to drier slopes even if fires were completely excluded. In the 40-50 inches rainfall belt, fires have been frequent enough to maintain an understory of *Acacia dealbata, A. melanoxylon, A. verniciflua, Pomaderris, Olearia* and *Prostanthera lasianthos,* to name the more common understory species. The extent to which rainforest could spread in this belt, given a greatly reduced fire-freqeuncy, is not clear, since edaphic factors become limiting and the necessary reduction in fire-frequency would occur only if there were a substantial change in climate or man were excluded. As a result of the fire-frequency of the last few centuries, pure rainforest is rare in the 35-40 inches belt and species such as *Eucalyptus regnans* are confined to the moister slopes in stands which do not attain the ages of those in old mixed forests with higher rainfall.

(*b*) Victoria.

Temperate rainforest and mixed-forest are developed only to a limited extent in Victoria. Temperate rainforest is confined to very favourable sites—S.E.-facing gullies and upper slopes, and mixed-forest occurs as a narrow fringe to these restricted areas of rainforest. Patton (1955) describes the Victorian fern gully as true temperate rainforest with *Acacia melanoxylon, A. decurrens, Lomatia fraseri, Atherosperma, Nothofagus* in the upper stratum and *Olearia, Bedfordia, Prostanthera, Zieria* and *Pomaderris* in the second story. Such a forest should be regarded as seral with *Nothofagus* and *Atherosperma,* the only climax species. The limited extent of true temperate rainforest in Victoria compared with Tasmania would appear to be due to hotter and drier summer conditions which make it difficult for rainforest to exist on N.W. slopes. Also the more frequently occurring extreme fire danger would enable fires to burn on S.E. slopes where rainforest and mixed forest might otherwise develop. Bad fires have been frequent since white settlement at Melbourne in 1835. Fergusson and Chinner (1955) list 1902, 1919, 1926, 1932 and 1939 as years in which forest fires caused "great damage, including serious loss of life", although vast areas of virgin *regnans* forest escaped destruction until the last of these fires in 1939.

But devastating forest fires did occur before white settlement and gave rise to extensive even-aged stands of *regnans.* Patton (1930) dismissed pre-white man fires as a factor which had any effect on present associations, partly on the assumption current at the time that *regnans* reached an age of several thousand years and, being a fire-sensitive species, could not have survived if fires had been frequent. However, it is now known that few *regnans* are likely to be more than 400 years old. In the head of the Ada River (Powell Town district of Victoria) pure rainforest is confined to a very small area along the creeks. A narrow band of mixed forest occurs and extending beyond this for several chains are coppice shoots of *Nothofagus* from trees burnt in 1939. This fire went through a small part of the c. 165-year-old stand of *regnans* without killing it. No really old *regnans* are to be seen, even near the creeks, but a few 250?-year-old-trees are scattered through the otherwise even-aged 165-year-old stand, little of which completely escaped the fires of 1939.

There is little doubt that white man's more intensive use of the land has been the cause of an increased fire-frequency in some areas. In the Otways, white man's clearing and burning have caused major changes. Carron and Hall (1954) stated that beech (*Nothofagus cunninghamii*), from which the township of Beech Forest derives its name, was practically extinct in this area.

(*c*) New South Wales and Queensland.
Nothofagus moorei.

Frazer and Vickery (1938) have described the simple structure of *Nothofagus moorei* forest in New South Wales. The inability of *Eucalyptus* to regenerate beneath *Nothofagus* was noted and the presence of old eucalypts among *Nothofagus* was taken as an indication of the advance of the rainforest species. Disturbance by fire would also account for the continued existence of the eucalypts in the mixture but the frequency of fires would need to have been low in order to ensure that *Nothofagus* was not wiped out. If fires are frequent, rainforest species would only make relatively short-term advances into adjoining eucalypt forest and there will be a repeated sequence of advance and destruction. Vegetation illustrated in Frazer and Vickery's 1938 paper appear to be typical of fire edges (Figs. 44, 45, 46, 47, and Plate XII). In one of these (Fig. 47) the butt of a tree shows the partial healing of successive fire-wounds and the ground cover of *Poa caespitosa* also indicates repeated burning. Herbert (1936) pointed out that the success of the advance of *Nothofagus moorei* into eucalypt forest in S.E. Queensland depended upon freedom from fire until *Nothofagus* had formed a closed community.

2. *Mixed Forest with Understory of Sub-Tropical Rainforest Species.*

The mixed forests of Tasmania have a very close counterpart in New South Wales and Queensland, where species such as *Eucalyptus grandis, microcorys, pilularis, saligna* and *Tristania conferta* have been maintained in mixtures with species of the sub-tropical rainforest by past fires. Swain (1928), writing of Queensland, said: "In his time the Queensland aborigine, scorning Mahomet, persuaded the game to come to him by applying his firestick in the springtime to the production of new hunting-grounds baited with grass fresh-shooting from the ashes. The Queensland cattlemen of today, perceiving the Eucalyptus forest forever asserting itself by bark-fall and leaf-fall and twig-fall and shade and canopy against the permanency of his pasturages, takes side with fire against the forests of the coastal hills, to arrest the silvical succession which otherwise and in so far as site factors permit, would develop through Brush Box (*Tristania conferta*) and Rose Walnut (*Endiandra sieberi*) into Araucarian jungle . . . On the slopes *Eucalyptus pilularis* has an advantage over the tenderer jungle trees in its greater hardihood, and this advantage is made binding by the incidence of bush fires. By these means it stays the development of the succession and establishes itself as a fire subsere of some stability, itself regenerating strongly from the ashes of the bush fires which have eliminated its competitors".

Webb (1956) and Baur (1957) also discussed the part played by fire in maintaining mixed forests, where the understories of rainforest species have completely excluded eucalypt regeneration. Nevertheless, several authors look to edaphic factors to explain the composition of mixed-forests (McLuckie and Petrie (1927), Frazer and Vickery (1938) and Burges and Johnston (1953)).

Mixed forests in high rainfall in temperate and sub-tropical Australia apparently has no widespread counterpart in the tropics. Richards (1952) suggests that the *Eucalyptus deglupta* communities in New Britain have depended for their existence on past fires, but in Africa, as in New Guinea and elsewhere, the rainforest passes abruptly into grassland or savannah which is burnt very frequently—Eggeling (1947), Jackson (1956), Morrison *et al* (1948), Richards (1952), Thomas (1945). On the highlands of Tasmania and Eastern Australia fires have played a part in the origin and maintenance of small *Poa caespitosa* plains in rainforest on basaltic soils—Herbert (1938) Baur (1957). Natural re-afforestation of such openings is slowed by frost.

Similarly, on the Pacific Coast of North America, fire has prevented the attainment of climax status for certain mixed *Pseudotsuga-Tsuga* forests (Allen, 1954; Hansen, 1950; Lindsay, 1932). In south-eastern U.S.A., fires have maintained *Pinus* spp. in mixed stands with *Quercus* and *Hicoria* (Barrett, 1943).

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APPENDIX.

Names, with authors, of those plants not contained in Blakely (1934), Curtis (1956). Rodway (1903), or Wakefield (1957).

Araucaria cunninghamii Ait.
Ceratopetalum apetalum D. Don.
Cirsium vulgare (Savi) Ten.
Endiandra sieberi Nees.
Lomatia fraseri R. Br.
Nothofagus moorei Maiden.
Podocarpus spicatus R. Br.
Pseudotsuga taxifolia (Poir) Brit.
Syncarpia subargentea C.T.W.
Tarrieta argyrodedron Benth.
Tristania conferta R. Br.