THE REGENERATION OF COMMERCIAL EUCALYPT FORESTS ON SURREY HILLS, N.W. TASMANIA.

By

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I, undersigned, Robert Keith Orme, state herewith that

(1) except as stated therein, this thesis contains no material which has been accepted for the award of any other degree or diploma in any University, and that

(2) to the best of my knowledge and belief, this thesis contains no copy or paraphrase of material previously published or written by another person, except when due reference is made in the text of the thesis.

Keith Orme
9/10/71

PREFACE

The contents of this thesis are placed in two volumes to facilitate reading and to enable easy binding.

Volume 1 consists of the main text, some small tables, references, and the index to both volumes.

Volume 2 consists of the majority of tables, figures and the appendices.

The pagination of the thesis is continuous; the relevant tables and figures may be easily located in Vol. 2 near the page number of the relevant section of text. This enables the reader to view diagrams while reading the text.

The main table of results has been repeated on pages 58 and 225.

Detail irrelevant to the development of ideas in the text has been included in appendices.

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SUMMARY

The quantity and quality of eucalypt regeneration in all the important forest types on Surrey Hills and adjacent areas has been evaluated in the period between October 1969 and August 1971. The rate of stocking was determined by estimating numbers and distribution of seedlings. Growth was estimated by determining height increment with age. Both stocking and growth were related to a) the site quality evaluated from past forest growth, and b) by the logging and regeneration practice used on the area. The survey was conducted by sampling on a grid pattern using milacre plots at a spacing of 4 x 1 chains as described by Mount (1961). A total of 1,800 plots were sampled.

The results of sampling the distribution of seedlings in space show generally much greater over-dispersion on Surrey Hills as compared with seedling distribution in similar forest types in Tasmania.

The region consists of a complex mosaic of vegetation types ranging from pure Rainforest through Eucalypt-Rain-forest, Mixed Forest ecotones, pure Wet Eucalypt Forest,

Grass Savannah to Open Grassland or Sedgeland communities. This mosaic is a result of past climatic changes and anthropogenic influences. Within those areas where sufficient eucalypt has been present to justify exploitation, a local mosaic of eucalypt regeneration exists. Within blocks of one forest type sub-areas without any eucalypt regeneration exist. This is due mainly to the past distribution of seed trees, although management practice contributes. On the sub-areas where some level of stocking exists, the variance in stocking per milacre is very large and is greatly in excess of the average variance for milacre plots in other regions of Tasmania. This disproportionate increase in the over-dispersion of seedling distribution is a product of the regeneration practice rather than any intrinsic function of site quality or forest type. In areas of regeneration resulting from burning practices the minimum figure for successful regeneration has been estimated at 30% milacres occupied by one or more seedlings (Mount 1961). This minimum probably must be raised considerably to forecast successful regeneration in this area because of the higher over-dispersion in seedling distribution. The analysis of a large number of samples from various forest types shows that when 30% of the milacre plots in an area have one or more seedlings, then 50% of the area is unstocked.

Thus, the acceptance of 30% of stocked milacres as a minimum acceptable stocking rate assumes a large potential of unproductive area.

The present logging-regeneration practice does not result in high production in the regeneration crop. Not only is stocking highly variable and in general inadequate, but the growth rate of the regeneration is also lower with this practice than the rate obtained following seed-bed preparation by firing. In this present survey, the growth rates of regeneration on various sites treated by logging and disturbance have been compared with those on areas subjected to wild-fire or coupe-burning techniques in adjacent areas. While these sites are not always strictly comparable due to differences in soil type, the basis of comparison is valid. A series of trials on various soil and forest types to compare regeneration growth following seed-bed preparation by disturbance alone and by slash-burning is required.

Regeneration growth has been estimated by the calculation of the regressions of height on age of the potential commercial crop. This has been sampled by determining the mean height-age relationships for the two tallest seedlings on each 4 milacre plot at a spacing of 4 x 1 chains. Between 90 and 140 samples were taken from each area. Regression coefficients of height increment vary considerably within and between forest types under present management practice. Increments over ages of 2 - 10 years range from 8 inches/year on Eucalypt-Grass Savannah to 27 inches/year on Eucalypt-Rainforest types. By comparison, an increment of 57 inches/year on Eucalypt-Rainforest is found on burnt seed-beds of similar site quality in adjacent areas. The mean height of the tallest trees on sampled plots at 4 years on logged Eucalypt-Sclerophyll Scrub-Forest types was found to be 61 inches. The comparable figure for burnt Eucalypt-Sclerophyll Forest was found to be 162 inches; a factor of 2.5!

The wide variation in height increment for the various forest types when the seed-beds are prepared without fire would seem to result from differences in the amount of soil disturbance which can be effected. On sites which were previously open and carried grass or tussock (Diplarrhena), or in those sites where rhizomatous ferns were previously established, growth is poor due to the rapid re-establishment of competition.

A compounded index has been calculated which expresses the productivity of regeneration as the product of area stocked, by stocking rate, by height growth at a fixed age. This index allows the comparison of various regeneration treatments on each of the various forest types. In addition, the efficiency of each treatment on a particular forest type may be found for that site assuming full stocking. The productivity index indicates that the present practices are very inefficient compared with slash-burning techniques. Regeneration efficiency values, calculated as actual productivity as a percentage of ideal productivity for the treatments in use, range from 1/5th to 1/2 th of similar values for slash-burning treatments.

These estimates make no allowance for potential loss of productivity due to Dieback disease. This disease will further widen the disparity in relative efficiency between present practices and slash-burning as a regeneration technique. It is likely that loss of productivity due to Dieback disease will be very high with present treatments due to the growth of the rain-forest understoreys.

It is recommended that the present methods of seed-bed preparation be discontinued and that control coupe burning be adopted as a general management technique. The comparatively large areas without sufficient seed will require aerial sowing, hand sowing or planting depending on site requirements. These practices will ensure at least minimum stocking of all areas, a lower dispersion in stocking rates and higher and more uniform growth rates. The net results in productivity per acre are conservatively estimated at three times the present yield.

The risk associated with the use of fire is quite real, but because of the mildness of the climate and nature of the topography at Surrey Hills, it is considerably less than in areas of Tasmania where coupe-burning for regeneration has been practiced successfully for many years. Pure rainforest can be converted into the more productive eucalypt forest types using the same regeneration techniques. Additional slash-felling is usually required in this case to obtain the same quality of burn.

Table 0.1 is a summary of stocking estimates for the various forest types and treatments; the locations of the areas sampled are shown in figure 4.9.

Chapter I

Introduction

The aim of this work has been to investigate the standard of eucalypt seedling regrowth and regeneration practices at Surrey Hills and associated areas in N.W. Tasmania. The region is extensively forested and forms the basis for a large timber industry based on the coastal areas around Burnie. Products range from railway sleepers, mining timber and scantling to high quality dressed timber. Much of the production goes to various particle boards and to fine quality writing paper. The industry is now controlled almost exclusively by one commercial complex, Associated Pulp and Paper Mills Ltd. Smaller subsidiary companies carry out milling and forestry operations.

The productive area is now a large tract of forest commencing about 20 miles south of Burnie and extending southward some 40 miles. The coastal strip, once heavily timbered, is now largely cleared and in agricultural production. Belts of timber remain in valleys crossing this strip, however, they are situated on steep slopes and usually poorer soils. Large tracts of the forest areas (125,000 acres) are held in freehold possession by the Company. The balance of adjoining areas are State Forests or Crown Land. The Company has almost exclusive timber rights to a large proportion of this state land.

The large freehold blocks possessed by the company were acquired in 1924 from the Van Diemans Land Co. This land was granted early in the pioneering phase of Van Diemans Land (Tasmania). The history of this acquisition and development has been given by Needham (1960). Land acquisitions north of the original Surrey Hills and Ringwood VDL blocks have been made in the last 20 years. Approximately 30-40% of these recent acquisitions have been planted with *Pinus radiata*. The present survey is concerned with eucalypt regeneration in the natural forests on the original VDL blocks.

The Surrey Hills and Ringwood blocks are situated on a basaltic plateau ranging from 1700 feet elevation in the North to about 2,200 feet at the southern boundary; the majority lies at about 2000 feet. The plateau is undulating with deeply incised larger river systems to the North. The drainage pattern on the plateau is weakly developed and dendritic. Soils are mainly kraznozems, or deep yellow podzolics with gradational profiles. Precipitation ranges from 60 to 80 inches per annum increasing with altitude and towards the West. The seasonal distribution is not marked; summer monthly rainfall exceeds 3 inches.

The moderately fertile soils and high and uniform precipitation form excellent conditions for forest development. Tree growth is limited towards the southern and higher regions because of frost activity. This effect is marked when land has lost its forest cover. The climatic climax is Temperate Evergreen Rainforest dominated by the species Nothofagus cunninghamii. Were it not for a past history of climatic change and disturbance by man-induced fire, this climax state would have been general. However, it is clear that much of the present dominance by Nothofagus is of recent origin. Indeed much of the region was occupied by open grassland or savannah forests in the recent past and closed forests have only recently invaded this situation. Much of this invasion has occurred since white settlement. At present approximately ¼ of the total area is occupied by closed rainforest. The eucalypt forests are distributed throughout the region as an ecotone occupying marginal conditions between grassland and closed forest, or occur where high fire frequency has restricted the invasion by rain forest species. The general distribution of eucalypts as a mosaic throughout the area would indicate that the successful regeneration process must be one which will increase the areas with eucalypt stocking and restrict the competitive influence of rainforest.

The dominant species of *Eucalyptus* on this plateau is *E. delegatensis* R. T. Baker. The only other species of commercial importance is *E. obliqua* L'Herit which occurs at the northern edges of the region. A few other species such as *E. gunnii*, *E. rodwayi*, *E. simmondsii* and *E. dalrympleana* are present in specialized sites, or are scattered as minor elements. The bulk of the regeneration problem is concerned with the propagation of *E. delegatensis*. Since the species had a largely marginal ecotonal distribution between grassland and closed forest before logging, the regeneration survey has attempted to analyse the efficiency of seedling distribution on both the large scale and small scale basis. The survey has attempted to determine the growth efficiency of various sites and management practices. More details are available for stocking figures than growth because of the relatively few age-classes of regeneration available for sampling.

Large scale exploitation of the region commenced in about 1950. Up to this date sawlog operations were limited to accessible regions adjacent to the E.B.R. railroad or the Waratah highway. Earlier, forests in the Waratah-Guildford region were utilized for mining and railroad building. About 55% of the area has been cut over for sawlogs to date (1970). Much of the exploitation between

1950 and 1960 removed useful eucalypt but left culls and most rainforest standing. Much of the rainforest left after these earlier logging operations has died, or declined, due to disturbance. Eucalypts have both a high light demand in the seedling stage and require a suitable seed-bed for regeneration. Neither of these conditions was met, since the distance of the understorey was not sufficient to create them.

Later operations since 1960 have been more intensive, more rainforest has been removed and more suitable conditions for eucalypt regeneration have been created. In addition areas carrying rainforest scrub, mainly Drimys lanceolata, have been treated by dozing to create suitable seed beds and provide light for regeneration.

In contrast to the regeneration practices adopted in other similar forests in Victoria and Tasmania, fire has not been used in the preparation of seed-beds, or for clearing purposes. The general policies governing the practices used have been described by Needham (1947 and 1960).

Chapter 2

A. General ecology

1. Geography

Surrey Hills is located 30 miles south of Burnie, Tasmania; it consists of a 200 square mile block of freehold land, situated at an elevation of between 1900 and 2200 feet, (Map 2.0).

The Parrawe area, which is State Forest, is located 5 miles to the West of the Surrey Hills block.

The Loyetea, Loongana and Mt. Tor areas are situated from 2 to 10 miles east of Surrey Hills; these areas are also State Forest.

Although these areas are in close proximity to each other, they are serviced by separate road networks with little connection between them.

Guildford Junction is located in a central position at Surrey Hills, and Waratah is in the south-western section.

2. Physiography

Surrey Hills is a basalt plateau which is drained by several major rivers. The northern section of the area is drained northwards into Bass Strait by the Emu, Blythe, Cam and Leven Rivers. The central western section is drained by the Hellyer River which initially runs northward and then turns west to join the Arthur River, which in turn enters the sea on the West coast of Tasmania about 90 miles north of Strahan. The southern edge of the plateau is drained by tributaries of the Pieman River, the largest of these streams being the Hatfield. The Pieman River enters the sea about 40 miles north of Strahan.

The Parrawe area is sharply dissected, consisting of many ridges and gullies; it is drained by the deeply incised Arthur River and its tributaries. The elevation of the ridges is up to 2000 feet, the base of the gullies being about 1000 feet lower.

The areas at Mt. Tor, Loongana and Loyetea are of moderate topography. Loyetea is situated on the slopes between the Leven River and Mt. Everett, whilst the Loongana and Mt. Tor areas are situated on the slopes between this river and the Black Bluff Range.

3. Climatology

The mean annual rainfall at Surrey Hills ranges from 60 to 90 inches; it is greatest in the southern and western areas and least in the northern and eastern areas. The rainfall pattern has a winter bias, although the mean summer rainfall is in excess of 3 inches per month at Waratah.

Frost can occur virtually at anytime during the year. Foley (1945) has estimated an average frost free period of 33 days for Waratah, compared to 70 days at Tewkesbury (1500 feet, 17 miles north of Waratah). Screen temperatures of 32°F, or less, are recorded normally at Waratah from the 9th of April until the 14th of November. Waratah has recorded some of the lowest screen temperatures in Tasmania.

Table 2.1

Frost frequencies at various stations (Foley 1945)

	J	F	M	A	M	S	O	N	D
Tewkesbury (1500 ft.)	0	0	0	0.2	1.4	-	1.0	0.8	0
Waratah (2047 ft.)	1.9	1.5	2.1	4.4	-	-	-	4.9	1.7

Data calculated on screen temperature 32-36°F.

The summers are quite cool and only occasionally does the temperature in January exceed 80°F. The mean temperature in January is from 51-54°F. This is close to the lower limits for forest development.

Snow showers can be experienced at anytime of the year. However, the heavier falls are confined to late winter and early spring. Falls of snow are usually light at Surrey Hills, and normally melt within a few days of deposition. On the peaks, the Black Bluff Range in particular, snow may lie in patches until summer. Occasionally, logging operations have to be suspended due to heavy snow-falls. (More detail of the climate is given in Section2, Chapter 4).

4. Geology

Pike (1964) has described the geology of the northern section of Surrey Hills. "The dominant topographic feature of the area is a northerly sloping surface corresponding to the eroded tops of extensive Caenozoic basalt-flows. Rising as prominent features above the basalt are monadnock ridges of quartz conglomerate." (St. Valentines Peak 3,637 ft., Mt. Everett 2,920 ft., Mt. Pearse 3,000 ft.) The southern section is a continuation of the basalt plateau. Extensive outcrops of Devonian granite occur in the Kara region between St. Valentines Peak and Mt. Everett. No detailed geological description, apart from a large scale map, is available for the Parrawe, Loyetea, Mt. Tor and Loongana areas. Parrawe is an area of predominantly Permian sediments. The Mt. Tor area consists mainly of Cambrian material (lutites, arenites, hornfels), and further to the East (Loongana, Loyetea) Ordovician materials are dominant (Owen conglomerate).

5. Soils

Kraznozemic soils dominate the basalt areas. These soils are deep, well drained, friable clay soils with little horizon development. They tend to be acidic, are relatively high in organic matter content, and are moderately fertile soils which are used extensively for agriculture as well as being excellent forest soils.

Yellow podzolic soils are formed on Permian, Cambrian, Ordovician and Devonian parent materials. These soils have gradational profiles, and are quite variable in depth. They have not been exploited for agriculture purposes, perhaps because of their relative lower fertility, but they are, in general, quite productive forest soils.

Moor podzol peats are found on areas of quartzite. These soils are strongly acid, leached and infertile. Areas of sedgeland, or poor *E. simmondsii* forest, are situated on this soil type.

In Table 2.2 the occurrence of soil and vegetation types at Surrey Hills is given. (Stephens 1941, Loveday 1955,1958) (Graley 1961)

6. Vegetation types

Descriptions of the vegetation types have been given by Casson (1952), Gilbert (1958) and Jackson (1965).

The following plant communities are found at Surrey Hills. A detailed description of those types sampled in the survey is given in chapter 2B.

(a) Rainforest

Extensive areas of rainforest occur. The dominant species is *Nothofagus cunninghamii*, although *Eucryphia*, *Atherosperma*, *Acacia* and *Phyllocladus* are present, their occurrence being closely correlated with local edaphic effects. These forests have been described in detail by Howard (1970). Figures 2.1, 2.2 & 2.3 are photographs of rainforest communities.

(b) Wet Sclerophyll forest

This community is quite extensive in the northern areas and becomes less important with increasing altitude. *E. delegatensis* and *E. obliqua* are the dominant species present (Fig. 2.4).

(c) Mixed forest ecotones

Large areas of these ecotones occur which are gradations between types (a) and (b). Gilbert (1958) has described rainforest with a mature eucalypt overstorey as Mixed Forest. In this thesis ecotonal

Mixed Forest has been sub-divided on the basis of the following understorey types:

Eucalypt - Rainforest: Mixed Forest in the true sense used by Gilbert - a tall open stratum of Eucalypt (usually _E. delegatensis_ in this area) standing over a closed stratum of rainforest tree species of _Nothofagus cunninghamii_ and lesser associated species such as _Atherosperma moschatum_, _Eucryphia lucida_ and _Phyllocladus aspleniifolius_.

On good sites [(Bunkers Rd.) Eucalypt stratum 200 feet, rainforest stratum 120 feet,] the density of the Eucalypt stratum is dependent on the age of the rain-forest and the prevalence of Dieback disease,

Eucalypt - Rainforest Scrub: Mixed Forest in the true sense used by Gilbert (1958) - a tall open stratum of Eucalypt (usually _E. delegatensis_ in this area) standing over a closed stratum of Rainforest Scrub species of _Drimys lanceolata_ and lesser associated species such as _Phyllocladus aspleniifolius_, _Telopea truncata_ and _Nothofagus cunninghamii_.

On good sites (Mayday Rd.) Eucalypt- stratum 150 feet, Rainforest Scrub stratum 25 feet, the density of the Eucalypt stratum is dependent on the age of the rainforest and the prevalence of Dieback disease.

Figures 2.5, 2.6 and 2.7 are photographs of mixed forest communities.

(d) Savannah Woodland

Again, this community has been classified according to its understorey, Eucalypt-Grassland. It consists of an open woodland forest of *E. delegatensis* with a little *E. gunnii* or *E. rodwayi* and an understorey of *Poa caespitosa* and *Diplarrhena moraea*. (Fig. 2.8).

(e) Eucalypt- Sedgeland

The dominant species of this type is *Gymnoschoenus sphaerocephalus*. This community is restricted to areas of shallow soils, usually derived from quartzite. Although its area on Surrey Hills is limited, it occurs over a major portion of the West and South-West of Tasmania. (Fig. 2.9).

7. History

The available evidence concerning past climate suggests that there has been a considerable climatic change in the post-Pleistocene era. Evidence obtained generally from Western and Central Tasmania from lake sediments indicates a markedly dryer climate, from approximately 9,000 B.P. to 4,500 B.P., followed by a generally wetter phase to the present Jackson (1968), Townrow (per. com. 1971). During the dry phase of the post-Pleistocene the dominant community in this region was eucalypt forest, the areas of rainforest being restricted to moist gullies. In the later wetter phase the rainforest community spread from the gullies at the expense of the eucalypt areas. This change in forest dominance was impeded by the continual application of fire by the aboriginal population since this burning had the effect of favouring the eucalypt forest, even in climatic conditions favouring rainforest.

Early descriptions of the Surrey Hills area remarked specifically on the open park-like nature of the landscape with extensive areas of grassland (Hellyer in Bischoff 1827). Today, extensive areas of Rainforest and Mixed Forest occupy former Savannah Woodland sites; a mosaic of smaller grassland/still exists, however, these

openings

show recent evidence of forest succession. It is clear that the coming of white man has drastically altered the appearance of this area.

With the decline of the aboriginal population the pattern of burning has changed. Spring burning of savannah areas was practiced by the V.D.L. Co. between 1830 and 1950. However, this burning regime cannot have been as extensive as that practiced by the aborigines because of the increase in rainforest areas and of general forest density since 1830.

Since 1920 there has been an increase in fire frequency with a corresponding decrease in fire intensity (see Chapter5, Section 2) which appears to have kept the areas of savannah more or less constant. However, increased fire-protection since 1950 has resulted in a faster invasion on the edges of these plains, except for the Racecourse, Guildford and Middlesex Rd. areas where cattle are still grazed.

In summary, it may be said that total savannah grassland decreased from 1830 to about 1920, then remained constant from 1920 to 1950, and is at present slowly decreasing. There has been an increase in forest density since 1830 and an associated increase in rainforest areas at the expense of eucalypt forest and grassland.

8. Climax and disclimax communities

Jackson (1968) has discussed fully the factors contributing to the present state of forest vegetation.

(a) Present climax communities

(1) Rainforest

Pure Rainforest is a climax community at Surrey Hills. It is able to regenerate directly without the influence of any seral stage. These climax communities are located on both kraznozemic and podzolic soils. The species composition of this community changes with edaphic factors, but the basic structural pattern remains constant. Rainforest can establish itself directly on grassland without the necessity of a seral eucalypt stage. There are examples of this occurring at South Parrawe where Nothofagus and shrubs, mainly Drimys, have colonized deserted agricultural clearings on rainforest sites.

All the present forest areas of the locality have average rainfalls in excess of those values given by Curtis (1949) and Jackson(1965) as necessary for the development of rainforest (55 inches per annum with a summer rainfall in excess of 2 inches per month). There is little doubt that, in the absence of fire, rainforest would become dominant in all areas, the rate of succession being a function of soil fertility and acidity.

(b) Present disclimax communities

The general relationships of the disclimaxes have been discussed by Jackson (1968). The status of those important to a discussion of regeneration in the Surrey Hills area is given below.

(1) Eucalypt - Rainforest

Large areas of this type occur at Surrey Hills. Gilbert (1958) considered that for *E. regnans* forests in the Florentine Valley this disclimax could be maintained with a mean fire frequency of between 150 and 200 years. This estimate requires adjustment when applied to the mixed forest areas of *E. delegatensis* on Surrey Hills. It would appear that in the presence of a rainforest understorey, *E. delegatensis* on Surrey Hills would succumb from the Dieback disease associated with altitudes above 1800 feet. The Dieback becomes appreciable when the understorey development exceeds 70 years, hence a lower mean fire frequency would be required to maintain this disclimax state.

(2) Eucalypt - Rainforest scrub

This is another extensive Mixed Forest community with an understorey age of between 50 and 100 years; in this area it is characterized by the Winteraceous species *Drimys lanceolata*. This community replaces

Wet Sclerophyll Forest at higher and wetter elevations, and is also present in similar plateau forest areas in Tasmania (Mersey Valley, Mt. Barrow).

(3) Eucalypt - Sclerophyll Scrub

This forest type is restricted to the northern section of Surrey Hills. Both E. obliqua and E. delegatensis are present, E. obliqua becoming dominant at lower elevations. The composition of the understorey is related directly to the fire frequency. With frequent burning the understorey is reduced to a mixture of Bracken Fern (Pteridium esculentum) and Epacridaceous shrubs. With longer intervals between fires the understorey is composed of wet scrub species such as Phebalium squameum. These lower altitude forests are the most productive forest sites on the Surrey Hills block because of the more equable climate.

(4) Eucalypt - Grassland

With frequent firing (5-20 years) other forest types on soils of high fertility are reduced to Grass-lands, or Savannah Grasslands. There is ample evidence of this trend for instance, adjacent to the E.B.R. railway line. This savannah community can, in the absence of fire, be converted to pure Rainforest.

The succession sequence will depend, to a large extent, on the availability of seed. In the absence of eucalypts, as for example at South Parrawe, the grassland on derelict farms has been replaced by *Drimys lanceolata*. Seed of this species has been distributed by birds. *Nothofagus cunninghamii* is present in the grassland where seed is available.

(5) Eucalypt - Sedgeland

Repeated firing (5 - 10 years) of these communities has resulted in a disclimax state containing a few relatively fire resistant species. The main species is the Cyperaceous plant *Gymnoschoenus sphaerocephalus*. Associated shrubs with fire-resistant lignotubers such as *Casuarina distyla*, *Melaleuca squamea*, *Agastachys odorata* and *Eucalyptus simmondsii* also occur. These communities develop on Cambrian quartz conglomerates and other siliceous rocks. Due to high fire-incidence a peaty groundwater podzolic profile of high acidity soon develops.

Areas of Sedgeland that have not been burnt for 20 years contain increasing quantities of Wet Scrub species. In the absence of fire this community would slowly revert to a poor Rainforest or Scrub Forest.

9. Forest succession

(a) At altitudes less than 2000 feet in the northern section of Surrey Hills where the rainfall approaches 60 inches per annum and the evaporation rates are relatively high, the successions in the absence of fire are as follows:

Eucalypt-Forest with Bracken understorey → Eucalypt Forest with Wet Sclerophyll-Scrub understorey → Eucalypt Forest with Rainforest and Wet Scrub Sclerophyll species Rainforest.

(a) At altitudes above 2000 feet where the rainfall approaches 80 inches per annum and relatively low evaporation rates occur, the successions on fertile soils in the absence of fire are as follows:

Eucalypt forest with Grassland understorey → Eucalypt Forest with Rainforest-Scrub understorey → Eucalypt Forest with Rainforest understorey → Rainforest.

In the absence of eucalypt seed, Grassland is invaded by Rainforest Scrub species and Rainforest directly if a seed source is available.

Figure 2.9 illustrates the sequence of forest succession at altitudes above 2000 feet at Surrey Hills.

2 B. Forest types sampled in the survey

The following descriptions give the basic floristic composition of the various forest types. In Chapter 4 an analysis is given of the understorey species.

(a) Eucalypt-Rainforest (Mixed-Forest)

This type is mapped as Hardwood-Myrtle (H.M.) on the company P.I. maps. The complexity of the association is determined by a large number of site factors. The main factors contributing to the present composition include past firing-patterns, edaphic effects and the amount of disturbance due to logging.

The species usually present in this type are given in Table 2.3.

The age of the understorey in this type is variable and is generally between fifty and two hundred years. The mortality of the eucalypts in this association is high. To gauge the actual mortality percentage I would suggest that plots be established in uncut forest and scored annually to assess the degree of *E. delegatensis* Dieback, and its rate of development. I would suggest that the figures obtained could be of considerable economic importance, especially since a large percentage of the remaining uncut forest is of the Mixed Forest type.

(b) Eucalypt-Rainforest scrub

This association consists of an overstorey of either E. delegatensis, E. gunnii or E. dalrympleana, over a scrub understorey of variable age. Understorey ages of up to 70 years have been recorded in the Mt. Cattley area.

Although Nothofagus cunninghamii occurs , it is of a young age and has not suppressed the other species present. In fact, the so called Eucalypt- Rainforest-Scrub association is a seral stage in the development to the climax Rainforest association. The dominant species are Drimys lanceolata and Phyllocladus aspleniifolius. Other species usually present are:- Telopea truncata, Monotoca glauca, Cyathodes juniperina, Pultenaea juniperina, Cenarrhenes nitida, Lomatia tinctora and Pittosporum bicolor. The main fern species present include Histiopteris, Hypolepis and Blechnum spp.

After disturbance by dozer this scrub recolonizes the site within three to four years, unless influenced by undue browsing pressure from native animals.

Dieback of E. delegatensis is prevalent in this type, especially in the gullies.

(c) Eucalyptus-Sclerophyll scrub

This association consists of an overstorey of E. obliqua, E. delegatensis or E. simmondsii, over an understorey composed of shrub-species. The understorey type and its species composition is mainly dependent on site quality and fire history. The oldest understorey found was a mixture of Acacia mucronata, Leptospermum spp. and Phebalium squameum. It was 37 years of age at the time of sampling, having resulted from extensive fires in 1931-32. Areas which had been burnt more frequently had the typical fire-sere vegetation of Epacridaceous shrubs and bracken.

Species common to this type included the following:-

Species > 10 feet high

Acacia mucronata	Leguminosae
Phebalium squameum	Rutaceae
Leptospermum lanigerum	Myrtaceae
Melaleuca squarrosa	Myrtaceae
Banksia marginata	Proteaceae

Species < 10 feet high

Oxylobium ellipticum	Leguminosae
Oxylobium arborescens	Leguminosae
Pultenaea juniperina	Leguminosae

Monotoca glauca	Epacridaceae
Epacris impressa	Epacridaceae
Cyathodes juniperina	Epacridaceae
Pteridium esculentum	
Gahnia psittacorum	Cyperaceae

(d) *Eucalypt-Grassland*

This type consists of an overstorey of *E. delegatensis*, *E. gunnii*, *E. rodwayi* and *E. simmondsii* over a low scrub and grassland. Increased fire protection allowed invasion by scrub-species, in particular *Drimys lanceolata*, *Nothofagus cunninghamii* and *Acacia melanoxylon*. The main species present are:-

Grassland species

Diplarrhena moraea	Iridaceae
Dianella tasmanica	Liliaceae
Lepidosperma filiforme	Cyperaceae
Poa caespitosa	Gramineae

Shrubs

Lomatia tinctora	Proteaceae
Epacris gunnii	Epacridaceae
Cyathodes juniperina	Epacridaceae
Cyathodes parvifolia	Epacridaceae
Pultenaea juniperina	Leguminosae

An intensive study is underway at "Campbells" concerning the regeneration problems of the type and is dealt with at length in Section II of this report.

20. Distribution of Forest Types

In table 2.4 a summary of the areas of different forest types in the Ringwood and Surrey Hills blocks is given.

Table 2.4

Distribution of Forest Types at Surrey Hills

Forest Type	Total Area
Rainforest	28,000
Eucalypt-Rainforest	13,000
Eucalypt- Rainforest Scrub	37,000
Eucalypt-Grassland	19,000
Grassland	10,000
Sedgeland (Button-grass)	13,000
Miscellaneous areas	5,000
	125,000 acres

The total cut-over area in the various eucalypt types up to 1971 is approximately 38,000 acres, or slightly more than fifty per cent of the total commercial eucalypt area. An estimate of the cut-over area in the pure Rainforest type is 16,000 acres, or fifty five per cent. The accuracy of the estimates of logged areas can only be easily checked when new aerial photographs become available.

CHAPTER III

METHODS

3 A. Sampling Methods for the Estimation of Stocking

The method of assessment of stocking by quadrat sampling, or frequency counts, was first applied to regeneration survey work by American workers and has been widely applied since then (Cunningham, 1960).

Theoretically, if the size of the sampling-area is selected to approximate the number of stems required at maturity, or at a specified time in a rotation, then the percentage stocking determined by this sampling-area will give a direct measure of the extent of stocking. For example, naturally stocked dense stands of forty year old *E. obliqua* are found to be stocked at a rate of 85 - 90% by sampling plots with an arc of 1/100th acre or one centacre. This could be taken as a measure of full stocking for regeneration surveys. The centacre quadrat is, however, too large to search quickly and accurately for small seedlings. A much smaller quadrat 1/1000 acre ("milacre") has been accepted as a desirable size for regeneration surveys in eucalypts. A percentage stocking for milacre plots of 30 - 40% is generally accepted as adequate stocking.

Many relationships have been developed between percentage milacre stocking and a number of stems per acre and these have been well reviewed by Cunningham (1960), Mount (1961).

If natural seedlings were distributed at random, the distribution of seedlings per quadrat approaches a Poisson distribution and 30% milacre stocking would be equivalent to a total stocking of 357 seedlings per acre. In practice, due to the uneven distribution of seed bed and poor distribution, the seedlings are clumped or over-dispersed and many more than this are required to give 30% stocking by milacres.

Table 3.1

Milacre Frequencies and Densities Corresponding to Centacre Frequencies of 85 and 90 percent (Mount 1961)

Centacres	Milacres					
	h = 2.5*		h = 5.0*		h = 10.0*	
	%	per acre	%	per acre	%	per acre
90%	30	442	36	791	39	1493
85%	25	344	31	609	35	1132

* h is a measure of "clumpiness" or heterogeneity of the seedling distribution.

h = 2.5 Artificial seeding on a uniform seed bed, i.e. a burnt area aerially sown with seed.

h = 5.0 Natural seeding on a fairly uniform seed bed, i.e. burnt area, some dozer tracks, reserved seed trees

h = 10.0 Natural seeding on a non-uniform seed bed, i.e. well dispersed dozer tracks through unburnt forest.

Figure 3.1 is a plot of seedling number/% milacre stocking for various h factors.

So it can be seen that a percentage milacre stocking is a more reliable estimate of the effective stocking of an area than a statement of the total number of seedlings per acre.

American studies have recommended minimum stocking figures for seedlings of 30 - 40% by milacres. In Tasmania where a lot of work has been done on this subject, 30% stocking by milacres has been taken as the minimum acceptable figure on suitable and almost uniform seed beds. Such conditions are available after hot fires. The next question is to what area should this be applied? For example, a hundred acre unit could average 30% but be made up of fifty acres with 60% and fifty acres with none. To overcome this problem Mount developed a system of mapping rules (see Appendix II) which, when applied to milacre survey results, allow the mapping out of areas adequately stocked and the of understocked areas requiring further treatment, such as spot sowing or tube planting. These rules have been in practice with the Tasmanian Forestry Commission for nearly ten years now. Mount found that when the rules are applied, the % milacre stocking for the stocked and understocked areas are greater than forty percent and less than ten percent respectively. The rules tend to underestimate the area stocked, but they are designed for one year old seedlings when further mortality can be expected and this is considered reasonable.

For older regeneration Mount has developed a strip counting system for mapping regenerated areas. The standards for this method are given in Appendix II. In spite of the fact that these two systems of mapping are very different in principle, it has been demonstrated that there is a reasonable degree of conformity between the two systems in attaining estimates of the area stocked at Surrey Hills. ($r = 0.84$, $tr = 7.64$, P .001).

Although 30% milacre stocking can be taken as an acceptable figure for a unit area, it is emphasised that the seed bed must be relatively uniformly distributed throughout to allow 90% of an area to be mapped as fully stocked. I found that at Surrey Hills 30% milacre stocking usually corresponded to 50% stocking and not 90% because of the non-uniformity of the seed-bed distribution

3 B. Assessment Methods and Techniques Applied

The method of assessment of the regeneration is that developed by the Forestry Commission for assessing the success of regeneration techniques in the A.N.M. concession. It has proved to be a reliable technique, indicative of the actual situation. It consists of measuring milacre plots spaced at chain intervals along stips located in a coupe. From a series of parallel strips at 4 chain intervals a pattern of stocked and unstocked plots will emerge, delineating areas of well stocked and poorly stocked regeneration.

The original system was designed for regeneration less than four years of age. In the present survey it has been used without modification in regeneration up to twenty years of age. However, an independent parallel assessment was conducted throughout by the strip method used for older regrowth by the Forestry Commission. The milacre grid system and the continuous strip method gave excellent correlation. ($r = 0.84$, $tr = 7.64$, $P < .001$). For primary data see Column 7 and 8 appendix I and Figure 4.5. Greater reliance can be placed on the assessment by milacre grids since these carry no bias by the assessor.

The above Forestry Commission systems were used to determine eucalypt stocking, but for these research surveys much additional information was obtained as follows:-

1. <u>For the unit as a whole</u>
   Logging, fire and treatment history were recorded. Wherever possible, this included dates of logging, method and volume obtained. Because of the lack of records for many areas this information has been estimated where necessary from the age of the oldest regeneration by ring counts.

2. <u>Along the strips</u> records were made of:-
   a) Seed trees, estimated diameter and species within a half chain of strip line,
   b) Eucalypt stumps - To give an estimate of logging intensity,
   c) Eucalypt regrowth by stem counts in frequency classes. This information is used in the tabulation of column 7 of Appendix I.

3. <u>At each 1 chain interval</u> records were made of:-
   a) Original understorey: Species, and density of eucalypt seedlings on a defined milacre plot,

b) proportion of seed-bed on the 4 milacre plot,

c) height, age and species of the two tallest eucalypts on each 4 milacre plot, or within twenty feet if the 4 milacre plot was unstocked,

d) type of seed-bed on which seedlings occur (disturbed, undisturbed and burnt).

e) aspect, soil type, drainage.

f) the state of the seed-bed, to anticipate if any further improvement to the stocking could possibly be expected. Improvement in stocking was not observed after the initial establishment period of twelve months for burnt seed beds and three years for mineral soil beds, unless further logging disturbance had occurred. In some areas this was quite common.

The field sheet used to collect this data is illustrated in figure 3.2.

Seedling ages were derived from ring counts. E. delegatensis exhibits a distinctive pattern of spring and autumn wood which enables accurate age determinations. In areas of seedlings of known age (e.g. Mt. Housetop fire area) this method has proved to be reliable. If the age of a seedling was indeterminate, then it was recorded as such and not included in the data except for tabulation of the mean seedling height.

A distinction between accurately measured or counted data and estimated data should be drawn. Estimated data includes height of understorey species, and percentage estimates of vegetation cover and soil disturbance. The number of visible stumps and seed trees on the defined strip line were counted. Heights, ages and numbers of eucalypts on 4 milacre defined plots were accurately measured.

The estimates of soil disturbance must be treated with caution. In the case of a fire or recent dozer disturbance the estimates are reliable. However, with older regeneration it is difficult, sometimes impossible, to state what percentage of soil disturbance had occurred, or even if it was disturbed at all. This comment is particularly true in the case of the grass understorey since the re-establishment period of grassland species (Poa, Diplarrhena) after disturbance is less than two years.

3 C. Location of samples

Difficulty was experienced locating sampling strips because of the unsystematic pattern of logging. A stratified random system of sampling was used. Areas to be sampled were chosen subjectively from photo interpretation types (P.I. types). These selected sample areas were inspected in the field. If logging had occurred a strip was located at random within the type and the sample measured. Very few areas were sampled in which logging practice had been relatively uniform. However, in the areas logged more recently, e.g. Mayday Road, the location of sample strips was made easier by more uniform logging.

Strips were located at random within subjectively chosen P.I. types. These strips were terminated when the logging boundary was reached, or a visible change in the forest type occurred. In Mixed Forest the P.I. type boundaries were sometimes inaccurate. An effort was made to find agreement with field assessment. In some areas strips were placed subjectively, irrespective of the P.I. type, upon Company suggestion.

A representative sample appears to have been achieved in all cases.

3 D. Sampling efficiency amongst types

Table 3.2 is a summary of the proposed and actual sampling for the regeneration survey.

Table 3.2 Summary of areas & types sampled

Forest Type and Locality	Proposed Sample	Actual Sample
1. Eucalypt over moderate to dense sclerophyll scrub at Kara		
a. Not burnt after logging	500	314
b. Burnt after logging	200	101
2. Eucalypt over rainforest Surrey Hills - Hampshire		
a. Understorey also logged	500	409
b. Understorey not logged	500 *	-
c. Logged and burnt by wild fire Loyetea - Loongana	-	51
d. Treated and burnt - Parrawe	200	70
e. Understorey not logged	-	100
3. Eucalypt over rainforest scrub		
a. Pepper scrub dozed	200	265
b. Pepper scrub not dozed	400 *	-
c. Pepper scrub logged and burnt	-	70
4. Eucalypt over grassland	400	333
* Deleted	2900 Cns.	1801

The types 3(b) and 2(b) were not found in sufficient size to sample. As a result, 1801 chains out of the proposed 2900 chains were surveyed. It was found that the homogeneity of data was sufficient for the sample to be reduced in the case of areas which had been burnt.

There are other surveys of regeneration treatment available from the Forestry Commission if more data is required for burnt plots. At Mt. Tor an area of 1300 acres was surveyed for regeneration giving an overall area stocking of 73%.

3 E. Data Analysis and presentation

Results of the survey are summarised in Appendix I. This table is replicated here for convenience.

The derivation of the values given in the results tabulated in Appendix I are discussed below.

Column 5 and 6 showing milacre and 4 milacre stockings are direct percentages of the total numbers of plots in each category on any strip. When the strips are in close proximity and in similar forest types these figures have been amalgamated.

The percentage area stocked (column 7 and 8) has been derived by two different methods. In column 7 the estimate of percentage of area stocked was derived from the stock mapping system designed by the Forestry Commission for use in areas of older regrowth (greater than four years of age). If 4 or more seedlings were found on the area of 1 chain x ¼ chain this section of the strip was classified as stocked. This represents a minimum stocking of an estimated 160 well spaced seedlings/acre. The figures estimated by this method are generally less than the total number of seedlings present because only the seedlings visible on the strip are counted. This underestimate of the actual numbers has been allowed for in the design of the system. The percentage of the areas classified as stocked and unstocked has been used to give the percentage of area stocked (stock-mapping) for each strip. In column 8 stocking is determined by the use of the mapping rules developed by Mount (1961) (see Appendix II). The strip has been divided into stocked and unstocked portions and a percentage stocking figure derived. Although this system was designed for use in coupes and has not been used on a strip basis prior to this survey, it should provide a valid sample of the area concerned. On a test area of 500 acres located at Bunkers Road (Fig. 4.7) it was found that the percentage of area stocked, as derived from the linear summation of stocked and unstocked portions of the strips the area determined by planimeter measurement was in fact identical (see Chapter 4).

The seedling counts along the strips have been used to give one estimate (column 9) of the total number of seedlings per acre. A second independent estimate of seedling number per acre is shown in column 10. This estimate is derived from the seedling counts made on each milacre plot, and it is a more reliable estimate than that obtained by counting along strips, because it is based on a full search of sample-areas. The estimate of seedling number by counting along strips gives an underestimate as it is dependent on counting all regeneration visible within $\frac{1}{4}$ of a chain.

The percentage composition by species (column 11) was obtained from counts on the milacre plots since the species of each seedling on each milacre was recorded.

The number of seed trees and stumps visible in a 1 chain x $\frac{1}{2}$ chain strip were counted. These figures have been converted to frequency per acre and are given in column 12 and 13 respectively.

The percentage of soil disturbance due to logging or burning on the 4 milacre plot was estimated (column 14). These figures were summed to give a total [illegible] for each strip. In most types where logging had occurred more than five years ago it was difficult to estimate the percentage of soil disturbance. In areas with a grass understorey little reliability can be placed on the soil disturbance figures, unless logging occurred less than 2 years prior to sampling.

CHAPTER 4

Results and Discussion

Introduction

The results from the survey work are given in Appendix I. To provide a systematic presentation for these data it has been necessary to amalgamate samples. Thus, an overall sample mean has been calculated for each stocking parameter, forest type and treatment. The mean values are an average of a range of samples located in areas of commercial forests of slightly varying site indices.

A series of two way tables are used to present this data. The explanation of the results found in any table is given in the associated text, along with the range of data and any supplementary information.

The individual tables have been combined to give an estimate of the relative productivity for each forest type and treatment; this combined table is discussed fully in Chapter 5.

4A. Stocking

A1 Seedling number

The survey data is presented in table 4.1. With increasing tre tment there is a proportionate increase in seedling numbers. A detailed block by block description of this table is given in Appendix 4.

A2 <u>% Area Stocked</u>

The survey data are presented in table 4.2. With increasing treatment there is proportionate increase in the % area stocked. A more detailed block by block description of this table is given in Appendix 4.

A3 <u>% Milacre Stocking</u>

The survey data are presented in table 4.3. With increasing treatment there is a proportionate increase in % milacre stocking.

A detailed block by block description of this table is given in Appendix 4.

A4. Correlation of Stocking Parameters

A series of average relationships has been derived between the various stocking parameters used during the regeneration survey. Unfortunately, the data from the various seed-bed types had to be amalgamated to obtain the relationships. A meaningful relationship could not be derived for each seed bed type (i.e. ash-bed, mineral soil and undisturbed) because of the lack of data. For instance, one does not find very high values such as 80% or 100% milacre stocking in logged, unburnt Eucalypt-Rainforest types. The range of data obtained for each treatment and type is small.

The various relationships derived will be of considerable use in future regeneration survey work since they enable interconversion of stocking parameters. The relationships are only applicable if the regeneration is derived from natural seed distribution. If artificial seedling techniques such as aerial seed broadcasting are used, then the relationships must be modified.

The following relationships have been established from the survey data. The curves in each case have been plotted by hand.

Figure 4.1 Percentage milacre stocking/seedling number per acre

The amount of aggregation in the distribution of eucalypt seedlings can be described mathematically by H, the heterogeneity factor (Mount 1961).

This curve approximates that obtained from a heterogeneity value of 5 (H = 5). A comparison of data taken from this curve with data obtained by other workers is provided in table 4.4. There is remarkable similarity in the curves drawn by different workers in different forest types, although *E. delegatensis* shows over-dispersion at higher stockings. Cunningham (1960) noted this pattern for *E. regnans.* The distribution of eucalypt seedlings would be expected to be more over-dispersed than for coniferous seedlings because of the shorter distance of seed dispersal of the eucalypts.

Table 4.4 Percentage milacre stocking and seedling per acre

A comparison of relationships derived by various workers (After Cunningham (1960) modified)

Percentage milacre stocking	Total number of Seedlings Per Acre				
	Conifer Forests			*E. regnans*	*E. delegatensi*
	Bever (1949)	Wellner (1940)	Parker Potter (1951)	Cunningham (1960)	(This Survey)
10%	175	140	160	140	180
20%	345	330	320	345	400
30%	525	600	500	680	720
40%	810	950	650	1150	1150
50%	1220	1500	850	1820	1700

Figure 4.2 Percentage milacre stocking/Percentage four milacre stocking

This relationship illustrates the aggregation effect in naturally distributed eucalypt seed. The relationship again approximates to that defined by a factor of H = 5.

Figure 4.3 Percentage milacre stocking/Percentage area stocked (Mapping Rules)

On burnt seed beds 30% milacre stocking is normally accepted as a minimum stocking value since this is equivalent to 80% area stocking. On Surrey Hills 30% milacre stocking could not be accepted as a minimum stocking value since this is found to be equivalent to a stocked area of only 52%. This relationship stems from the non-uniformity in the distribution of suitable seed-beds conferring gross over-dispersion to the distribution patterns of eucalypt seedlings. The relationship between % milacre stocking and % area stocked defined on mapping rules is useful since it enables rapid conversion between parameters. A similar relationship exists between % four milacre stocking and % area stocked (Figure 4.4).

Figure 4.4 Percentage four milacre stocking/Percentage area stocked (Mapping Rules)

Figure 4.5 Percentage area stocked (Stock Mapping)/ Percentage area stocked (Mapping Rules)

The two estimates given by the independent systems yield comparable estimates. The scatter of some of the sample points is due to the inability to estimate accurately all of the eucalypt seedlings in areas of difficult topography, logging slash and thick scrub. The estimate of area stocked by the strip count method (Stock Mapping) has tended to give a slight under-estimate in most cases.

A5 Site Factors Effecting Stocking

1. Soil Disturbance

Records of soil disturbance on logging sites do not exist; accurate estimates of original soil disturbance on most treatments have been difficult to determine, except in areas of very recent disturbance. Consequently, caution is required when comparisons are made between types and treatments, and for this reason I have not given a detailed analysis of these estimates. (Table 4.5)

The salient point is that slash-burning results in the equivilance of complete soil disturbance, more than for any dozing technique. Although areas of pepper-dozing appear to be completely cleared, the maximum estimate of soil disturbance over a 50 acre area is 80%; it is doubtful if this could really be improved without virtual farmland clearing at a large unit cost.

The various estimates of soil disturbance are given in table 4.6.

Eucalypt regeneration is mainly restricted to burnt areas or areas of disturbed mineral soil, irrespective of the vegetation type. Very few seedlings were located in areas of residual vegetation and logging slash. Figure 4.6 illustrates the typical situation. If eucalypt seedlings could readily become established in areas of logging slash or undisturbed vegetation, then one would expect a more uniform pattern of seedling distribution than is observed. In the 29 Mile Road - Bunkers Road area eucalypt regeneration on five hundred acres of cut-over Eucalypt-Rainforest has been surveyed. From a series of five parallel strips, a pattern of stocked and under stocked areas have been delineated; this is illustrated in figure 4.7. A map of the areas of soil disturbance has also been plotted. The correlation between the two maps is good illustrating the dependence of eucalypt stocking on site disturbance.

Mount completed some contiguous milacre transects for seed-bed suitability at Gin Creek Road in April, 1961. His results are shown in the table 4.7.

Table 4.7 Results of Regeneration Surveys by Mount at Surrey Hills, 1961 (After Mount).

	Transect A	Transect B
Area	Gin Creek Road	Gin Creek Road
No. of milacres inspected	100	80
Year of logging	1958	1954-55
Seedbed		
% Disturbed	31%	55%
%Slash	52%	30%
% Undisturbed	17%	15%
% Milacre Stocking	47%	67.5%
No. of Seedlings on each Seedbed Type		
Disturbed Soil	502	304
Slash	Nil	Nil
Undisturbed Soil	24	4

Correlation between soil disturbance,forest type and treatment is also illustrated in figure 4.8.

2. Soil Type

There was no apparent difference in stocking rates on different soil types. These data are given in table 4.8.

Table 4.8 Stocking on Various Soil Types

Soil Types	Podzolic Soil (Granite)	Kraznozem (Basalt)	Yellow Podzolic Soil (Ordovician)	
No. of plots stocked	250 (24%)	684 (66%)	108 (10%)	1042
No. of stock-ed plots	190 (26%)	494 (68%)	47 (6%)	731
Totals	440 (25%)	1178 (66%)	155 (9%)	1773

% figures are % of the total number of plots in each category.

3. <u>Drainage</u>

Stocking was observed to be lower on sites with fair and poor drainage than for sites with good drainage. The data are given in Table 4.9. Also, it was noted that the species of eucalypt present on poorly drained sites were, in general, different to those on good sites. *E. simmondsii* and *E. rodwayi* occurred frequently on poorly drained sites.

Table 4.9 Stocking Rates on Sites of Different Drainage Potential

	Good Drainage	Fair Drainage	Poor Drainage	
No. of stocked plots	1013 (95%)	46 (4%)	12 (1%)	1071
No. of unstocked plots	637 (86%)	65 (9%)	38 (5%)	740
Totals	1650 (91%)	111 (6%)	50 (3%)	1811

4. Effect of Aspect on Stocking

There was no apparent difference between stocking rates on various aspects. The data are given in table 4.10. It is interesting to note the relative even distribution on plots with the various aspects sampled.

Table 4.10 Stocking Rates on Various Aspects

Aspect	Nil	North	East	South	West	
No. of stocked plots	507 (55%)	133 (14%)	83 (9%)	127 (14%)	76 (8%)	926
No. of unstocked plots	373 (54%)	127 (18%)	68 (10%)	76 (11%)	53 (7%)	689
Totals	880 (55%)	260 (16%).	151 (9%)	203 (12%)	129 (8%)	1615

% figures are % of the total number of plots in each category.

5. Competition

The species present on the plot were grouped into five common associations. The species of groups are the following:-

(i) Rain forest Species

Nothofagus, *Atherosperma*, *Eucryphia*, *Anodopetalum*, *Drimys*, *Dicksonia*, *Phyllocladus*.

(ii) Wet Ferns

Hypolepis and *Histiopteris*.

(iii) Scrub Species $>$ 7 ft.

Telopea, *Leptospermum*, *Phebalium*, *Acacia*, *Drimys*.

(iv) Scrub Species ≤ 7 ft.

Pultenaea, Cyathodes, Monotoca, Oxylobium, Phebalium, Pteridium, Pomaderris, Zieria.

(v) Grassland Species

Poa, Diplarrhena, Dianella, Lepidosperma.

These associations do not necessarily reflect the forest type under review, but the species colonizing the forest floor. For instance, groups (i), (ii) and (iii) may be found in the Eucalypt-rainforest type, whilst group (iv) is characteristic of the sclerophyll forest and group (v) of the more open woodland forest.

The data of species composition is given in table 4.11.

Table 4.11 Comparison of Stocking Rates with Different Vegetation Types

Competing Vegetation	(i) Rainforest Species	(ii) Wet Ferns	(iii) Scrub Species (7')	(iv) Scrub Species (7')	(v) Grass	
No. of stocked plots	76 (7%)	168 (16%)	119 (12%)	510 (50%)	160 (15%)	1033
No. of unstocked plots	118 (17%)	226 (32%)	96 (13%)	129 (18%)	138 (20%)	707
Totals	194 (11%)	394 (23%)	215 (12%)	639 (37%)	298 (17%)	1740

% figures are % of the total number of plots in each category.

There is less eucalypt stocking associated with groups (i), (iii) and (v) than in group (iv). This implies that eucalypt stocking was higher in areas where species of groups (i), (iii) and (v) were present. The species of group (iv) are generally found on areas recently logged with good soil disturbance, or areas where wild-fire had recently occurred. These species are, along with the eucalypts, the usual colonizing species of burnt or disturbed soil of this area. The species of groups (i) and (ii) are usually found in cut-over untreated Eucalypt-Rainforest or pure Rainforest. The species of group (iv), in particular Zieria and Phebalium, are found in cut-over treated Eucalypt-Rainforest.

Measurement of plots in two adjacent areas of differing treatments in the 29 Mile Road, has shown that there is a significant difference between the height growth of regeneration in the 2 samples (table 4.12). Logging operations in one area had removed both understorey and eucalypt logs. Logging in the other area had only removed the logs from the understorey leaving a residual canopy of mature eucalypts. Presumably there is sufficient light intensity for regeneration in this area as it has been shown by Ashton (1956) and Cunningham (1960), that lack of light can prevent the establishment of eucalypts.

Table 4.12 Effect of residual Eucalypt canopy on Regeneration

Area	Treatment	Residual Basal Area (Eucalypt)	Mean seedling Height	Standard Error
A	Understorey logged Winter 1966	100 ft.^{2}	54 in.	± 34 in.
B	Eucalypts & understorey logged Winter 1966	Nil	151 in.	± 58 in.

Data from twenty five four milacre plots located at random in two adjacent thirty acre areas (A and B) in the 29 Mile Road. Mean heights are of the two tallest seedlings on the four milacre plot. (i.e. the tallest 500 seedlings per acre.)

6. Effect of Browsing

The effect of browsing, mainly by the wallaby, (Thylogale billardieri) has reduced seeding numbers significantly, especially in the areas of already marginal stocking at Surrey Hills. Other species such as Bennetts Wallaby (Wallabia rufrogrisea var. bennetti) and the brush possum (Trichosurus vulpecula) are also present in the locality. There are areas at Mayday Road where pepper-dozing as a regeneration technique has failed, (Figure 6.5), probably due to the effect of browsing by native game. Gilbert (1958) has shown for

E. regnans that browsing, mainly by the wallaby, only occurred to seedlings after they had become a certain size. The browsing of seedlings germinating in Spring commenced in Autumn, or when the seedlings had reached about three leaf pairs. Between the heights of 6 inches and 3 feet seedlings appear to be very susceptible to browsing at Surrey Hills.

There is a large proportion of multi-stemmed seedlings in areas subjected to heavy browsing (Mayday Road, Cattley Road, Racecourse Road). For example, a sample of 3 year old regrowth in the Mt. Cattley fire area consisted of 96% multi-stems. Apical dominance would appear to have become established in 8 to 10 year old regrowth. The lack of competition between seedlings on the typical pepper-dozed unburnt site, because of smaller seedling numbers, is a possible explanation for this phenomenon. It will be of considerable interest to follow the incidence of multi-stemmed seedlings on the Mt. Cattley fire area over the next few years to see if apical dominance will be re-established. I have not observed such a high incidence of multi-stemmed seedlings in other areas of *E. delegatensis* regrowth in Tasmania (Florentine Valley, Mersey Valley, Camden) as occurs in the southern section of Surrey Hills.

4B. Growth

The height/age data, collected by the measurement of the two tallest seedlings at each 4 milacre plot, has been grouped into a number of samples. For each sample, relationships between seedling age and height have been calculated by linear regression; the regression equations are given in Table 4.13. A significant regression equation could not be obtained for sample number 7. Data of mean seedling heights are presented in Table 4.14; this includes data from the regression equations, mean heights from samples that were even-aged and the mean heights of seedlings of various ages in the case of sample number 7. The location of the areas of the various sample numbers is shown in Figure 4.9.

To ascertain growth rate of the dominant seedlings in each area the following procedure was adopted. Ten dominant seedlings were selected at random in each sample area (i.e. the tallest seedling on an area of one twelfth of an acre). The data has been derived from stem analyses of these ten seedlings, it has been plotted and is given together with the plots of the regression equations in Appendix 3.

The seedling heights at age 4 years have been used for comparative purposes between samples in Tables 4.15, 5.1 and 5.2 since this age group provides the maximum number of samples and does not exclude any major treatment.

B1 Height growth of Seedlings

Height is the most commonly used term for expressing site potential or productivity of a forest crop. The estimates given in Table 4.14 have been taken from the regressions of height on age derived from the sample data. The height values in Table 4.15 represent the average growth rates of the tallest 500 seedlings per acre of the present regeneration crop. The height growth of dominant seedlings, or the tallest seedlings selected at a rate of 12 per acre, is also given in Table 4.15. The general trend of the data in this table is quite apparent. A detailed breakdown of this table is given in Appendix 4.

B2 Site factors effecting growth and quality

(1) Site index, soil type, and disturbance

The growth rate of the regeneration crop varies from site to site and in general is proportionate to site index. At Surrey Hills, the height of the mature forest is fairly uniform (E2 and E3 forest, 130 - 150 feet). There are, however, local areas of forest with site indices higher and lower than for the average site. In one such local area, Bunkers Road, the heights of mature trees range from 180 to 200 feet.

The heights of dominant seedlings on the average Surrey Hills Mixed Forest site and the Bunkers Road site are 153 and 167 inches respectively. The disparity in seedling growth due to difference in site index is even more pronounced if the average heights of 4 year old seedlings are compared; these are 69 and 116 inches respectively, but this difference is complicated by the effect of additional soil disturbance in the case of the Bunkers Road area. In the Mt. Housetop fire area at Kara, an area of more uniform treatment, the mean seedling heights at 4 years in the northern and southern areas were 106 and 206 inches respectively. The difference in seedling height being due to differences in the respective site indices. At Kara on unburnt logged forest, the mean seedling height at age 4 on the lower quality sites (E3 forest) was 46 inches compared to 64 inches on areas of higher site quality (E2 forest).

Soil type is an inherent factor contributing to the site index of any site. No significant difference could be established between mean seedling height on different soil types of the same site index. No chemical analysis of soils were done. Kraznozemic soils are generally more fertile than podzolic soils. Areas of podzolic soils on granite at Kara, yellow podzolic soils at Parrawe and Loyetea and kraznozemic soils on basalt at Surrey Hills, have areas of high quality forest (E1). The small areas of forest located on precambriam rock (moor podzol peats) are of low site index (E3 - E4 forest), usually consisting of pure E. simmondsii.

(2) Browsing, insect predation and dieback

(1) Browsing

In addition to reducing stocking in marginally stocked areas, browsing has caused a check of up to a years height increment to regeneration on Surrey Hills. The southern areas, such as Mayday Road and Racecourse Road, have been severely browsed by native game. The susceptible height of regrowth to browsing is between 6 inches and 3 feet. The estimate of seedling height at age 4 for areas of dozed Eucalypt - Rainforest Scrub is only 38 inches, whilst in Mixed Forest of comparable site quality, the seedling height at age 4 is 116 inches.

The differences between these estimates I would attribute to browsing pressure rather than any intrinsic site quality difference. Game are attracted by the more abundant food in pepper-dozed or burnt areas. Browsing on large areas of regeneration ($\geq$ 300 acres) is not as intensive as on smaller discontinuous areas.

(ii) Insect predation

Partial defoliation of seedlings by leaf eating insects was quite noticeable in all areas at Surrey Hills. The main species responsible for this defoliation were members of the family Chrysomelidae, including *Chrysopharta bimaculata* and *Paropsis sp.* as well as several other unidentified species. The larvae of these species were responsibile for most of the defoliation, but the adults also contributed. Larvae of *Perga sp.* and *Roeselia sp.* were also noticed in areas of regeneration, but with a lower frequency than the chrysomelid larvae.

Species of *Glycaspis sp.* (Psyllidae) were common, especially on the stagnant regeneration in the grass understories. Associated with this species is a symbiotic fungus which gives the appearance of soot covered leaves, however, it is thought that little real damage is caused by this species. *Gallicus tasmanica* caused death of newly developed tips, again this was quite prevalent in the areas of slower growing regeneration.

My impression was that the incidence of insect damage and infestation, in general, was inversely proportional to the vigor of the regeneration. The incidence of damage due to Chrysopharta bimaculata was quite severe in local areas of regeneration, but this species attacked equally both areas of vigorous and less vigorous regeneration.

Greaves (1966) has shown for E. regnans seedlings up to 25 feet high that a 50% loss in height increment can be caused by infestation of C. bimaculata in years of high insect numbers.

(iii) E. delegatensis Dieback

The presence of E. delegatensis Dieback at Surrey Hills was reported by Needham (1960) and Ellis (1964). Ellis has investigated this phenomenon in mixed forest areas in North East Tasmania and has suggested that it is primarily due to competition between E. delegatensis and rainforest species, principally Nothofagus cunninghamii

Ellis related the incidence of Dieback to the age of the understorey and found that complete death of E. delegatensis was associated with an understorey aged 100 years at the 3,000 ft level.

At Surrey Hills, I have found that complete death of E. delegatensis is associated with understoreys aged between 75 and 110 years. Dieback is present in all Mixed Forest areas and is found to a lesser extent in the Eucalypt-Rainforest Scrub areas.

Not only does it result in the death of E. delegatensis, but diameter increment and hence volume increment of the effected trees is markedly reduced.

In logged mixed forest areas there are large numbers of residual understorey species. These residuals will permit a general understorey of rainforest scrub and tree species to form under the regenerating stand of eucalypts. Since Die back is wide spread and produces such a serious loss in yield, the wisdom of leaving residual rainforest scrub and tree species must be seriously questioned. The correlation between the onsetof visible Dieback deaths and rainforest understorey species seems to be well founded (Ellis 1964). The small amount of evidence collected at Surrey Hills by the author supports this conclusion. In addition, the measurements of yield plots by the Forest Research Institute (FRI Report 1970) in Southern Tasmania shows clearly that increment losses appear up to eight years before any visible signs of Dieback are apparent in the crowns. In the light of this evidence the danger of leaving rainforest species to quickly re-establish the understorey should be recognised. It is almost certain that the residuals cause uneven stocking due to shading; they must also compete directly and thus reduce increment in eucalypt regeneration. More importantly, however, they may cause the early onset of Dieback with serious loss of increment, or even the complete failure of the crop before merchantable maturity.

The present evidence in terms of poor growth rate of seedlings indicates that eucalypt regeneration in these forest types is being effected by the residual understorey, although no mortality has yet been recorded. For example, mean seedling heights at 4 years in logged Mixed Forest were 69 inches compared to 133 inches on burnt sites. Also the ratio of average height to dominant height of 4 year old seedlings is 45% and 65% on unburnt and burnt Mixed Forest sites respectively. The maximum growth rate of dominant seedlings is less on unburnt than for burnt sites, although the mature height of the eucalypts and previous site potential are the same. This observation is masked by the ash-bed effect, but the main influence is probably due to competition between seedling regeneration and the residual understorey. There is ample scope for research into all factors concerning E. delegatensis Dieback. The seedling regeneration does not appear to have suffered any Dieback, but the poor growth rate of this regeneration on former Dieback sites would suggest that incipient Dieback is already affecting the seedling crop. In view of the potential economic consequences due to Dieback this aspect requires urgent consideration. Examples of Dieback are given in Figures 5.1 and 5.2.

(3) The Ash-bed effect

The ash-bed effect, or the vigorous growth of seedlings growing on areas that were burnt in an intense fire, has been well reviewed by various authors including Pryor(1960), Attiwell (1962), Cromer (1967) and Renbuss(1967). The evidence suggests that the ash-bed effect is mainly due to two causes. Firstly, the effect of partial soil sterilization in the surface layers of the soil and secondly, an increase in the availability of nutrients to seedlings.

Mount (1969) has suggested that fire also results in the removal of chemical inhibitors from the site. Florence and Crocker (1962), Attiwell (1962) and Ashton (1962) have demonstrated the presence of litter leachates which are capable of inhibiting seedling growth. Recent research by the Botany Dept. of the A.N.U. has isolated this inhibitor.

In addition to the chemical and micro-biological aspects of the ash-bed effect one must consider the effect of competition removal by an intense fire. There is little available evidence concerning competition between mature trees, understorey and regrowth. Ashton (1956), who has studied the root systems of E. regnans, has suggested that competition between the eucalypt and shrub species is very intense, especially during the first 8 years after the establishment of regeneration.

The combined influence of the ash-bed effect and the removal of vegetation has been established in the field. Mean seedling heights at age 4 in areas of burnt and unburnt mixed forest are 116 and 69 inches respectively. Similarly in the Eucalypt - Sclerophyll Scrub type at Kara, the mean seedling heights at age 4 are 162 and 61 inches respectively for similar burnt and unburnt sites.

4C. Regeneration after Wildfire

Comparison of burnt and unburnt sites at Mt. Cattley;
Results and Discussion

At Mt. Cattley there is a large area that was accidently burnt in January, 1968. Surrounding this area are extensive areas that have been treated by pepper-dozing techniques (Needham 1960). A direct comparison between burnt and unburnt sites has not been possible because of slightly varying seedling ages, however, comparison between these areas in the future will give a good guide to the effectiveness, or otherwise, of pepper-dozing as compared with slash-burning techniques.

The location of plots A, B and C is shown in Figure 4.10. Results of the survey are given in Table 4.16. The area logged during winter 1967 is bounded by Mayday Road to the west, Cattley Creek to the North, approximately the eastern fire edge to the East and Cattley Road to the South. The area logged during Winter 1968 is that area South of Cattley Creek, East of the eastern fire boundary, South of Cattley Road, and West of a tributary of Cattley Creek.

The original forest consisted of mainly *E. delegatensis*, a few scattered *E. gunnii* and an understorey up to thirty feet high consisting of mainly *Drimys*, *Phyllocladus*, *Nothofagus*, *Telopea*, *Lomatia*, *Pultenaea* and grasses, herbs, mosses and ferns. Estimates from several ring counts of the understorey varied from sixty to seventy years.

The area has been severely browsed by native game. The high incidence of multi-stemmed seedlings being attributed to browsing damage. The height growth of the regrowth has been checked severely by browsing, but now the seedlings are above the susceptible height (3 feet). Consequently, the mean seedling heights of the various plots cannot be really compared for the present.

The estimated dates of seedling germination have been deduced from a knowledge of germination characteristics of *E. delegatensis* Grose (1957&1963), the logging history as given by A.F.H. staff and visual inspection. Ring counts of these seedlings were not very good because of the high incidence of browsing. The histograms of seedling heights show that there are at least two ages of seedlings in plot A and C and predominately one age group in plot B (Figure 4.11).

It would appear that most seedling germinations occur during the second Spring in pepper-dozed areas. A survey conducted in June, 1971, at Cattley Road in areas that have been pepper-dozed and logged in the Winter of 1970, showed that only 5 out of 113 milacre plots were stocked with seedlings. This implies that germination of ground stored seed is slight, the bulk of germinations arising from seed which falls during the Summer after logging operations have been completed. Thus, one would recommend that pepper-dozing operations should be carried out before early Summer in areas that are to be logged the following Winter, if regeneration burning techniques are not adopted in the future.

In the three plots measured stocking is adequate, however, in plot B, the burnt area, seed distribution has been better because of greater initial seed-bed availability.

The floristics of the burnt and unburnt sites are slightly different. The unburnt areas contain remnants of the understorey species as Telopea, Drimys, Nothofagus and Phyllocladus. Both burnt and unburnt areas have seedlings of Pultenaea and Drimys present in large quantities and the burnt seed-bed is mainly covered with mosses (Funaria and Ceratodon), grasses and herbs and shrub species such as Lomatia, and Coprosma. The fireweed Senecio is common to both burnt and unburnt sites. Zieria and Phebalium occur infrequently at Mt. Cattley. Marchantia is only found in quantity in shady locations such as burnt Rainforest and under heavy logging slash. On areas previously pepper-dozed (5 years ago) the ground vegetation on original disturbed seed-bed is still a mixture of grasses, herbs, Pultenaea, Lomatia and Coprosma, all heavily browsed. The old snig tracks are still fairly bare and the areas of former logging slash are covered with species such as Telopea, Drimys, Coprosma, Hypolepis and Histiopteris, being completely unavailable for any further eucalypt germinations.

The effect of canopy removal on the growth rate of regeneration would be quite interesting to measure. It is doubtful if any more stocking would occur in areas more than 3 years after logging. At Bunkers Road, sampling of regeneration has given a measure of the deleterious effect of canopy on growth of regeneration (Table 4.12). Admittedly, there is useful increment [illegible] on the smaller residual trees in these logged areas, but their retention will result in undue competition for the regeneration. Logging of regrowth 4 to 10 feet high will not cause as much damage to the regrowth as logging when the regrowth is much larger. If logging of this area is not justified on economic grounds then the poisoning of the residual stand could be considered.

The rate of re-establishment of pepper-dozed areas by scrub species may be gauged from the photographs taken of the same site at an interval of 18 months; these photographs are Figures 4.12 and 4.13. The location of this site is at Mayday Rd.

CHAPTER 5

General Discussion

To establish high yields of eucalypts on Surrey Hills requires some technique which will lower the natural advantage of rainforest species under the present climate. Since Rainforest is clearly the climax dominant on practically all sites it is necessary to create disclimax conditions, or at least delay the competitive effect of Rainforest till the crop is sufficiently matured.

At present there is an attempt to establish eucalypt regeneration on -

a) areas which were previously Mixed Forest carrying low numbers and poorly distributed eucalypts, and

b) areas on which much of the Rainforest has been left as a remnant after logging.

The situation under (a) means that the percentage of area carrying adequate stocking is limited while the situation under (b) means that the milacre stocking rate is excessively variable and growth and future performance of the eucalypts are jeopardized, especially if the effects of Dieback disease are included.

Due to the large range of disclimax forest types on Surrey Hills, and the wide range of treatment in the form of logging and disturbance, it is difficult to ascribe the efficiency, or lack of it, to any one particular cause.

The quality of regeneration is subject to three basic criteria or components, namely area stocked, stocking rate and a growth factor. Inefficiency in any one or more of these components causes inefficiency for the ultimate aim of productivity. Since sites differ and treatments have been so variable, inefficiencies occur in all three components at different and varying levels. Hence it is difficult to summarise the situation quickly. As an aid to evaluating the total efficiency of the regeneration a single index of productivity has been introduced. This index can be broken into its three components, if necessary, to diagnose the principle causes of inefficiency.

The productivity has been estimated by calculating a productivity index from the product of area stocked, stocking rate for those areas and mean height at age 4 years. Such an index affords a direct means of comparing productivity in various sites, or between various types, and can be used to show the effect of various types of management practice. Since the index can be analysed into three components it is possible to relate low productivity to one or more component.

The two main functions contributing to total productivity, stocking and growth have been assessed by the sampling system.

Stocking can be accurately determined but is complicated by extreme over-dispersion in seedling distribution. Quite apart from this over-dispersion, large areas in the various types of forest are unstocked or virtually so. Hence stocking requires two separate measures, % area stocked and % milacre stocking. The growth rate of seedlings cannot be accurately determined, since there are no long standing records, or site indices available. The survey data provide heights and ages of a large number of seedlings (about 500 per acre sampled). However, on most sites there are only one or two ages present and these are usually less than 5 years. By grouping the data within forest types, height on age regressions can be calculated for the age-range 2 - 8 years with reasonable accuracy. These regressions are of course averages for many different site qualities and must be interpreted with some care.

The results of applying the index calculation are shown in Table 5.1. This table shows the three components of the index and the compounded index for treatments and forest types. The table indicates clearly the effect of various treatments. Where forest has been logged without any additional treatment the index is low. This low value is due to low values in all three components of the index. Where additional soil disturbance has occurred stocking measures are higher, although still not comparable with those values obtained from slash-burning treatments.

The growth component shows great variability. It accounts for the inefficiency in Eucalypt-Grassland and Eucalypt-Rainforest Scrub types. Growth on Eucalypt-Rainforest sites with disturbance by additional dozing is comparable with burnt sites. However, this sample was exceptional in site quality and it is unlikely that similar growth values would be attained on average sites. In general, the only consistently successful treatment involves burning. All burning treatments give high values for each component. The areas of Eucalypt-Grassland are exceptional. These are dealt with in greater detail in section 2 of this thesis. A block by block discussion of Table 5.1 is given in Appendix 5. As a further guide to the efficiency of management practice as it effects regeneration, the ratio of actual to potential productivity can be calculated. This value makes allowance for differences in site index and allows a closer examination of the effect of treatment relative to full stocking. Potential productivity for any site is calculated on the assumption of 100% area stocked, 90% milacre stocking and a height at age 4 years derived from the mean of the 12 tallest trees per acre. Table 5.2 shows the actual productivity as a percentage of potential productivity calculated in this way.

Expressed in this form the efficiency of slash-burning techniques is obvious. Much of the regeneration on Surrey Hills is at present realising only 1/5 to 1/2 of the efficiency of slash-burning treatments.

The estimates of relative productivity make no allowance for potential loss of production due to the Die-back disease. Ellis (1964) has correlated this disease with the age of the rainforest understorey. The present manage-ment practices allow rapid re-establishment of the rainforest understorey. Eucalypt seedlings are forced to compete with this understorey from the onset. Slash-burning techniques give eucalypt seedling regeneration a good initial start by temporarily eliminating rainforest species from the regrowth forest.

The older crop of eucalypt seedlings on former Die-back sites at Surrey Hills contain a large percentage of rainforest species; they are growing slowly and, in the future, offer little prospect of producing useful products because of the threat of Dieback combined with low stocking. In fact, it is quite likely that the eucalypt crop is at the present suffering from incipient Dieback on such sites.

The present technique of pepper-dozing results in an increase in stocking, but it allows the rainforest scrub to re-establish quite quickly which immediately re-imposes the threat of Dieback occurring at some stage during the rotation. The present stands of eucalypt being logged for example in the Mayday Road area, are mainly even-aged (about 150 years) with a rainforest scrub understorey age varying from 50 to 80 years. Previously, there has been a difference in age between the eucalypts and the rainforest understorey species because the Rainforest has become established slowly under the young pole stands of eucalypt. With the use of non-burning regeneration techniques, the rainforest understorey becomes established more or less simultaneously with the regenerating eucalypt crop. The end result of this situation in terms of Dieback is unknown, but it is not very promising. One could suggest that the eucalypt crop would die at 70 years with very reduced increment prior to this death.

Since some loss within the shortest crop rotation seems inevitable, it would seem important that every effort be made to use regeneration techniques which will lessen the economic loss due to this disease. It is also clear that some research of a substantial nature should be instituted as a matter of urgency. (Figures 5.1,5.2)

An alternative to E. delegatensis, perhaps, is to utilize the rainforest species for production forestry in the future. However, in terms of the gross production of wood the eucalypts are far superior to species of the rainforest understorey. On good sites in the Florentine Valley regnans, obliqua and probably delegatensis produce 2,000 super feet (Hoppus), or 6 tons per acre per year for the first 80 years, whereas the combined production of Nothofagus cunninghamii and Atherosperma moschatum would not often exceed one quarter of this amount (Gilbert 1958). With present methods of paper making eucalypt is superior to the rainforest species as a raw material for pulp (Turner per. com. 1971). Therefore, the objective of any regeneration technique should be to produce good quality eucalypt wood to the full capacity of the site.

CHAPTER 6

Conclusion and Recommendations

7A. Conclusion

The regeneration surveys have covered a variety of forest types and treatments, and give a very good estimate of the actual situation. The following conclusions have been drawn:-

1. Stocking estimates by two independant sampling methods using several parameters show, without exception, stocking is minimal and generally inadequate in untreated forest. The lowest estimates were sampled in areas of logged Mixed Forest; the highest estimates were sampled in areas of Eucalyptus-Grassland.

2. Estimates of stocking in areas where additional soil disturbance had been effected were higher than estimates from areas that had been logged by normal operations.

3. Estimates of stocking in areas of wild-fire, or areas that had been treated by slash-burning were the highest and most satisfactory results of all treatments.

4. The growth rate and general vigor of seedling regeneration in burnt areas was superior to that in unburnt areas.

5. Estimates of productivity derived from a combination of growth and stocking factors give a quantitative estimate

of the relative efficiency of present management practice.

7B Recommendations

The general recommendation is that slash burning techniques be adopted in most forest types. These techniques have been widely practiced for the regeneration of ash-type eucalypt forests (regnans, obliqua, delegatensis and sieberi) by the Forests Commission of Victoria, A.N.M. and the Tasmanian Forestry Commission since the late 1950's.

It is suggested that a series of large burning trials be established at Surrey Hills. This would provide conclusive evidence within a short period as to the merits of slash-burning techniques on Surrey Hills. Other evidence as to the effectiveness of burning techniques can be gauged from the two areas of wild fire already on Surrey Hills. (Mt. Cattley, Leven Road.)

The techniques of slash-burning have been improved significantly during the last 15 years and the latest techniques should be used. The risks involving the use of fire as a regeneration technique are real, but there is no effective alternative.

The results of slash-burning techniques, in terms of eucalypt seedling stocking and growth rate, depend on the intensity of fire. If burning is done under too mild conditions the end result is not very good, but the risk of escape slight. On the other hand, if the fire is more severe the endresult is excellent, but the risk of escape much higher. The climate and topography are more favourable for slash-burning at Surrey Hills than in the Florentine Valley where such techniques have been used for fifteen years. The use of slash-burning techniques will reduce the potential fire hazard of these logged forests. For instance, at Mt. Cattley many acres of regeneration were lost as a result of wild fire.

Seeding with eucalypt seed will be required in those areas of Mixed Forest where seed trees are sparse, or where areas of pure Rainforest are involved. The use of species such as *E. regnans* could be contemplated in the more northern areas at Surrey Hills at least on a large experimental basis. Figure 6.4 relates the natural distribution of *E. regnans* to altitude and latitude.

Examples of slash-burning techniques are illustrated in figures 6.1 and 6.3, whilst examples of pepper-dozing are illustrated in figures 6.2 and 6.5.