NOTES ON THE SILVICULTURE OF MAJOR N.S.W. FOREST TYPES

6. SPOTTED GUM TYPES

Contents **Page**

APPENDICES:

Forestry Commission of N.S.W.
SYDNEY

15th January, 1985

NOTES ON THE SILVICULTURE OF MAJOR N.S.W. FOREST TYPES

6. SPOTTED GUM TYPES

1. INTRODUCTION

Communities dominated by Spotted Gum[1] are among the most important forest types in new South Wales, with the dominant species itself providing about 7 per cent of the Crown hardwood sawlog cut in recent years, and ranking between fourth and sixth in term of volume of sawlogs produced. The communities also are one of the major sources of hardwood in Queensland, where they have an even mare extensive natural distribution than in N.S.W.

Besides their commercial significance, the Spotted Gum types contain some of the most beautiful forest stands in N.S.W., epitomised by the particularly scenic stretches of the Princes Highway south of Nowra; and the successful marriage of urban living with retained native trees In Sydney's northern beachside suburbs.

Spotted Gum types have some other interesting features. They range from woodland stands to tall wet sclerophyll forest, sometimes being invaded by rainforest; their management similarly varies from areas with an emphasis on the production of sawlogs to those maintained for mining and other small-timber production. Over large areas they are among the easiest of all eucalypt forests to manage; yet in some localities there are problems in ensuring adequate regeneration. They are the only major forest stands in Australia being deliberately managed to produce a species from the Bloodwood group of eucalypts (the subgenus Corymbia of Pryor & Johnson, 1971). (Whilst the Western Australia Marri, another Bloodwood, is a major component of the Bunbury woodchip, export project, management there aims at promoting other species in the forests, and the project itself was developed to provide a market for Marri which was tending to dominate stands following the selective removal of the favoured other species).

The silviculture of the Spotted Gum types has been the subject of some research in both N.S.W. and Queensland, whilst the relative proximity of the pleasant South Coast stands to Canberra's bleak artificiality has assisted in some concentration of study in these types by both CSIRO groups and students from the Australian National University. For this, the compilers of these Notes are most grateful.

2. BOTANY AND FOREST ECOLOGY

2.1 Taxonomy

Although Spotted Gum types normally contain several associated species of eucalypts (see section 2.3) of the taxonomy of Gum itself in of some significance.

Two closely related species, Spotted Gum *(Eucalyptus maculata)* and Lemon-scented Gum *(E. citriodora)* have long been recognised. Lemon-scented Gum is confined to Queensland occurring naturally north from about the Maryborough area (lat. 26º), while Spotted Gum occurs southwards from about Gladstone (lat. 24º). The species are very similar in appearance, and are most readily distinguished by the oil content of the Lemon-scented Gum leaves, giving the foliage of this species its very distinctive aroma. (In China the leaves of this species are used for oil distillation; F.A.O., 1979). Lemon-scented Gum also has narrower leaves and generally smaller buds and fruits than Spotted Gum.

[1] For botanical names of species mentioned in text, see Appendix 1. The taxonomy of Spotted Gum itself is discussed further in Section 2.1.

Larsen (1965) examined the variability in these two species, using collections from a range of sites from lat. 24º 30’S (Mantuan Downs, Qld.) to lat. 37º 40’S (Mt. Tara, Vic.; the southernmost natural occurrence of the tree). He noted considerable hybridisation between the two species in the zone of overlap in Central Queensland.

Larsen's Spotted Gum sources showed clinal variation in a range of characteristics from north to south, with increases in capsule size, seed yield, leaf width, and leaf width: length ratio as latitude increased. However two sources, both from northern N.S.W., consistently deviated from this pattern. One, from Southgate S.F., north of Grafton (lat. 29º 33’S), possessed very broad leaves and large capsules; the other, from Richmond Range S.F. (lat. 28º 37'S) had small capsules and narrow leaves, and could be distinguished from specimens of Lemon-scented Gum only by the absence of the citronellal scent. Specimens from Southport, Qld. (lat. 27º 57’S) showed some similarity to the Southgate source, and those from Mt. Glorious, near Brisbane (lat. 27º 15’S), reflected a relationship with the Richmond Range population.

On the basis of this study Larsen suggested that three forms of Spotted Gum should be recognised:

- the typical species which shows a latitudinal gradient in various botanical features;
- a broadleaved form from southern Queensland and the Grafton district, occurring on particularly unfavourable, lowland sites.
- a narrowleaved, small-fruited form, also from southern Queensland and northern N.S.W, restricted to favourable, elevated sites.

He commented that Lemon-scented Gum probably showed no greater differences from typical Spotted Gum than did the other two forms. However he declined to describe these forms as new species, and instead informally identified the broadleaved form as “*var. blakei*”, after Dr. S.T. Blake who had studied this form and considered it should be regarded as a separate species, and the narrowleaved form as “*var. grayi*” after H.R. Gray, a long time lecturer at the Australian Forestry School: Gray had drawn attention to this form near Enoggera, Qld., in 1928.

S.T. Blake died in 1973, but four years later (Blake, 1977), a manuscript of his was posthumously published, describing the broadleaved form as a new species, *E. henryi,* named after Queensland forester Neil Henry, who had brought this form to his attention. Oddly, he made no reference to Larsen's work. All of Blakes’ cited localities for his new species are close to Brisbane, but he noted: *"I have seen from the train trees of what appears to be the same species southward from Brisbane almost to Grafton."* In fact it extends well south of Grafton, and appears to be the characteristic form of much of the Clarence-Moreton Basin. Comparing it with the typical form of Spotted Gum, Blake observed:

> *"These two species resemble one another in bark, but the much larger leaves of **E. henryi** give to the crown a heavier and denser appearance. Herbarium specimens are coarser in every way. The operculum is almost or quite as long as the calyx-tube and about as wide as it instead of decidedly shorter and broader as in **E. maculata** while the whole bud bears a narrow rib or angle from pedicel to the tip of the operculum. Young plants of the new species are very different from those of **E. maculata** and **E. citriodora**. Seedlings of the latter two are strongly setose[2] with leaves that are peltate[3] except for the first few, the peltate setose leaves being rather numerous and found also on coppice growth and reversion shoots on mature trees. On seedlings of **E. henryi** peltate leaves are rare, the scanty bristles soon disappear, and the relatively enormous stiff intermediate leaves are very characteristic of older seedlings and coppice shoots; growth is also very slow compared with the others. In the adult leaves, the angle of divergence of the lateral veins is slightly wider in **E. henryi."***

[2] setose: bristly
[3] peltate: Leaf attached to its stalk (petiole) on its lower surface, instead of on its margin.

Blake added that *E. maculata* and *E. citriodora* resembled each other much more closely than either resembled *E. henryi.*

Pryor & Johnson (1971) placed the Spotted Gums in the series Maculatae, section Ochraria (Yellow Bloodwoods), of the subgenus Corymbia. They provided for three species (one at the time left blank, to allow for the then impending publication of *E. henryi): E. citriodora* CCC:A, *E. maculata* CCC:B and *E. henryi* CCC:C. Together these formed the superspecies Maculata, which alone made up the series Maculata. Although aware of Larsen's work, Pryor & Johnson made no allowance for the Richmond Range form as a distinctive taxon.

This still seems to leave the taxonomic status of Spotted Gum in a rather unsatisfactory position. In the Brisbane area the broadleaved form *(E. henryi)* and the normal *E. maculata* can occur together but remain quite distinct; they flower at different times and intergrades between them are not known (D.I. Bevege, pers. comm.). However in parts of the far North Coast of N.S.W. all three of Larsen's forms can be found in relative proximity, and in its typical occurrences the narrowleaved Richmond Range form seems no less distinct than the broadleaved *E. henryi* (or "var. blakei"); both the local forms seem to intergrade with typical Spotted Gum, so that it is often difficult to suggest which form one is dealing with. Within their area of occurrence, the broadleaved form appears to occupy the "harder" sites, at relatively low altitude, and the narrowleaved form higher altitude sites with deep, fertile, basaltic soils. The typical form occurs on the intermediate sites. Clinal variation in respect to soil fertility and altitude may explain the change in characteristics better than the description of further species, varieties or subspecies.

In these Notes, reference to "Spotted Gum" can mean any of the N.S.W. forms, unless the context or specific mention imply otherwise.

Apart from the intergrading and hybridisation between forms, referred to above, Spotted Gum can hybridise with other species of the subgenus Corymbia, and this is referred to by F.A.0. (1979) in the discussion on *E. citriodora.* In Nature such hybridisation seems rather unusual, except on the South Coast, from the Nowra area as far south as Mogo S.F., where hybrids between Spotted Gum and Red Bloodwood are occasionally encountered and have in the past been known as *E. nowraensis.* In southern Queensland hybrids between Spotted Gum & Pink Bloodwood have been reported.

2.2 Provenance Variation

As indicated above, there is considerable natural variation within Spotted Gum, and it might be expected that this would be reflected in differences in growth and silvicultural behaviour when different provenances are grown together.

Andrew (1970) reported a trial in Zambia using seed from the identical sites sampled by Larsen, with an additional source from TR 73033 (now Curryall S.F.) in the Mudgee District, about 16 km southwest of Cassilis: this is the most inland occurrence of Spotted Gum in N.S.W. The trial was terminated after 3 years, but results to that time showed:

- The Victorian (Mt. Tara) source had poorest height growth (8.66m - significantly poorer than most other sources). Second poorest height (10.0m) was from TR 73033. Best heights were from Southgate S.F. (11.70m) and Murgon, Qld (11.21m).
- Differences in DBH were not significant, but sources with the largest mean DBH were Richmond Range (10.67cm) and Southgate S.F. and Bermagui (both 10.52cm); the smallest were TR 73033 (9.12cm) and Nowra and Mt. Tara (both 9.53cm).
- Largest mean volume was shown by the Southgate S.F. source (0.064 m^3), which was significantly larger than the sources from Mt. Tara and TR 73033 (both about 0.022 m^3).

The differences previously noted by Larsen with respect to leaf dimensions were essentially maintained in Zambia, and there were significant differences between sources relating to the number of stems that developed lignotubers, ranging from 38.6% for Monto, Qld. and 37.1% for Southgate S.F., to 0.8% for Mt. Tara and 0.7% for Bermagui.

Andrew also conducted a multivariate analysis of his data. The inferences drawn from this strongly supported Larsen's conclusions concerning the Richmond Range and Southgate S.F. sources, the latter *("var. blakei")* being the most distinct, with the largest trees and the largest, relatively round leaves. The Richmond Range source *("var. grayi")* was second in size and, excepting a single Lemon-scented Gum provenance, had the narrowest leaves. The Mt. Tara and, to a lesser extent, TR 73033 sources also showed characteristics distinct from other provenances.

A N.S.W. provenance trial of Spotted Gum was established at two sites in 1964. Details of these sites are:

- **Richmond Range S.F.;** lat. 28º 42'S; alt. 365m; mean annual rainfall 1 400mm; soils derived from sediments with basalt enrichment; wet sclerophyll forest site carrying Spotted Gum, Sydney Blue Gum, White Mahogany and Bloodwood.

- **Bom Bom S.F.;** lat. 29º 44'S; alt. 70m; mean annual rainfall 880mm; heavy clay soils derived from shale; tall woodland site with Spotted Gum, Grey Box and Broadleaved Ironbark.

Sources used in the trial are shown in Table 1, and ranged from northern sources in Queensland to a good South Coast site, and included typical *"var. grayi"* (Richmond Range) and "var. blakei" (Bom Bom) forms, as well as inland occurrences from both Queensland (Dalby) and N.S.W. (TR 73033).

Table 1

SOURCES USED IN N.S.W. SPOTTED GUM PROVENANCE TRIAL

LOCALITY	LATITUDE	ALTITUDE (m)	M.A. RAINFALL (mm)	OTHER NOTES
Maryborough, Q	25º 35'	Low	1 100	Northern coastal site
Dalby, Q	27º 32'	About 350	640	Dry inland site
Richmond Range SF	28º 44'	450	1 400	Soils with basalt influence
Mt. Pikapene SF	29º 2'	490 (?)	850	Ridge site; sandy
Mt. Pikapene SF	29º 2'	290	850	Gully site; sandy loam
Grange SF	29º 31'	300	1 300	High quality site; tall trees
Bom Bom SF	29º 41'	70	880	Heavy soils
TR 73033	32º 38'	550	600	Inland site (Curryall SF)
Benandarah SF	35º 32'	30	880	High quality South Coast site

Reporting on the establishment of this trial, Floyd (1964) noted that the two Queensland sources and TR 73033 exhibited very long taproots with few laterals; they suffered heavy tubing losses, and also had greatest losses from damping off. By contrast, N.S.W. coastal sources had well branched root systems.

The trials have been periodically measured since establishment, and a summary of the 1977 results, when the plants were aged 13 years, is shown in Table 2. These results have not been subject to statistical analysis.

Table 2

SPOTTED GUM PROVENANCE, TRIAL - SUMMARY OF 1977 RESULTS

Source	Bom Bom Planting Site			Richmond Range Planting Site		
	Stocking st/ha	Mean DBH (cm)	Mean Ht (m)	Stocking st/ha	Mean DBH (cm)	Mean Ht (m)
Maryborough		Not planted		667	8.7	13.6
Dalby	824	9.6	10.2	941	8.7	14.2
Richmond Range	1 608	8.8	11.7	1 725	11.6	19.1
Mt. Pikapene - range	980	10.5	10.7	1 490	11.8	18.0
Mt. Pikapene - gully	941	9.9	11.1	1 843	10.0	16.5
Grange	1 412	8.2	10.6	667	10.5	15.9
Bom Bom	1 236	9.3	12.0	1 216	10.1	12.0
TR 73033	1 765	6.9	8.6	1 059	7.0	9.0
Benandarah	1 451	7.7	8.7	2 078	10.7	17.8

Features of these results include:

- The superior growth shown on the better Richmond Range site, as would be expected.
- The tendency for an inverse relationship between stocking and mean DBH on the poor Bom Bom site, but no such effects (indeed rather the reverse) on the more fertile planting site, where competition is likely to be delayed.
- The local seed source giving the best height growth in both sites.
- The generally good performance of the Richmond Range, and to a somewhat lesser extent the nearby Mt. Pikapene, sources at both sites.
- The relatively good performance of the Benandarah source at Richmond Range.
- The poor behaviour of TR 73033 source at both sites (except for survival, i.e. stocking, at Bom Bom).
- The poor performance of the Queensland sources at Richmond Range, and of the Benandarah source at Bom Bom.

The results warrant more detailed analysis after future re-measurements, and suggest the desirability of the assessment of other characteristics, along the lines of Larsen and Andrew's studies. In the meantime they confirm the wisdom of using local seed sources in any artificial establishment programmes, unless one has firm evidence to the contrary.

2.3 Forest Types

The types dealt with in these Notes are essentially those making up the Spotted Gum league in the classification of forest types by the Forestry Commission of N.S.W. (1965). This describes the Spotted Gum league in the following terms:

"This is probably the second most important league in N.S.W as a supplier of logs. It occurs throughout the coastal districts, and recurs to the west of the Divide near

Mudgee[4]. It is characterised by the presence of Spotted Gum which makes up 20 per cent or more of the stand, and which frequently completely dominates the stand. In structure the types in this league range from tall wet sclerophyll forest to open dry sclerophyll forest and tall woodland.

As in the case of the Blackbutt league, the indicator species can occur in association with a very large number of species. Some of the more widespread of these combinations are recognised here as distinct types, but the first type (Spotted Gum, No. 70) is intended to cover the remaining miscellaneous combinations.

The league as a whole generally occurs in drier localities than the Blackbutt league, but the two leagues do merge in many places in a Blackbutt-Spotted Gum type. Altogether, seven types are recognised in this league."

The seven types described are:

70. **Spotted Gum**. Variable type in which Spotted Gum may occur in pure stands or with various associates, including Yellow and other Stringybarks, Woollybutt, Silvertop Ash, Red Bloodwood, Mountain Grey Gum, Ironbarks, Tallowwood, Sydney Blue Gum, Turpentine, Brush Box, Forest Red Gum and others. The understorey is variable: on parts of the South and Central Coasts there is a dense layer of Burrawang, and in part of the Clarence Valley, of the related Pineapple Palm; elsewhere it may be of grasses or xerophytic (more rarely mesophytic) shrubs. Stands can range from dry to wet sclerophyll forest, and height from about 20 to 45m, and they are normally found on soils of moderately heavy texture, under an annual rainfall of 750 to 1 300mm. Widespread throughout coastal districts, usually at elevations below about 450m.

71. **Richmond Range Spotted Gum.** Stands dominated by the distinctive, narrowleaved form of Spotted Gum *("var. grayi"),* forming a tall, wet sclerophyll forest stand, often over 45m in height, with Tallowwood, Sydney Blue Gum, Brush Box and sometimes Steel Box as associates, and frequently with an understorey of rainforest plants. Typically at elevations over 300m in the vicinity of the Richmond Range, on soils that are usually subject to some basaltic influence.

72. **Spotted Gum - Grey Box.** Tall woodland stands up to 40m in height, found on heavy clay soils with a rainfall of under about 1 100mm. Grey Box and Spotted Gum clearly dominate the stand, with other associates including Broadleaved, Narrowleaved and Grey Ironbarks, Red Bloodwood and Forest Red Gum. Common In parts of the Clarence River basin, where the Spotted Gum is often the broadleaved *E. henryi* (or "var. blakei"), but the type occurs further south along the North Coast with the normal form of the species.

73. **Spotted Gum - Sydney Blue Gum/Bangalay.** Wet sclerophyll forest stands up to 45m high, dominated by Spotted Gum and Sydney Blue Gum, Bangalay or some mixture of the two, with Blackbutt, Woollybutt, Turpentine, Red Mahogany and other species as associates. Occurs in the more favoured sites in forests dominated generally by Spotted Gum, particularly on the South Coast where it forms a typical and widespread gully stand, usually with wattles or rainforest species in the understorey.

74. **Spotted Gum - Grey Ironbark/Grey Gum.** This tends to be the reverse of the previous type, occupying the excessively drained, shallow soiled ridges in areas where Spotted Gum type occurs on the slopes, forming dry sclerophyll forest stands up to about 35m in height. Widespread (with Grey Ironbark, not Grey Gum) on the South Coast, but extends into northern parts of the State. Besides the named dominants, other associates include Blackbutt, various Stringybarks, Bloodwood, White Mahogany and Tallowwood.

[4] * In reality this western occurrence (Curryall S.F.) is slightly east of the Divide, which is indistinct and of low altitude in this area of the Hunter Gap.

75. **Spotted Gum - Yellow Stringybark.** Wet sclerophyll forest, with Spotted Gum associated with Yellow Stringybark; other associates may include Mountain Grey Gum, Woollybutt and various other Stringybarks, usually with a fairly dense understorey. Occurs on south-easterly aspects towards the inland limit of Spotted Gum on the South Coast, linking the Spotted Gum types with the Moist Tableland Hardwood types (Messmate - Brown Barrel league).

76. **Spotted Gum - Blackbutt.** Both these major timber species occur together in what is usually a dry sclerophyll forest, and can be associated with a wide range of other species. It is found throughout coastal districts where conditions are becoming marginal for Blackbutt - usually through the occurrence of more heavy textured soils.

With one fairly major exception, Spotted Gum types have not been in districts receiving detailed ecological study, so that most of the efforts at including these communities in ecological classifications have been on a fairly broad-brush, State-wide approach. Pidgeon (1942) recognised a Spotted Gum - Grey Ironbark - Narrowleaved Ironbark Association[5] with a number of types, all containing Spotted Gum; she noted that the community was usually a dry sclerophyll forest (occasionally wet sclerophyll), with a wide range in the drier coastal sites. Specht et al. (1974), following Hayden (1971), listed for N.S.W. a Spotted Gum - Grey Ironbark Alliance, occurring as Tall Open-forest (wet sclerophyll), Open-forest (dry sclerophyll) or Woodland; for Queensland they gave up, and referred merely to "Eucalypt (tall) open-forest alliance", carrying a large number of species[6]*. Beadle (tall) included a Spotted Gum Alliance within his "Tall **Eucalyptus** Forests of the Eastern Coastal Lowlands": he listed two associations only (Spotted Gum and Spotted Gum-Steel Box, the latter essentially the equivalent of the Richmond Range Spotted Gum type), but provided a long list of associated species.

The one detailed study in a Spotted Gum area is that of Austin (1978), as part of the CSIRO South Coast land use study. Austin distinguished a "Spotted Gum Group", containing three "types", each with a number of "communities":

1. Spotted Gum - Grey Ironbark - Bangalay type
    - Grey Ironbark - Spotted Gum Community
    - White Stringybark - Spotted Gum
    - Bangalay - Spotted Gum . Bangalay - Yellow Stringybark
2. Blueleaved Stringybark - Spotted Gum - Yellow Stringybark type
    - Spotted Gum - Blueleaved Stringybark
    - Spotted Gum - Yellow Stringybark
    - Spotted Gum - Maidens Gum
3. Spotted Gum - Grey Ironbark - Sydney Blue Gum type
    - Spotted Gum - Grey Ironbark
    - Spotted Gum - White Stringybark
    - Spotted Gum
    - Spotted Gum - Ironwood
    - Spotted Gum - Sydney Blue Gum.

In addition he recognised a Red Bloodwood - Blackbutt - Spotted Gum type in the Red Bloodwood Group. Both the Spotted Gum and the Red Bloodwood Groups occurred at low altitude, the latter on infertile sites and the former on mesic sites of relatively greater fertility. Austin rightly stressed that vegetation occurs as a constantly changing continuum. The degree of subdivision in this continuum will depend on the purposes of the exercise, and a fairly detailed break-up, such as that developed by Austin, may prove valuable in interpreting some aspects of silvicultural behaviour.

[5] Botanical workers have usually employed botanical names in defining their communities; the equivalent common names are used here for consistency and stability.

[6] Dr. D.I. Bevege has noted that in Queensland the Spotted Gum types are distinctive enough, but that it is the associated species (Ironbarks, Grey Box, Pink Bloodwood, etc.) that provide the more consistent site indicators.

2.4 Environment

Spotted Gum, and consequently the Spotted Gum types, have a wide geographic distribution and occur under what appears to be a very wide range of environmental conditions. Unfortunately there have been no broadscale studies on the pattern of Spotted Gum occurrence, though there have, been some local investigations on the South Coast, while the current CSIRO Division of Plant Industry programme on Kioloa S.F. (Aston et al., 1978; Pook, 1978) will ultimately yield vast amounts of information on the response of Spotted Gum to environmental factors, if not on the factors responsible for the occurrence of the Gum types.

Climatic data for sites carrying Spotted Gum types are shown in Appendix 2 of the sites represented, Tabbimoble and Grafton are in the vicinity of the Clarence Basin, Tabbimoble typifying the higher rainfall sites near the coast; Cassilis is close to the most inland occurrence in N.S.W., on Curryall S.F.; Muswellbrook and Raymond Terrace are representative of stands in the Hunter Valley, with Muswellbrook near the main inland limits of the types; Prospect is in the rather limited occurrence of Spotted Gum in an arc west and south of Sydney; and Ulladulla, Narooma and Bega straddle the major South Coast occurrence, though Bega itself is slightly inland from the nearest stands, and probably with a rather lower rainfall. Unfortunately no information is available for two other interesting occurrences, those of the Richmond Range stands and those at rather higher altitudes in the western part of the Clarence Valley (e.g. Boundary Creek and Washpool S.F.'s).

The data show a typical array of coastal temperature regimes, with many of the sites experiencing frosts in local openings during the winter months. Mean annual rainfall ranges from about 600mm in the driest sites to over 1 500mm. All stations show a tendency, more marked in the north, for wet summers (yielding 30 to 40 per cent of the annual rainfall) and dry winters or springs (14 to 20 per cent of annual precipitation). The change from a summer to a uniform or winter rainfall pattern roughly coincides with the southern limits of the Spotted Gum types.

Spotted Gum types occur on soils derived from a wide range of parent materials, including granite, basalt, metamorphosed sediments, shales and certain sandstones. The soils typically, though not invariably, have a fairly heavy texture, particularly in the subsoil, and may have quite shallow surface horizons: a feature of Spotted Gum appears to be its ability to extend its roots deeply into heavy soils, a characteristic that has led to its use in the restoration of bauxite-mining areas in Western Australia. Presence on basalt or basalt-enriched soils is unusual, possibly because of greater competitive ability from other species, but occurs with the narrowleaved Richmond Range form of the species *("var. grayi").* The types avoid the infertile Hawkesbury Sandstone areas around Sydney, but occur on sandstone that gives rise to soils of higher fertility (e.g. parts of Narrabeen series, as on the Newport - Palm Beach Peninsula).

Studies on the South Coast have thrown some light on the relationship between soil conditions and the occurrence of Spotted Gum compared with other local species. McColl and Humphreys (1967) looked at various factors, and obtained some evidence that Red Bloodwood soils had different physical qualities from, and were of a lower nutrient status than, Spotted Gum soils; the two species appeared to differ in their ability to take up, and perhaps in their requirements for, soil phosphorus, calcium, nitrogen and possibly manganese. Further work by McColl (1969) showed, not unexpectedly, a gradient in soil physical and chemical properties from Bloodwood ridges, through the slopes where Spotted Gum occurred with Grey Ironbark or Blackbutt, to the Sydney Blue Gum gully sites. The pattern was effectively correlated with an increase in the availability of soil P, which was enhanced by high Ca levels, but reduced by the presence of high soil Al levels: P x Ca/Al provided a useful estimate of P available for uptake by the plants. Bloodwood occurred where this value was low, Spotted Gum at intermediate levels, and Blue Gum at the higher levels.

Like many smooth-barked eucalypts, Spotted Gum slows a very high ash content in its bark (about 6-12 per cent), and this is correlated with very high Ca levels in the bark (Lambert, 1981).

Speaking at a 1982 seminar on current ecological research in the South Coast forests, R.G. Florence suggested that on the South Coast Spotted Gum tends to be more competitive on soils with higher nutrient levels, especially available P, and that it has high levels of Ca and P in the foliage, and probably a requirement for high soil levels of these: this feature, with respect to Ca, had previously been observed in the Whiporie S.F. area (comment from F.R. Humphreys). Dr. Florence noted that eucalypt forests often do not form a closed nutrient system, and that there is frequently loss of P from the top layers of the soil, accompanied by a release of P by rock breakdown in the lower layers. Accelerated loss from the upper soil layers could lose Spotted Gum its competitive position in the stand on more marginal sites.

To summarise, Spotted Gum is a species that seems to show some preference for the more heavy-textured soils. It also appears to be relatively nutrient demanding, particularly for P and Ca, though "relatively" is the operative word: compared with many eucalypts, Spotted Gum can occur on sites that are decidedly not of high fertility.

Whilst Spotted Gum may be locally influenced in its occurrence by **topography,** as in the ridge-gully sequence examined by McColl, topographic position itself does not greatly affect occurrence, and the tree may be found from dry ridgetops to moist gullies. Although it is described as withstanding limited waterlogging in cultivation (Elliot, 1983), in the field Spotted Gum tends to avoid such sites; in the Grafton district the typical Spotted Gum - Grey Box type of the area is replaced by Forest Red Gum or Broadleaved Ironbark - Grey Box types on the low-lying sites where drainage is impeded and waterlogging occurs (Baur, 1962).

Fire can affect regeneration, but is not otherwise a major factor influencing the occurrence of Spotted Gum.

Spotted Gum is tolerant of infection by *Phytophthora cinnamomi,* though its growth may be somewhat retarded (Halsall and Williams, 1984). This resistance could be a further factor in delineating the Spotted Gum types.

Comparing the environmental requirements of Spotted Gum with those of Blackbutt, the other major species of the N.S.W. coastal districts:

- Both occur generally in the same climatic zones, but Spotted Gum extends naturally into areas with a lower rainfall.

- Whereas Blackbutt requires **well-drained** soils of relatively light texture or good structure, Spotted Gum appears to prefer soils of moderately **heavy** texture. This is probably the most important individual factor differentiating the two types.

2.5 Other Ecological Considerations

Like most coastal and tableland forest communities in N.S.W., Spotted Gum types can occur in an intimate mixture with other types. Nonetheless, and probably to a greater extent than most others, Spotted Gum stands do tend to occupy extensive tracts in their areas of occurrence: this in part undoubtedly reflects the wide ecological amplitude of Gum itself.

The types meet and merge with many of the other coastal forest types - Blackbutt, almost certainly under the influence of lighter soil textures; the dry coastal hardwood types, possibly due to more rapid soil drainage and nutritional balances that are less favourable to the growth of Spotted Gum; moist hardwood types in the favourable gully sites and, in parts of the far North Coast, on plateau sites with soils of high fertility; Forest Red Gum on more poorly drained sites.

Spotted Gum types appear to provide generally favourable wildlife habitat. Recent studies on Kioloa S.F. by S. Davey (Australian National University) suggest that Spotted Gum stands of high site quality, under selection management, provide habitat for arboreal mammals equal to any known elsewhere on the South Coast. Davey's list of recorded mammals is included in Appendix 5 of the 1983 Management Plan for the Batemans Bay Management Area. Stands with open, grassy understoreys support high populations of macropods, and the periodic flowering of the Gum stands is highly attractive to wildlife. Terrestrial fauna in the Deep Creek catchment on Mogo S.F., essentially a Spotted Gum area, has been surveyed by Croft (1980), and wildlife in the broader CSIRO South Coast study area was reported by Nix et al. (1978). No other studies specifically looking at the fauna of Spotted Gum types in N.S.W. are known, but some further studies are under way in Queensland.

3. OCCURRENCE

The occurrence of Spotted Gum, the tree, essentially is identical with the occurrence of the Spotted Gum types.

In N.S.W. the species is found south to about the Bega River (Tanja S.F.), with a rather scattered occurrence north to near Bermagui and thence tending to dominate much of the coastal forests as far north as Termeil S.F., extending from the coastline inland for over 30km and to altitudes of up to about 300m. From Termeil to Nowra the occurrence is again rather scattered, though with some large individual areas. Two small and unexpected stands occur at an elevation of about 600m on the eastern side of Wingello S.F., growing on Permian Nowra Grits.

The tree is absent from the Hawkesbury Sandstone areas, but there are belts through the Campbelltown - Camden - Liverpool - Prospect district, and again along the Newport - Palm Beach Peninsula. It is present in the Gosford district, is an important constituent of parts of the State Forests along the Watagan Range, particularly at the lower elevations, and is widespread through much of the Hunter Valley, extending west to near Merriwa, with the isolated westernmost State occurrence on Curryall S.F., southwest of Cassilis, about 200km inland.

It has a fairly wide distribution along the North Coast, with significant stands in the Bulahdelah district and thence north to beyond the Manning River (Yarratt S.F.). The next major appearance is in the northern part of the Hastings and in the Macleay Valleys. Site quality varies from poor on some of the low altitude areas, to excellent in some of the higher altitude stands such as Yessabah S.F. (altitude probably about 700m). Again its occurrence is then sparse until the sedimentary deposits of the Clarence Basin are reached north of Woolgoolga, though it is scattered through some forest areas further south (e.g. Newry S.F., Conglomerate S.F.), and there are some fine stands (probably of the narrowleaved Richmond Range form) on the northeastern edge of the Dorrigo Plateau (Kangaroo River and Bagawa S.F.s).

The Clarence Basin, extending north to Casino, represents another major occurrence of Spotted Gum. Whilst the low altitude stands, largely present as the broadleaved form *(E. henryi),* occur mostly as tall woodland of only moderate quality, some very high quality stands occur around the western rim of the Basin, at altitudes of up to 500 to 600m (Boundary Creek, Marara, Grange, Washpool (Redbank Section) and Girard S.F.s). Within this area also are the high quality stands of the Richmond Range form *("var. grayi"),* e.g. Mt. Pikapene and Richmond Range S.F.s).

Outside of N.S.W. there is one small, isolated occurrence of Spotted Gum in Victoria at Tara (or Tarra) Mountain, about 25 km from Orbost. This is nearly 200km from the nearest N.S.W. stands, and it is interesting to speculate on its origin - a relic of a once wider distribution? A chance long range dispersal that found conditions to its liking?

Spotted Gum extends north into Queensland to about Gladstone, thence Lemon-scented Gum replaces it. It has a far more westerly distribution in Queensland, reaching as far as 380km inland near its northern limits; in some of these western stands it is associated with White Cypress Pine (Dale & Hawkins, 1983). It is a major hardwood timber in the Maryborough district, where it commonly occurs with Broadleaved, Narrowleaved and Queensland Grey Ironbarks and with Broadleaved White Mahogany. The occurrence of the Spotted Gum types in Queensland was reviewed by Swain (1928).

The distribution of the Spotted Gum types is portrayed fairly well on the map of forest types in N.S.W. (Forestry Commission of N.S.W., 1978), though this fails to highlight the stands in the Macleay Valley. The 1971-72 forest resource inventory of N.S.W. showed the occurrence of 497 000 ha of Spotted Gum types in the State, making it one of the most extensive of the major forest types; about 180 000 ha occurred on State Forest at that time, and over 200 000 ha were in private ownership (Hoschke, 1976).

4. UTILISATION

Spotted Gum types carry some of the State's finest timber producing trees, and the types have been important suppliers of timber for more than a century. Appendix 3 gives details of the properties of Spotted Gum and some of its major associates, from Bootle (1983). Spotted Gum itself has usually been a well regarded and favoured timber species, and it has been employed in a wide variety of end uses, though its popularity has sometimes fluctuated. Quoting a report published in 1890, Maiden (1917) lists some of its uses at that time:

> *"Our correspondents have used Spotted Gum for railway fencing, hammer and axe handles, way-levers, shipbuilding, paving-blocks, sleepers, decking and deck guards for bridges and wharfs, girders in bridge and flood openings, house carpentry, door-frames, sills and joists, buggy and dray shafts, and other portions of the bodies of vehicles, wheelwrighting, farm implements, boat timbers, tip wagons, railway buildings, railway and other bridges (laminated arches of railway bridges, sheeting, wings, wales and decking, hand-railing, braces, ballast guards, walings, girders).*
>
> *Spotted Gum is largely replacing American Hickory in the coach factories along the coast for wagons, buggies, sulkies, etc., and large orders are being filled for coach factories in Sydney and elsewhere, care being taken to cut the timber free from sap, heart, and gum-veins."*

Allowing for changes in technology over nearly a century (and for a few unusual terms), the uses outlined in Appendix 3 are not very different, while Bootle in his section on uses of wood, details many more specific applications of Spotted Gum including diving boards, polo sticks, meat skewers, turnery, carving and many boat-building applications, though general building construction remains probably the major end use of the timber. Handle manufacture remains a small, but select, market for good quality logs of Spotted Gum, and the species has been successfully used for the production of peeled veneer. Besides the uses mentioned, Spotted Gum has been used for sleepers and is a favoured species for mining timber (partly due to its ease of debarking), while small or poor quality logs are frequently used to produce pallet material and dunnage. It is also used to some extent for paper and hardboard manufacture, though not particularly favoured for either purpose. The major defects of the timber are its proneness to produce gum veins, and its wide sapwood (up to 50mm wide, often with a further zone of intermediate wood), which is extremely susceptible to lyctid attack unless treated: however the favourable response of Spotted Gum to preservative treatment greatly diminishes the role of the wide sapwood as a defect.

Districts with significant areas of Spotted Gum forests usually support important sawmilling industries, while the production of preservative-treated poles is the other major outlet for Spotted Gum, though soft rot is proving worrisome with these in some areas (Bell, 1984).

In addition to their uses as wood, Spotted Gum and its associates are used for charcoal production in several districts, while Bootle states that the dry sawdust from Spotted Gum has been used for fish smoking and curing.

Spotted Gum, along with many of its associates (including the Boxes, Ironbarks and Woollybutt), is highly regarded as a **honey** tree, and apiarists make full use of the forests during flowering seasons. Orman (1978) records the presence of over 600 apiary sites (almost all based on the Spotted Gum types) in the State Forests of the Batemans Bay region alone.

Other products have in the past come from these types. On the South Coast **tan bark** was for many years an important industry, coming from Black Wattle growing in part in the Spotted Gum stands, while on several occasions Burrawangs have been briefly used for the extraction of **starch** (Orman, 1978).

Many of the Gum types carry a grassy understorey, which is commonly used for stock **grazing.** Under private ownership many such sites have been largely cleared for pasture purposes, retaining scattered Spotted Gum trees for shade and shelter. The same grassy understorey often supports substantial macropod populations.

Spotted Gum itself is one of the most attractive of the eucalypts, its clean, distinctively coloured, often dimpled bark, with its characteristic spotted appearance, and its usually rather dense crown making it a particularly photogenic tree. Coupled with its associated trees and, on the South Coast and along the Newport - Palm Beach Peninsula, with the common understorey of Burrawangs, the Spotted Gum stands are deservedly highly valued for their beauty, and attract high levels of **recreational use** in some districts. The same features have made Spotted Gum and its close relative, Lemon-scented Gum, a popular subject for ornamental use. The tree is also often planted in rural properties, being one of the more densely foliaged eucalypts where shade is required and being planted not only in coastal areas but also in western districts, as in the grounds of the Agricultural Institute at Yanco and of the Forestry office at Baradine. It is also being used with some early promise in the reclamation of open-cut mining sites, with the long-taprooted strain from Curryall S.F. (see section 2.2) showing up well in trials in the Gunnedah district, and has been used for a similar purpose on bauxite-mining sites in Western Australia.

5. HISTORY OF USE AND MANAGEMENT

Spotted Gum appears to have been valued as a ship-building timber from the first half of last century. This fact, together with the high durability and strength of many of its more common associates, seems to have given the Spotted Gum types an early level of esteem which has possibly diminished a little over the succeeding century and a half: fast growth, blandness, ease of working and availability in quantity are to-day the more popular attributes.

The development of the Spotted Gum types as timber producers was apparently most marked on the South Coast, where high quality stands fronted directly on to many of the local estuaries, bays and even beaches. At such sites small shipyards, timber shipment points and sawmills were constructed. Writing of this region, Lane (1978) has noted that timber getting was an important local industry from the earliest days of European settlement, with pit-sawyers being supplanted by sawmills by about 1850. Select timber was transported to Sydney by ship from the local "ports". Spotted Gum was the most sought after species, and the earliest forest reservations were in the Gum areas.

On the Central Coast the use of the hardwood forests, of which the most accessible were dominated by Spotted Gum, also commenced at a relatively early date, and by 1920 the forests of the Wyong district were reported to be cut out. Many of the Spotted Gum stands close to Morisset, and probably also around Cessnock, have been maintained as small-timber forests since that time.

On the North Coast development tended to be rather later, though a large hardwood mill at Coraki, employing 60 men, was operating by 1882, using logs brought down the Richmond River. A large proportion of these logs would have come from the Spotted Gum stands of the Casino district. In general, however, major-harvesting in the Spotted Gum types on the North Coast did not get under way till about 1900, starting in the more accessible forests (e.g. Bom Bom and Glenugie S.F.s in the Grafton district, Tamban S.F. in the Kempsey district), and then gradually moving into the more remote areas.

As with most of the State's hardwood forests, early logging was highly selective, with the same areas often being logged over on a number of occasions as standards of utilisation improved. A not atypical sequence of events is recorded in the 1977 Management Plan for the Casino Management Area:

> *"The forests of the Management Area have been selectively logged over many decades with sawlogs, sleepers and poles being the main products. The intensity of harvesting has varied but generally has been more intense in the more accessible forests such as Bungawalbin, Braemar, Myrtle and Carwong.*
>
> *Brief working plans were drawn up for Carwong (1917) and Braemar (1918, 1920, 1924) State Forests. Similar prescriptions were adopted for both forests and involved the disposal of all marketable mature timber followed by closure of the forests except for improvement fellings and thinnings.*

Silvicultural treatments were initiated in the more accessible forests following extensive logging operations prior to 1916. In Bungawalbin, Braemar, Camira, Carwong, Ellangawan and Myrtle forests, early exploitation resulted in cut-over stands, described as 'scanty, faulty and principally over-mature' (Bungawalbin Working Plan 20/4/1926).

Subsequent silvicultural prescriptions in these forests were based on ringbarking useless trees with a view to regeneration and future cutting under the Australian Group Selection System.

The combination of heavy culling and grazing in Bungawalbin, Carwong and Ellangowan forests during the 1920's resulted in poor regeneration. However, good regrowth stands were reported in Myrtle, Braemar and Camira forests during the 1930's as a result of ring-barking during the 1920's. Culling and thinning operations carried out in Braemar and Carwong forests during the late 1930's and early 1940's also produced good regeneration in the areas treated.

More recently, large scale Timber Stand Improvement Operations were carried out in Braemar (up to 1957), Bungawalbin (up to 1964), Mororo (1961) and the Tabbimoble forests (1950 and intermittent operations up to the present time)."

In parts of the South Coast tree-marking was introduced in the 1940's, and has continued in use to the present time. Its introduction into other areas was somewhat later.

Expressed in general terms, the Spotted Gum types have received periodic selective harvesting, often coupled with culling or other silvicultural treatment. A distinction can be made between the better quality stands, where management aims at sawlog production, and the poorer sites where mining timber, poles or small sawlogs are the main products: the former naturally support a greater range of size classes and tend to be the sites of greater scenic interest and attraction. Whilst management has usually aimed towards selection logging systems, with the retention of ample growing stock, there are stands in many districts where the end results of some operations have more closely resembled a clear felling with seed trees.

The Spotted Gum types are essentially stands of the accessible coastal districts, and as a result most stands have been logged in the past. Nonetheless some virgin stands still exist, particularly in the western foothills of a number of districts on both the South and North Coasts.

6. Regeneration Requirements

6.1 Seeding Habits

An outline of the flowering and seeding habits of some of the species present in the Spotted Gum types is given in Table 3, taken from Boland et al. (1980). More information concerning Blackbutt is given in No. 4 of these Notes, and on Sydney Blue Gum in No. 1.

Table 3
FLOWERING AND SEED COLLECTION TIMES: SPOTTED GUM TYPES
(from Boland et al., 1980)

Species Flowering	Seed	Duration	No. Crops	Notes	
Bangalay	Dec-Feb	Dec-Feb	* *		
Blackbutt	Sep-Mar	Dec-Feb	* * *	+	
Bloodwood, Red	Jan-Apr	Jun-Mar	* *		(1)
Gum, Forest Red	Jun-Nov	Jan-Mar	* *		
Gum, Spotted	May-Sep	Jan-May	* *		
Gum, Sydney Blue	Jan-Apr	Nov-Mar	* *		
Mahogany, Red	Oct-Feb	Aug-Sep	* *		
Stringybark, Yellow	Nov-Mar	Dec-Feb			

Notes**:* ***Seed collection: *most convenient months for collection.*
Duration: indication of period in which particular seed crop is present on tree:
****Long duration - some seed available most months;*
***Medium duration - major seed collection should be confined to months shown.*
No. Crops: *+ indicates species often carries more than 1 seed crop on tree.*
(1) 6 - 8 weeks elapse between budding and flowering.
(2) More regular in north of its range.

Spotted Gum itself has been the subject of study in several areas in relation to its flowering and seeding, and the results of these studies to some extent conflict with the summary presented by Boland and his colleagues.

The most complete study was reported by Dale and Hawkins (1983) for observations and collections made in the Chinchilla district of southern inland Queensland and covering data collected at a number of sites over various periods between 1934 and 1973. Their major findings:

- Buds on average matured for a period of 10 to 11 months before flowering, the start of the "maturing" period being when the small buds were first detectable in litter traps: initiation of the bud primordia would probably be several months earlier than this. The maximum period between bud formation and flowering was 19 months.
- Flowering was observed, at various times, in all months of the year, but generally occurred between October and January, with November the main month.
- Flowering usually lasted for about two months, but could extend for 3 or 4 months.
- Over 35 years of observation, general to heavy flowerings of Spotted Gum occurred at intervals of from 1 to 6 years; no regular cycle of flowering could be observed. In two years during this period no flowering occurred.
- Capsules began to mature only 2 months after flowering, but the mature capsules remained unopened on the tree for 22 to 34 months before seed shed, and persisted in the crown for up to 8 months after seed fall.
- The production of a heavy seed crop usually produced a marked thinning in the foliage of the Spotted Gum.
- Heavy seed-fall was recorded in all months of the year (over 50 000 seed/ha/mo in good seed years), but maximum fall normally occurred between October and January. Annual seed-fall varied between 4 000/ha in a poor year to 4 500 000/ha win what appears to have been a 'bumper' crop.

For the Brisbane area, Specht & Brower (1975) found Spotted Gum to be a fairly regular autumn-flowerer, but with occasional flowering commencing in summer or occurring briefly in mid-winter. Flooded Gum was a more regular and reliable flowerer than any of the other associated eucalypts studied with it - Narrowleaved White Mahogany, Pink Bloodwood and Northern Grey Ironbark.

Working in northern N.S.W. (chiefly in Grafton district stands dominated by the broadleaved *E. henryi),* Floyd (1956?, 1961) obtained results similar to those from inland Queensland: flowering peaking about December; heavy crops of flowers at intervals of 5 to 10 years; unopened capsules still on trees up to 5 years after flowering. In the earlier report he mentions a local foreman's having collected viable seed only 2 months after flowering, but he queries the veracity of this in the 1961 report on the basis of its non-confirmation in a study on the South Coast: in the light of the Queensland work, the foreman from Glenugie S.F. would appear to have been correct.

In the Sydney district Spotted Gum normally flowers in the winter months (Beadle et al., 1962), and it tends to be regarded as a winter bloomer ' on the South Coast, though in 1983, a year of heavy flowering that followed a protracted and severe drought, the period of blooming lasted for about 6 months up to July; there appeared to be considerable variation in the time of flowering of trees in the one stand. Gum is sometimes regarded as having one good seed year in three on the South Coast, though a report by Floyd (1952) refers to its having an *"irregularity and infrequency of good seed years"*; he also mentions trees still bearing green, unopened fruits 5 years after flowering. As noted above, capsules may mature more slowly on the South Coast than in the warmer, more northerly sites.

Features of the seeds of major species from the Spotted Gum types are given in Table 4, again from Boland et al. (1980).

Table 4

SEED FEATURES : SPOTTED GUM TYPES

Species	No. Viable Seeds/kg			Germination	
	Mean	Highest	Temp (1) (ºC)	First count (2)	Final count (2)
Bangalay	406 000	1 050 000	25^{0}C	10 days	21 days
Blackbutt	59 000	195 000	20;25	7	21
Bloodwood, Red	77 000	102 000	(25)	5	14
Box, Grey	351 000	764 000	25;30	5	21
Box, Steel	252 000	487 000	(25)	3	10
Gum, Forest Red	600 000	2 620 000	25;30;35	5	14
Gum, Spotted	109 000	252 000	25	5	14
Gum, Sydney Blue	538 000	1 540 000	25	5	14
Ironbark, Broadleaved	211 000	399 500	(25)	5	14
Ironbark, Grey	419 000	1 320 000	(25)	5	21
Mahogany, Red	(215 000	790 000	25	5	21 (3)
	(111 000	376 000	20;25	5	21 (4)
Stringybark, White	162 000	280 000	20;25	7	21
Stringybark, Yellow	60 000	140 000	15	10	21
Woollybutt	132 000	161 000	(25)	7	28

Notes:

(1) Temperatures recommended for germination tests. Where figure is bracketed, e.g. (25), this temperature is satisfactory, but others have not been tested; where two or more figures are given, e.g. 20;25, all have been found satisfactory.
(2) "Count" figures relate to laboratory tests, but give a relative measure of the speed of germination.
(3) For *E. resinifera*
(4) For *E. pellita* (Large fruited Red Mahogany)

For Lemon-scented Gum, Boland et al. give a mean value of 106 000 viable seeds/kg, and a maximum value of 220 000/kg, very close to the values for Spotted Gum. Dale and Hawkins (1983) in southern inland Queensland recorded a range of from 102 000 to 240 000 viable seeds/kg for Spotted Gum - well in the range of Boland et al. However Floyd (1961), working with *E. henryi* from Bom Bom S.F., recorded about 89 000/kg, indicating rather heavier than average seeds, as would be expected from this larger fruited form. (Boland et al. refer to the seed of *E. henryi,* but do not include a separate entry for this form in their table of seed weights. Presumably seed of this form is lumped with the normal form in the table.) Larsen (1965) unfortunately omits seed weights from his study on the variation within Spotted Gum, but there is an Inference from other data that the Richmond Range form *("var. grayi")* had smaller seed and the broadleaved form ("*var. blakei"* or *E. henryi*) had larger seed than normal *E. maculata*, and this is certainly the case with *E. henryi.*

B. J. Furrer (pers. comm.) notes that Spotted Gum seeds are black and shiny, 2 to 3mm in diameter, and somewhat flattish. Fine red-orange chaff accompanies the seed.

None of species commonly occurring in the Spotted Gum types are indicated as requiring seed pre-treatment (e.g. stratification) for germination.

6.2 Regeneration Establishment

Whilst there are some exceptions (see Section 6.5), in most situations the Spotted Gum types regenerate readily and well - a statement as true for the tall wet sclerophyll forest stands of Richmond Range and Boundary Creek S.F.'s as for the more widespread xeric stands. The regeneration ultimately derives from seedling establishment, but it seems that mostly this derivation is indirect and that either already established lignotubers or coppice from the stumps of previous stems form the bulk of the regeneration that is released following stand treatment or the natural death of one or more trees.

Some of the moister stands may in fact normally regenerate direct from seed, germinating on disturbed sites: the mechanics of regeneration establishment have not been studied in such sites, but field evidence suggests that, except for parts of the South Coast, adequate regeneration is readily obtained, whatever the immediate source.

Spotted Gum has been used on a limited scale for planting overseas, with somewhat wider use of Lemon-scented Gum (F.A.O., 1979). As previously noted, it is planted in Australia for ornamental, farm and reclamation purposes, but its artificial regeneration receives negligible silvicultural use, though Furrer (1971) recommended the planting of Spotted Gum seedlings in jiffy pots (peat pots; see Horne, 1979) as the most certain way to regenerate the moister gully sites in South Coast forests. In reality this technique has been very seldom employed. One site that was planted on Kioloa S.F. was subsequently described as *"one of the least successful regrowth areas"* (Neave, 1983), but in fact this particular area was severely burnt after planting, and its regeneration failure should be attributed to the fire, not to any deficiencies in the technique. Jacobs (1955; para. 189) refers to some direct sowing trials in South Australia in the 1920's. Blackbutt is still sometimes used for enrichment in Spotted Gum sites, either by planting (e.g. Kioloa S.F.) or by direct seeding (e.g. Yessabah S.F.), but the activity seems to have little in its favour unless the sites carry a Blackbutt component that is unlikely to reproduce itself naturally.

6.3 Seedling-Establishment

As noted above, in most areas the regeneration of Spotted Gum and its associates comes from a lignotuber pool, and the behaviour and response of this "pool" will be looked at in Section 6.4. However there appears to be no physiological need for young Spotted Gum to pass through a lignotuberous resting phase, and under favourable circumstances Gum seedlings may develop into active regrowth without any intermediate resting stage, even though many, if not all, the seedlings will develop the physical swelling of a lignotuber. Whether or not a lignotuberous stage exists, the plants ultimately come from seed.

Spotted Gum will usually carry a reserve of viable seed in its crown: whilst good flowerings may be irregular, unopened capsules will remain in the crown for periods of two to five or more years, and the seed falls quoted by Dale & Hawkins (see Section 6.1), with annual yields ranging from 4 000 to over 4 million viable seeds/ha, are likely to be repeated in many Gum stands. Thus in logged stands retained stems will usually carry a reserve of seed that will be released over a possibly lengthy period, though post-logging burning may well cause a general opening of capsules in the crowns, while there will be a further source of seed, released over a short period, in the crowns of the felled stems. Whilst inadequacy of seed supply is sometimes mentioned as a cause of Spotted Gum regeneration failure, it is suspected that this is rarely a major cause.

Floyd (1952) has outlined a technique for ensuring seedfall ahead of logging in Spotted Gum by the "seeding-ringing" of selected trees. The seed trees were chosen at a stocking of about 10 per hectare and were sap-rung. As soon as possible after ringing a light ground fire was put through the area to produce a receptive seedbed: he noted that a hot fire should be avoided, as it would encourage wattle germination. Heavy seedfall, commencing within a fortnight of treatment, resulted, and the area was subsequently logged. He recommended that treatment should be applied in late autumn to take advantage of the usually favourable establishment conditions in the following months on the South Coast. More recent foresters in the area have commented that the technique would be difficult to apply on any scale because of unfavourable ground fuel types.

The seed of Spotted Gum carries a similar number of viable pieces per gram to many other commercially important eucalypts (Table 4), but in fact the individual viable seeds tend to be rather larger in size: lesser quantities of chaff bring about the apparent comparability in seed weights. Unlike some species of the Bloodwood group, Spotted Gum seed is not winged, but its usual flattened shape allows a rather better distribution around seed trees than might otherwise be expected: a reasonable distribution of seeds within about 30m of the seed tree is probably normal.

The seeds germinate speedily under favourable conditions (Table 4), and from observations of the closely related Lemon-scented Gum small lignotuberous swellings appear at the base of the seedling at an early stage. However, if growing conditions remain favourable, as with nursery plants and as undoubtedly sometimes happens in field situations, the lignotuber will not exceed 1cm in diameter, and the seedling will continue to make active height growth (see Section 6.7). This may indeed be the norm for regeneration in some of the better quality wet sclerophyll forest and it certainly happens with planted seedlings, but it is probably highly unusual in most Spotted Gum stands.

As with other eucalypts, germination and early establishment are aided when the seed falls on a well-prepared and receptive seedbed. Burning is a usual means of seedbed preparation, and Henry and Florence (1966) give some examples of its effectiveness in relation both to Spotted Gum and Queensland Grey Ironbark establishment in coastal Queensland forests. In one case top disposal burning led to prolific seedling establishment, which then developed into the lignotuberous stage; in another they recorded a "striking reaction" to ash-bed effects, with a number of plants over 2.5m tall only a year after burning. In the latter case the Spotted Gum seedlings had clearly by-passed the lignotuberous resting stage.

High germination rates may not result in good establishment: as a small seedling Spotted Gum is intolerant of fire, weed competition and shading, it dislikes very moist sites (e.g. as a result of rising water tables), and It appears to be moderately demanding in nutritional requirements. These certainly all appear to be factors hindering regeneration establishment on parts of the South Coast (Neave, 1983). As noted by Furrer (1971), fire, by promoting weed growth may at times be deleterious to Spotted Gum establishment. Regeneration establishment on granite soils on parts of the South Coast is commonly regarded as difficult.

Nonetheless in most situations adequate regeneration occurs, usually forming the lignotuber pool. It seems likely that in Nature small numbers of seedlings would establish following the irregular, but probably fairly frequent, fires; occasional seedlings may even have established in the absence of fire. Over a period these would build up and maintain the pool from which small patches of regeneration could develop following the death of individual overstorey trees, maintaining a very uneven-aged forest structure. In most cases this still applies, though there appear to be some circumstances where man's activities have drastically reduced this regeneration pool.

6.4 The Lignotuber Pool

6.4.1 Extent and Response

As already indicated, a pool or store of dormant lignotubers is a feature of most Spotted Gum stands, possibly excluding the moister types.

Floyd (1961) provided some measures of the prevalence of lignotubers in the Grafton district (broadleaved form, *E. henryi*), in stands that initially appeared deficient in potential regeneration several years after logging. At Glenugie S.F. close study revealed 1 040 lignotubers per hectare carrying stems under 1.8m in height; 700 of the lignotubers had stems less than 30cm high, hidden in the grassy understorey. These were removed, but 4 years later over 300 new lignotubers or seedlings were present on the site (257 Spotted Gum, 49 Ironbark), with an average height of 28cm.

Most of these were probably older plants overlooked in the original enumeration, though some were certainly new recruits since the earlier treatment.

Two sites at nearby Bom Bom S.F. were also enumerated, with similar results: see Table 5. Lack of lignotubers was clearly not a factor in these forests. Similarly, stockings of about 2 500 lignotubers or regeneration stems per hectare are reported by Dale & Hawkins (1983) for Spotted Gum in the coastal districts of southern Queensland, and an average of 172/ha in study plots in inland stands: they considered these apparently low inland figures acceptable for an area where only 70 to 100 stems per hectare would constitute a well-stocked stand.

Table 5

FREQUENCY OF LIGNOTUBERS - BOM BOM S.F.
(No. per hectare by height classes)

Species	Ridge site			Gully site		
	Under 30cm	30cm+	Total	Under 30cm	30cm+	Total
Spotted Gum	141	15	156	766	116	882
Grey Box	200	27	227	119	96	215
Narrowleaved Ironbark	143	5	148	-	-	-
Grey Ironbark	52	12	64	-	-	-
Broadleaved Ironbark	-	-	-	383	119	502
Forest Red Gum	-	-	-	348	5	353
Other Spp	-	-	-	5	27	32
Total	**536**	**59**	**595**	**1 621**	**363**	**1 984**

Henry & Florence (1966), in a particularly comprehensive summary, reported on a number of studies carried out over a lengthy period in the Queensland coastal Spotted Gum - Ironbark stands. These mostly carried the typical form of Spotted Gum, though in one case the broadleaved form, subsequently to be named after the same Neil Henry, was present. Major features of these studies were:

- Although seasonal variations occurred, the pool of regeneration remained relatively stable over long periods (13 years in one series of studies).
- Within 15 months of germination a seedling may develop a lignotuber about 2.5cm in diameter, and showing that a number of shoots have already sprouted from it and died back. Previously such plants were believed to be much older.

- Whilst established lignotubers declined in numbers very gradually (averaging 3 to 4 per cent loss per year), a much more rapid loss occurred under the shade of dense lantana - a 79 per cent loss was recorded in 4 years, whereas in a nearby open site only 4 per cent of the lignotubers originally identified were lost in the same period.

- Annual burning caused the loss of most Spotted Gum seedlings that germinated; by contrast other eucalypts that germinated were able to maintain or increase their numbers. However established lignotubers of Spotted Gum showed no evidence of more rapid depletion under annual burning than under complete protection.

- Burning stimulated the growth of active shoots from lignotubers, but unless the plants were so situated as to maintain active growth they could become suppressed and be subsequently lost from the pool. In a specific study 31 lignotubers, established following a fire in 1944, were observed. In 1951, when they were burnt in a second fire, they all carried shoots under 1.65m in height. Subsequent development was:

4 months after fire	vigorous shoots on 29 lignotubers
2 years after	29 still present, 6 over 1.50m high and dominant over wattle and other species
4 years after	only 1 still dominant over wattle
7 years after	only 1 still dominant over wattle
7 years after	20 still alive, only 1 effective but below wattle
13 years after	1 lignotuber and 1 suppressed stem still present

- There appeared to be no significant differences between the response of the broadleaved and normal forms when growing together.

- Removal of overstorey triggered immediate, and at times substantial, response from lignotubers that were already present in the understorey, typically in straggling form with a number of row shoots. In 15 months after one treatment the average height increment of all lignotubers was 1.2m; maximum increment shown was 3.5m.

- Response was retarded in lignotubers close to the edge of openings in the forest canopy, and this is clearly demonstrated in Fig. 1, showing height of former lignotubers at various distances from the canopy edge, two years after the creation of the opening (based on the heights of the two tallest stems in each 5m sector along transects proceeding away from the canopy edge). Full response in height growth was only achieved at distances greater than 15 to 20m from the canopy edge.

The competitive influence of adjacent vegetation and its retarding effect on lignotuber development suggest that an opening of at least 30 to 40m in diameter is needed in these stands to produce stems that can show unimpeded development, and larger openings to produce a vigorous group of regrowth. In smaller openings lignotubers may develop active growth, but the growth will be slow and the stems are likely to produce poorly formed, non-vigorous stems characteristic of these stands. Whilst the work of Henry & Florence was carried out in Queensland, similar effects are recorded by Furrer (1971) for the N.S.W. South Coast. Furrer does not give as much detail about this edge effect as Henry & Florence, but from several of his figures it appears that it is of a similar order to, but possibly slightly less extensive than, the values reported from Queensland.

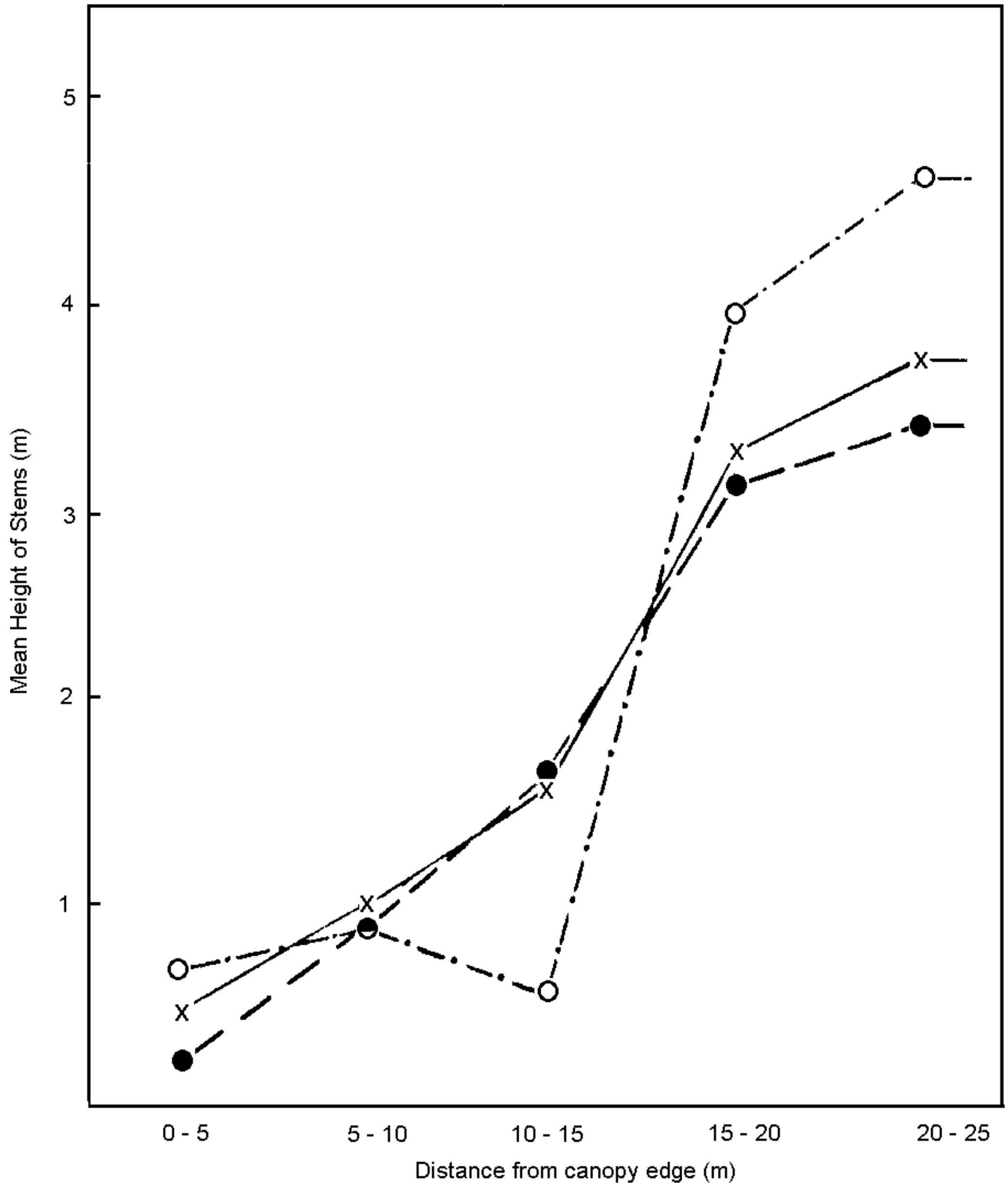

Figure 1: Relationship between height growth of lignotubers and distance from canopy edge - Spotted Gum-Ironbark forest (from Henry & Florence, 1966). (Assessed 2 years after creation of canopy opening; lines represent heights along different transects.)

Furrer however notes that some regeneration (almost certainly developing from lignotubers) occurs between openings where the stand has been thinned or culled out. Such regeneration has lower stocking and poorer height growth and crown vigour-than that in the larger openings. He provides figures suggesting that adequate regeneration can appear where the overstorey basal area is reduced below about 10 m^2/ha. In their Queensland study, Henry & Florence found that the presence of 30 seed trees per hectare, mostly of pole size, was sufficient to force seedling regrowth into the lignotuberous resting stage and prevent its further development.

Other factors also may influence the response of lignotubers of Spotted Gum and its associates. Floyd (1961), using fenced plots, showed that cattle grazing could hold back the development of stems from lignotubers. In his study on Bom Bom S.F., the benefits from fencing were more marked on a ridge site than in a gully. Fencing, this time against wallabies, also proved beneficial on the South Coast in allowing regeneration to develop, though perhaps the general response of the understorey was even more striking than that of the lignotubers. In this case the effects were greater towards the gullies than on the ridges (Baur, 1958).

In some of the moister Spotted Gum forests on the South Coast there appear to be rather specific problems associated with the lignotuber pool and indeed with regeneration generally. These will be examined in Section 6.5.

6.4.2 The Lignotuber Life Cycle

From the information given above a picture of the dynamics of the lignotuber pool can be put together, and there seems little reason to doubt that the basic features are not the same wherever this pool is present, i.e. in most Spotted Gum stands:

- The number of lignotubers constituting the pool will fluctuate from year to year, though in any particular site it tends to stabilise around a fairly constant value.
- There may be substantial differences between the numbers of lignotubers in the pool in different sites.
- A well-established lignotuber up to 2.5cm in diameter can develop in a little over a year from germination.
- Additions to the pool come from seedlings that are able to survive long enough to form a robust lignotuber; most seedlings do not do this, and die within a year of germination.
- It seems likely that most additions to the pool follow occasional fires, which provide suitable conditions for germination and establishment.
- Whilst a Spotted Gum seedling can proceed actively to sapling size without an intermediate lignotuber resting stage, this seems unusual in most sites.
- The lignotubers tend to produce a few straggling branches that can be obscured in the grass or other undergrowth. Most of these stems are under 30cm high.
- The stems can be repeatedly destroyed by grazing, fire or other damage, but will be replaced from the woody base.
- The Queensland figures on the depletion rate of lignotubers (from 2 to 4 per cent a year) suggest that individual lignotubers will live between 25 and 50 years on average.
- Much higher depletion rates occur when the lignotubers are heavily shaded, as by dense lantana.
- Whilst repeated light fires appear to have no effect on lignotuber mortality (though they may reduce the rate of accretion of new lignotubers), heavier fires can promote the development of vigorous shoots, but then lead to accelerated mortality if the rejuvenated plants are unable to continue their development. (At the same time the heavier fire probably allows for an increased recruitment of new lignotubers.)
- Lignotubers respond rapidly with the production of actively growing shoots to removal of the canopy, but appear to require openings of at least 30m in diameter before maximum growth rates can be attained. It is from these responding stems that most or all of the new trees in the stand will come.
- Excessive grazing or browsing pressure can hold back this response to canopy opening.

6.5 The South Coast Problem

As already indicated, in the moister Spotted Gum types on the South Coast there can be difficulties in obtaining adequate regeneration of Spotted Gum. Unlike the drier, and generally more widespread, types these moister sites often lack a lignotuber pool, and to the extent that the pool does occur it may only respond weakly to opening.

This problem has long been recognised, and was discussed by Furrer (1971), who considered weed growth in the moister sites to be the cause of the problem, as others earlier had blamed it on wallaby browsing. Furrer favoured heavy treatment of the South Coast forests to remove the large residual non-merchantable overwood, and considered that seedbed preparation by tractor was needed in the moist sites, so as to avoid the weed problem following burning.

Recently some of the heavily treated or clearfelled sites on Kioloa and South Brooman S.F.s have been examined by Neave (1983) in an effort to identify factors influencing the success or otherwise of Spotted Gum regeneration. Whilst the study raises more questions than it answers, Neave makes a number of suggestions and points resulting from his work:

- Except for the drier, exposed, upper slope positions, unsatisfactory regeneration could be found in all topographic positions, though most marked in the lower slope sites.
- On the South Coast Gum is nearing its geographic limits, and it appears to show a weaker competitive ability than other associated eucalypts which typically have more specialised environmental requirements than Spotted Gum.
- A lignotuber pool tends to be absent in the lower slope positions.
- The nutrient status may be marginal for the early development of Gum, further reducing its competitive ability. Coupled with this, there is a suggestion that in some sites a period must elapse to allow the Gum seedlings to get their roots into the more nutrient-rich lower soil horizons: this would favour the release of lignotubers, but not the direct progression from seedling to sapling.
- In some areas clearfelling has apparently led to a rise in the watertable, reflected by the presence of a hydrophilic understorey (e.g. *Gahnia, Lepidosperma*), again disadvantaging Spotted Gum.
- Poor Gum regeneration was associated with sites where there was a presence of *Goodenia*, a vigorous grass cover or a vigorous presence of other tree regeneration.
- Despite the problems, in about half the sites sampled there was a good stocking of vigorous Spotted Gum.

Neave suggests that the answer to the difficulties in obtaining regeneration after logging in these problem sites lies in building up a lignotuber pool, sufficiently well established to be able to respond vigorously once the overstorey is finally removed. To do this he recommends a series of light overstorey openings that would allow the lignotubers to become established - in effect, a form of the Uniform System. One suspects that it might need be coupled with more aggressive prescribed burning, to convert the moister stands to areas with the facies of dry sclerophyll forest.

There is undoubtedly a problem in obtaining Spotted Gum regeneration on parts of the South Coast, and most notably in the moister coastal stands of Batemans Bay district, though at least some foresters query whether it is indeed a South Coast problem, rather than a broader problem of moister sites generally, and whether its prominence may not partly reflect the extent of external research effort directed at this one district, rather than at a wider range of Spotted Gum forests. Certainly the problem should not be overemphasised in relation to the amenable nature of Gum through most of its South Coast occurrence. To the extent that it does exist, it is a problem of absence of regeneration from many of the high quality lower slopes, and of unpredictable regeneration on some of the higher slope positions, and it is made more tantalising by its occurrence on sites where Gum has clearly been able to regenerate and to dominate the resultant stands in the past. It appears to be a problem with no simple or single explanation, and possibly with no ready solution under present day conditions. Both Furrer and Neave have made valuable contributions towards its understanding, but as B. J. Furrer (pers. comm.) has recently stressed, there appear to be other factors involved than those suggested by them. These may include fire regime and possibly even long-term climatic change.[7]

6.6 Coppice

Spotted Gum and its major associates are species that normally coppice well. This is of little significance in the case of the larger stems removed as sawlogs, but in stands being managed for mining timber or other small-wood production, or where such products are being removed as thinnings; coppice is likely to prove the major source of regeneration.

The early response of coppice tends to be much faster than that of lignotubers released in the same operation. Some South Coast figures are probably typical:

Age	State Forest	Mean Ht. (m) - Coppice	Mean Ht (m)- Lignotubers
18 months	Corunna	3	0.75
2-3 years	Bolaro	6	Just responding after drought
4 years	Boyne	8	2-3

Despite this initial advantage in growth, there is a belief on the South Coast that regeneration released from lignotubers will gradually catch up to the coppice over a period of about 15 years, though no statistical evidence of this has been seen.

There appear always to be some stumps that fail to coppice, and occasionally these may be quite numerous, as in a stand on Currumbene S.F. harvested for mining timber in 1977: Excellent regeneration from the release of lignotubers is present, but few of the stumps had coppiced. It seems probable that failures of this nature are generally due to the treatments being carried out when starch levels in the stems are low, so that the stumps have few reserves that can be used for new growth. Starch reserves are depleted during periods of active growth flush, and working with a number of N.S.W. species (though not Spotted Gum), Bamber & Humphreys (1965) showed that stem starch content tended to be at its minimum in autumn and at its maximum in spring. Harvesting during the former period is likely to result in poor coppicing response.

Unlike most stands managed by a coppice system, Spotted Gum types usually receive repeated selective harvesting, rather than a regular, but less frequent, clear cutting to produce a new, even-aged crop. This is largely due to the selective and variable nature of the main small-wood markets, whether for mining timber or poles. Whilst this may reduce the efficiency of the current coppice system in terms of total productivity (Curtin, 1970), it does not generally seem to have adversely influenced the development of successive new coppice crops, though ultimately some form of heavy treatment - virtually clear cutting - is likely to be necessary to remove the unmerchantable stems which gradually build up in the stand: it is probably significant that some of the best mining timber stands in the Wyong district are ones that have received a very heavy opening up, either from logging and treatment (e.g. Yambo stands, Olney S.F.) or from storm damage (e.g. Gale Point, Ourimbah S.F.), within the last four or so decades.

In many forests the usual selective logging cycle for these coppice stands is about 8 years.

The same selective markets have, in the past, often caused stems to be cut with undesirably high stumps: mining props, for example, are traditionally recovered from the toe (i.e. small end of stem) down, and operators have preferred to avoid cutting through the butt swell close to ground level when the bottom half metre or so of the stem will not be used. This practice led the Forestry Commission often to carry out a subsequent coppicing treatment, when stumps were reduced

[7] One reviewer of an early draft of these Notes, after referring to Andrew's Zambian provenance trial (Section 2.2), suggested that the answer might be in introducing a hardy northern source, with strong lignotuberous development, into these southern stands.

to a height of 10-15cm and shaped to drain moisture away, thus favouring the development of wind-firm, decay-free coppice of maximum potential merchantable length. In more recent years a better control of operations has meant that stumps are usually left in this form by the prop-cutters. Certainly they should be.

6.7 Regeneration Damage

As in other communities, a large number of agencies can damage or destroy regeneration in the Spotted Gum types.

Young seedlings are subject to the usual array of climatic vagaries, including losses during hot, dry periods. Frost has been blamed for the absence of regeneration from some broad South Coast gullies, though a raised watertable may be no less to blame, while Dale & Hawkins (1983) note that hail can damage flower or seed crops.

Fire will destroy young seedlings, and annual burning may prevent the recruitment of Spotted Gum seedlings to the lignotuber pool, though associated eucalypts appear to be less affected (Henry & Florence, 1966). However established lignotubers seem little affected by regular low intensity fires. Developing regeneration, whether from seedling, lignotuber or coppice, can be killed back to ground level by fire, thus preventing the development of a regrowth crop in sites subject to regular, short-interval burning, as occurs In some of the stands close to the city of Cessnock.

In the moister types, the use of fire can promote aggressive **weed** growth - a feature, of course, of many of the moister coastal forest types (e.g. see Nos. 1 & 4 of these Notes). Various wattles, Goodenia and Soldier Vine are among the weeds that can swamp regeneration following fire. Lignotuber stocking is reduced rapidly under a dense cover of lantana (Henry & Florence, 1966), and presumably of other undergrowth species. B.T. Furrer has expressed the view that Goodenia may not merely shade out regeneration, but have an actively antagonistic effect on young eucalypts.

Spotted Gum appears to suffer little from insect attack on the trees, though Dale & Hawkins mention insects as a source of damage to seed crops, while Carne & Taylor (1978), in their only reference to Spotted Gum, refer to a fly that causes severe galling of the buds.

Mammals can damage Spotted Gum regeneration in a number of ways. Dale & Hawkins (1983) report that giant fruit bats (flying foxes) have been known to strip large quantities of blossom from trees. Pigs, rooting in the undergrowth on the South Coast, can physically destroy established regeneration including lignotubers: as far as is known the damage is accidental, and it could prepare a receptive seedbed for later regeneration. Browsing and trampling, by both native and domestic animals, has been shown in fencing plots to reduce or prevent the development of regeneration and associated plants, and macropod browsing is known to cause particularly heavy damage to regeneration in moist situations in the Batemans Bay district (V. Hervert, pers. comm.). Among the birds, Gang Gang Cockatoos, Crimson Rosellas and probably other parrots can destroy considerable quantities of unripe capsules by chewing individual capsules and by clipping off fruiting branchlets.

6.8 Early Development

The major features of the early development in the Spotted Gum types have already been dealt with:

- The usual development of a small, but well established, lignotuberous plant within 12 months of germination. Whilst the woody lignotuber will continue to grow, the leafy branches will tend to remain low and sprawling until the removal of overhead canopy produces the opportunity for active vertical growth.

- Under some circumstances, involving favourable growing conditions, germinates can continue active growth without an intermediate lignotuberous resting phase. Henry & Florence (1966) record seedlings on ash-beds reaching heights of up to 3m in 1 year and 4.3m in 2 years; seedlings in a CSIRO trial on Kioloa S.F., given presumably optimum growing conditions, have reached about 10m in height in 4 years; the best provenances in the North Coast trial (see Table 2) at age 13 years had average heights of 19m on the fertile Richmond Range site and 12m on the less favourable Bom Bom site. Spotted Gum can be a very fast early grower.

- More usually regeneration develops from the release of the lignotuber pool, and again height growth can be rapid. Henry & Florence quote a Queensland study where the best plants, all with stems under 1.2m at the time of release, had heights of up to 5m after 1 year and of over 6m after 2 years. In other Queensland sites Florence et al. (1970) record stems exceeding 7m in height 2 years after release, and up to 11m in height and 9.7cm in DBH 4 years after: in these cases the regrowth would almost certainly have been lignotubers with a distinct vertical stem at the time of release, but the increments recorded in the 4 years' stand (height CAI of 1.8m and DBH CAI of nearly 2cm) indicate that the regrowth response was indeed both real and rapid. On the South Coast regrowth heights of between 2 and 4m at age 4 appear common, and on one site, not atypical, heights up to 10m had been reached in 10 years. Growth may of course be much slower, and the work of Henry & Florence, reproduced as Fig. 1, clearly illustrates the retarding effect of proximity to overhead canopy.

- Coppice development is even faster, and on the South Coast appears commonly to average about 2m a year on the best stems for the first three or four years, with heights of up to 8m noted at 6 years, 12 in at 12 years and 20m at 15 years. Coppice response will be further examined in Section 7.2.

- Among the associates of Spotted Gum, Blackbutt is non-lignotuberous and usually demonstrates faster early growth; Sydney Blue Gum probably usually reacts as a non-lignotuberous species (i.e. grows through without an intermediate phase) and again will normally be the faster grower. The other, typically lignotuberous, associates appear to respond in a similar manner to Spotted Gum and to show growth rates that are usually of the same order or somewhat slower, though sometimes their response may be faster than that of the Gum: on the South Coast it is not unusual for White Stringybark to grow more rapidly than Spotted Gum in the same stands, and Grey Ironbark and Sydney Peppermint are also regarded as ready and fast starters. In the Raymond Terrace area, Curtin (1961) ranked Spotted Gum as one of the slowest of the local species in early growth, while in southern Queensland Broadleaved White Mahogany can outgrow Spotted Gum in regenerating stands.

7. GROWTH AND YIELD

7.1 The Virgin Forest

As seen, the Spotted Gum types vary from tall, wet sclerophyll forest bordering on, and sometimes being invaded by, subtropical rainforest, through to open woodlands where the Gum is associated with White Cypress Pine in inland southern Queensland. It may therefore seem presumptuous to write of "the virgin forest" as though the types exhibited the same traits throughout this very wide geographic and environmental range. Perhaps it is.

Nonetheless there do appear to be important features shared in common throughout this range, quite apart from that of the distinctive appearance of Spotted Gum itself.

Firstly, with a possible exception in the case of the better quality stands, and particularly those involving the Richmond Range strain, Spotted Gum and most of its associates appear to regenerate from an existing pool of lignotubers. Under pre-European conditions, with a probably more frequent and regular burning pattern, this may have applied no less to even the most mesic and fertile sites.

Secondly, Spotted Gum and its eucalypt associates, both as trees and lignotubers, show a high level of immunity to major fire damage. Certainly in the coastal districts, fires could burn regularly without having much effect on the overstorey trees and without depleting the lignotuber pool; by maintaining a reasonably open understorey they indeed facilitated the establishment of lignotubers and their subsequent survival: one suspects that on the South Coast, for example (as in other N.S.W. forest areas), a major effect of European settlement has been to allow a thickening up of the undergrowth in many of the moister sites, leading to the reduction or loss of the lignotuber pool.

The third feature, related to the presence of the lignotuber pool and in many cases to the use of fire, is that the virgin Spotted Gum stand was uneven-aged. The release of lignotubers would follow the loss of existing canopy trees by natural death or windthrow and in either case often pushed towards mortality by fire-caused butt damage. In the larger gaps the regeneration would respond actively, and it was here that most of the future stand dominants undoubtedly appeared; in small gaps the response would be weaker, and the resultant trees would usually tend to be malformed and suppressed. Nonetheless, and although more work on the subject is needed, it is probable that the suppressed stems, released from the dominance of an adjacent stem, often still retained some capacity to respond, albeit initially slowly, and in some cases they would go on to become dominants themselves - their future would depend on the nature of other stems in the vicinity. As in many fields in this life, a lot depends on luck.

The result of these features was that Spotted Gum stands naturally were made up of trees of a wide range of ages and of sizes, with the two not necessarily being closely related. The major difference between stands in different parts of the species range would have been in stocking, ranging from fairly heavily stocked stands on the better sites to quite open stands in the less favourable positions. Furrer (1971) assessed one such unlogged stand on Kioloa S.F. Its make-up by dominance classes is shown in Table 6. (The use of these dominance classes in an uneven-aged stand may be queried, but the classification, coupled with one for crown vigour, was routinely employed in the description of Forestry Commission continuous forest inventory plots at the time of Furrer's work and appears to have given a reasonable indication of growth potential and tree condition in these stands). This would be a stand at the more favourable end of the spectrum, as indicated by the high BA of the stand, and it would have typified many of the State's better quality Spotted Gum forests at the time of European settlement. Furrer notes that in terms of the bole volume of the standing trees, only 32 per cent (100 m^3/ha out of about 315 m^3/ha) was considered saleable; nearly half the BA was in useless trees; 15 stems per ha only were classed as having a good crown, but 95 had poor crowns; and there were 26 stems per hectare with a DBH exceeding 70cm, and 9 exceeding 1 metre.

Table 6

DETAILS OF VIRGIN - STAND, KIOLOA S.F.
(from Furrer, 1971; stems over 10cm DBH)

DOMINANCE CLASS	**STOCKING** (/ha)	**BA** (m^2/ha)	**MEAN DBH** (cm)
Dominant	10	11.3	120.9
Co-dominant	47	18.9	71.4
Subdominant	90	9.1	35.8
Suppressed	67	4.9	30.2
All Stems	214	44.2	51.3

Stands elsewhere would have varied, often in the direction of less dense stands, with lower BAs and generally smaller trees. However it seems that even the poorer areas of Spotted Gum type carried uneven-aged stands with a wide range of size classes present, including a few quite large trees. When we look at stands that are managed for mining timber under a coppice system, we should remember that the stands did not always look the way they do today.

In succeeding sections, growth in these coppice stands will be looked at separately from that in stands being managed for the production of larger stems (poles, sawlogs).

One final preliminary comment about Spotted Gum growth might be noted. Spotted Gum itself is a tree that can carry a very thick bark. Sometimes (particularly following fire or drought), trees may shed much outer bark while making little new bark or wood at the cambial level. The result is that diameter measurements, taken even several years apart, may show a distinct reduction in diameter throughout the stand.[8] Growth indications in Spotted Gum, based on short-term measurements, may give very misleading trends.

7.2 Coppice Stands

Coppice is a very widely applied system around the world, and one particularly well suited to many eucalypts[9], including most of those occurring in Spotted Gum types.

Whilst traditionally coppice systems operate as short rotation systems of even-aged stands, often with a low stocking of stems retained as standards for longer growth, in N.S.W. the Spotted Gum and associated types being grown primarily for mining timber production are usually uneven-aged, with selective harvesting at relatively short intervals (commonly only about 8 years) to supply current, but variable, market needs. Stands may contain coppice of two or three age groups, as well as some standards that are usually maintained for pole or small sawlog production. Stands have in the past been managed by the more conventional even-aged system (e.g. for pulpwood in the Raymond Terrace district), but this seems unusual at the present time. However, as noted in Section 6.6, periodic reversion towards an even-aged condition is likely to be desirable for the long-term productivity of these stands.

The main information on the growth of N.S.W. coppice stands comes from studies by Curtin (1961, 1970a) who looked at even-aged stands in the Raymond Terrace area (1961), and subsequently at a wider range of stands. Curtin's study areas were not all of Spotted Gum type, but his conclusions appear to have general application. In his 1970 paper, Curtin summarised his earlier conclusions in the following terms:

1. *“After clear falling there is an extremely rapid development of coppice shoots and lignotubers for the first 3-4 years. This development is associated with rapid growth in height, diameter and basal area, such that half the rotation size may be reached in the first 4 years. (e.g. diameters averaging about 9cm and a BA of about 9 m^2/ha in 4 years).*

2. *Following this early rapid growth, there is an equally dramatic fall in diameter and basal area growth. At that time (1961) it was suggested that basal area increment (BAI) dropped to about 1 m^2/ha per annum and remained fairly constant over time. More recent data now suggests that BAI will continue to reduce gradually with age.*

3. *While the BAI of these stands are relatively high, this growth is distributed over large numbers of trees per hectare. Consequently the mean diameter increment of these stands drops very rapidly with age and is often below 0.25cm per annum.*

4. *Within one stand there is a general trend of increasing diameter increment (DI) with individual tree diameter. However there is often a curious depression of DI for those trees in the lower middle size classes. At that time it was suggested that the smaller size classes might have been stimulated by fire. This phenomenon has been found to occur in many plots established since 1961 and requires more investigation.*

5. *There is some evidence that coppice growth competes strongly with select standards.*

6. *There are large differences in growth rate between individual species, White mahogany, Grey Gum, White Stringybark, Peppermint and Ironbark being superior to Bloodwood, Spotted Gum, Red Mahogany and Smoothbarked Apple.*

7. *Volume increments varied from 0.45 to 2.4 m^3/ha per annum.*

[8] One former prominent researcher, who made notable contributions to the silviculture of N.S.W. eucalypt forests, spent an afternoon calculating how long it would take the plot to do a drongo, when three consecutive annual measurements of a growth plot on Glenugie S.F. showed consistent shrinkage of stems and reduction in BA.

[9] The only reference to eucalypts in R.S. Troup's classic “Silvicultural Systems" is one extolling their virtues under coppice in India.

8. *An examination of size class distributions suggested that reasonable merchantable yields could be obtained from stands with a mean diameter of 13cm by logging from above. There was a complete absence of knowledge on the way such a stand might develop after logging, particularly with respect to the interaction of new coppice shoots with the older suppressed trees. Similarly there was no knowledge of stand reaction to thinning from below."*

Some of the unknowns were examined during the subsequent 9 years and also reported in 1970. Among the later findings:

- Coppice can strongly hold back the growth of standards.
- When the stands are subdivided into their respective dominance classes, each class contributes to the total growth in direct proportion to the basal area of the class. For example, if 30 per cent of the BA is in the suppressed class, then this class will accumulate 30 per cent of the total growth. This suggests that the competition offered by suppressed trees to the select (dominant) trees of the stand remains intense, at least under dry conditions.
- There is so much variability between individual trees of the same species and dominance class, growing in the same stand, that the selection of "cut" and "leave" trees during silvicultural treatment is very difficult.
- These stands have a strong tendency to "lock" under conditions of high stand density and low rainfall. Consequently the growth redistribution obtained by thinning is very important and enhanced relative to high quality species such as Blackbutt.
- For optimum diameter response, basal areas should be reduced to about 7 to 9 m^2/ha.

Curtin hypothesised some coppice stand growth relationships that are presented both as graphs and a table in his 1970 paper; he also presented some actual data from the Cessnock district on the growth of coppice of known age: this would be largely Spotted Gum, and his data, converted to metric, is reproduced in Table 7.

Coppice is likely always to be important as a means of regenerating and managing many areas of Spotted Gum types, particularly those of lower quality used for the production of small-wood. There is still much to be learnt about it, especially in the response of individual stems to release. Some information on such matters should come from studies already under way, but not yet analysed, while long experience in forests in the Newcastle region indicates the continuing success of coppice as a means of managing these types.

Table 7

AVERAGE SIZE OF COPPICE STEMS OF KNOWN AGE - CESSNOCK MANAGEMENT AREA

Age years	**Mean DBH** (cm)	**DBH-MAI** (cm)	**DBH-PAI** (cm)
3	3.3	1.10	0.80
9	8.1	0.90	0.65
11	9.4	0.85	0.65
13	10.4	0.80	0.50

7.3 Large-timber Stands

Growth in Spotted Gum types, and more particularly growth of Spotted Gum itself, have been looked at by a number of workers from the South Coast to Queensland in stands being grown for the production of sawlogs.

Some of their results, relating to diameter growth, are summarised in Table 8. Features shown here include:

- Large differences between different stands or areas.
- Large differences between different components of the one stand (e.g. compare References 2 & 3, 4 & 5, 7 & 8).

Excluding the even-aged stands (Refs. 2 & 3) and Floyd's North Coast figures (Ref. 6), a rather limited range of increments shown by any component within a stand over the range of diameters, with a general tendency for decreasing increment with increasing DBH.

Grimes (1978), working in the Maryborough, Qld., district, and Keady (1978), on the N.S.W. South Coast, have both examined the role of crown characteristics on the growth of trees in the Spotted Gum types, and as expected both noted highly significant effects. Grimes recognised five crown characteristics - position, size, density, dead branches and epicormics. Each characteristic was given a score ranging from up to 3 (for epicormics) to up to 9 (for density), with the points added for a maximum of 27 points for a particularly good tree. The system is illustrated in Appendix 4. Some of the influences of crown on growth are demonstrated in Table 8 (Refs. 7 & 8), and a further illustration is given in Table 9.

Table 8

SPOTTED GUM TYPES - ANNUAL DIAMETER GROWTH TRENDS

REFERENCE	DBH class (cm)							
	0-10	10-20	20-30	30-40	40-50	50-60	60-70	70-80
1	-	.20	.30	.33	.36	.36	.30	.30
2	1.65	1.17	1.02	.76	.64	.56	-	-
3	.76	.61	.43	.33	.15	-	-	-
4	-	-	-	.75	.70	.65	.60	.55
5	-	-	-	.48	.42	.37	.32	.28
6	-	.43	.38	.30	.23	.15	-	-
7	-	.59	.49	.48	.41	.43	.41	.41
8	-	.68	.64	.60	.58	.63	.58	-
9	.25	.34	.38	.36	.34	.32	.26	.34

References:
1. *Furrer (1971), uneven-aged Spotted Gum, Benandarah S.F.*
2. *Furrer (1971), even-aged Spotted gum, dominance class 1, South Coast.*
3. *As for 2, dominance class 3.*
4. *Keady (1978), all species, vigour class 1, South Coast.*
5. *As for 4, vigour class 3.*
6. *Floyd (1962), as presented by Curtin (1968), Spotted Gum, best 100 stems per ha, North Coast sites.*
7. *Grimes (1978), Spotted gum, all stems, south eastern Queensland.*
8. *As for 7, stems with high crown assessment rating.*
9. *Grimes & Pegg (1979), all species, south eastern Queensland.*

Table 9

INFLUENCE OF CROWN ASSESSMENT ON DBH PAI. (cm/an)

(from Grimes, 1978)

Assessment Score	SPECIES			
	Spotted Gum	Broadleaved Ironbark	Qld. Grey Ironbark	White Mahogany
Under 12	0.12	0.09	0.08	-0.32
12-15.9	0.25	0.24	0.21	0.21
16-19.9	0.42	0.45	0.39	0.47
20-23.9	0.64	0.70	0.65	0.74
24-27	0.88	0.65	-	-
Mean	0.49	0.50	0.36	0.52

Keady's classification, outlined in Fig. 2, is based largely on evidence of present or past restriction of the crowns of trees, and it makes a basic split into three groups of trees - mature dominants, unrestricted pole regrowth, and others. Again it provides a basis for distinguishing trees with different capacities for growth and a summary of his results (all species, but predominantly Spotted Gum) from Bodalla S.F. is given in Table 10.

Of the two, Keady's system is the simpler and speedier to apply, though possibly providing a slightly less precise correlation with growth: certainly a direct comparison of the two approaches should be instructive. Both tend to emphasise the quality of the crown, which both workers found to have a major influence on growth. Keady's system receives some use on South Coast forests as a guide in the treatment of the stands.

Figure 2: Outline of Crown Quality Classification of Keady (1978)

Curtin (1968), re-examining data presented earlier by Floyd (1961) from a range of North Coast plots, showed the large effect of stand BA on diameter increment. This is demonstrated in Table 11, which refers to the influence of stand BA on the growth of the best 100 stems per hectare. Curtin states: *"…. both diameter and BA should have an influence on diameter Increment, and it is quite likely that even under conditions of a constant total BA, the diameter increment will drop off with increasing DBH However the increments listed (in Table 11) are proposed as the most suitable for all size classes under given conditions of total BA."*

Curtin suggested that the substantial decrease in diameter increment recorded by Floyd (see Table 8, Ref. 6) was largely a result of BA differences between plots. Curtin presents a similar effect in his review of the growth of Spotted Gum in a plot on Wyong S.F., measured over a period of 45 years (1917-1962).

Various estimates of volume growth in irregular Spotted Gum stands have been made, and a few of these are outlined in Table 12. Values around 1 m^3/ha/an appear to apply fairly widely, though in most cases this includes the growth put on to trees regarded as unmerchantable at the time of the studies.

Even-aged Spotted Gum stands are not usual, but some do exist and the growth on three such areas on the South Coast was comprehensively reviewed by Furrer (1971). These areas were a plantation established in 1942 on Benandarah *S*.F., 1917 regeneration on Corunna *S*.F., and 1895 regeneration on Termeil S.F.[10] From this information Furrer developed two yield tables, one for a stand being grown primarily for sawlogs on a rotation of 80 years, and one for a stand primarily managed for mining timber on a rotation of 40 years. These tables were metricated by Borough et al. (1978), and in this amended form are reproduced as Tables 13 and 14.

These even-aged stands, under fairly intensive management, show considerably higher volume increments than the irregular stands.

Table 10

INFLUENCE OF CROWN QUALITY CLASSIFICATION ON DBH PAI.

(from Keady, 1978)

Main Category	Class	Mean P A I (cm)	Stand Deviation	Confidence Limits of mean
Dominant Stratum	1	0.66	0.22	0.59 - 0.73 *
	2	0.47	0.25	0.41 - 0.53 *
	3	0.18	0.13	0.08 - 0.28 *
	4	0.38	0.20	0.35 - 0.41 *
	5	0.18	0.13	0.14 - 0.22 *
Pole	6	0.77	0.24	0.66 - 0.88 *
	7	0.60	0.19	0.57 - 0.63 *
	8	0.38	0.19	0.35 - 041 *
Other	9	0.29	0.15	0.25 - 0.33 *
	10	0.13	0.11	0.12 - 0.14 *
	11	0.33	0.18	0.30 - 0.36 *
	12	0.16	0.11	0.14 - 0.18*
	* Confidence limits are at the 0.05 probability limit			

[10] The Termeil stand has sometimes been described as having originated in 1910, but according to Furrer the earlier date is considered more realistic.

Table 11

INFLUENCE OF STAND BA ON GROWTH OF 100 BEST-STEMS/HA
(after Curtin, 1968)

Total Stand BA (m^2/ha)	**BA incr.** (m^2/ha/an)	**DBH incr.** (cm/an)	**Mean DBH** (cm)
5	0.27	0.73	23.2
10	0.19	0.57	21.5
15	0.16	0.44	22.8
20	0.15	0.38	24.2
25	0.13	0.32	25.9
30	0.12	0.25	28.9
35	0.11	0.22	30.8

Table 12

IRREGULAR SPOTTED GUM STANDS - GROSS VOLUME INCREMENT ESTIMATES

Reference	**Locality**	**Other Notes**	**Volume M.A.I.** m^3/ha/an
Furrer (1971	Benandarah	- CFI plots - mean; all stems	1.47
	Benandarah	- CFI plots - range	0.39 - 2.93
	Currowan	- study plot - all stems	1.24
Curtin (1970b)	Yarratt	- spotted gum types only	1.36
Curtin (1968)	North Coast	- growth plots (estimate)	1.00
Henry (1960)	S. Qld	- untreated stand	0.65
	S. Qld	- treated stand	1.03
Grimes & Pegg (1979)	S. Qld	- stems 20cm +	0.96
	S. Qld	- stems 40cm +	0.59

7.4 Stand Treatment

As with most eucalypt forests, Spotted Gum types receive stand treatment through periodic harvesting and in many cases through subsequent silvicultural treatment, usually culling. As markets for lower standard logs improve, harvesting under proper control can provide most of the necessary treatment, though the need for some culling or releasing is likely to remain with us for many years.

The previous review of growth indicates that the increment of individual trees in the Spotted Gum types is severely restricted by high stockings (e.g. by BAs above about 20 m^2/ha) and is strongly influenced by the crown condition of the trees. The release of regeneration also requires an opening of the stand (Section 6.4.1).

Virgin stands would typically carry high BAs, with a large volume that would not be merchantable even by to-day's standards (Section 7.1). Early logging was usually highly selective, but culling to remove the trees of no apparent merchantable value was being practised in at least some Spotted Gum stands prior to the 1920's, and increased after that. Reviewing its effectiveness, as shown by C.F.I. plots on Benandarah S.F., Furrer (1971) could state that treatment had been successful, with 81 per cent of total stand volume in useful stems and with no unmerchantable dominants, and few unmerchantable co-dominants, present. Growth was being concentrated on the useful sector of the stand.

From Queensland, Henry (1960) reported the effects of various intensities of treatment applied to a heavily logged Spotted Gum-Broadleaved Ironbark type: this was probably the first attempt to assess the value of timber stand improvement treatments in Australia. The heavier treatments showed marked responses in diameter and volume growth (see Table 12), and also revealed an improved value increment (though, as Ferguson & Reilly (1975) subsequently demonstrated in a "paper" exercise on the South Coast, net social benefit may have been greatest in some of the less intensive treatments.)

In both N.S.W. and Queensland there has been debate on the suitability and response of some of the stems retained after the silvicultural treatment of Spotted Gum stands. Florence et al. (1970) suggested that many of the smaller retained trees are physiologically old and show only a weak response to treatment. They proposed an alternative logging and treatment schedule to the one then in vogue in Queensland, favouring the removal of the more poorly formed and least vigorous component of the stand, and the retention of the better trees regardless of size. In practice the revised schedule tended to remove more stems and volume than the previous schedule, but the retained stems averaged considerably higher increments than those previously retained.

In N.S.W., where there has been an almost universal desire over the past two or three decades to apply heavy logging to virtually all eucalypt forests, the tendency has been to remove more, and retain less, than in Queensland. Nonetheless the debate has continued. Treatments intended to retain suitable stems have often found - or allegedly found - few to retain, so that the treatment has ended up as a clearfelling with scattered seedtrees. The situation has been complicated by a sale system that imposes somewhat arbitrary size limits on quota logs, leading to criticism where stems slightly below the size of quota logs have been sold on the grounds that their crowns or form, were so poor that they would never make a quota log. For the long-term productivity of the stand, the decision has almost certainly been correct. The criticism has been, however, that in areas where there is an impending deficiency in quota logs, even the slow increment of such trees is likely to be sufficient to push them up to quota size at the time such logs will be most in demand. But the answer seems better to reduce mill quotas, than to disallow the sale of these small stems of low productivity.

Table 13

YIELD TABLE FOR SPOTTED GUM MANAGED PRIMARILY FOR SAWLOGS
(After Furrer, 1971)

Age (years) And condition	Stocking (stems per Hectare)	Mean DBH (cm)	Basal area (m^2/ ha)	Merchantable Volume K (m^3 /ha.)
10	988	11.4	10.3	Nil
25 BT	988	18.0	25.5	136
25 BT	395	17.0	9.0	30
25 AT	593 { 296 297	18.9 { 24.6 10.6	16.5	106 { 106 Nil
40 BT	593	23.9	26.5	171
40 T	321 { 148 173	19.7 { 23.6 15.5	9.8	56 { 49 7
40 AT	272 { 148 124	28.0 { 36.1 12.7	16.7	115 { 115 Nil
60 BT	272	34.5	25.7	182
60 T	173 { 49 124	23.0 { 35.6 15.5	7.2	42 { 37 5
60 AT	99	48.8	18.5	140
80	99	58.4	26.5	200

KTotal yield 328 m^3/ha; mean annual increment 4.1 m^3 /ha.

Table 14

YIELD TABLE FOR SPOTTED GUM MANAGED PRIMARILY FOR MINING TIMBER
(after Furrer, 1971)

Age (years) and Condition	Stocking (stems per hectare)	Mean DBH (cm)	Basal area (m^2 ha)	Merchantable Volume K (m^3 ha)
10	988	11.4	10.3	Nil
20 BT	988	16.3	20.4	74
20 T	198	19.8	6.1	33
	543	17.0	12.3	41
20 AT	790	15.2	14.3	41
	247	10.2	2.0	Nil
	543	23.9	24.3	181
40	790	21.3	28.1	184
	247	14.0	3.8	3

K Total yield 217 m^3/ha; mean annual increment 5.4 m^3 /ha.

7.5 Site Index

In their comprehensive review of growth in the Spotted Gum forests south of Maryborough, Grimes and Pegg (1979) noted marked differences in growth between different forests, suggesting corresponding differences in site quality. Using heights from all trees measured in the yield plots, they were able to construct nests of curves for DBH against height (Figure 3). Comparison with data from forests near Brisbane showed almost identical relationships, suggesting that these curves can be used as a reasonably constant measure of site index. They identified site index as the predominant height at a DBH of 30cm, and suggested that the SI of a stand could be determined by measuring the heights for diameter classes represented in the stand, and referring to the curves or to a table that they appended.

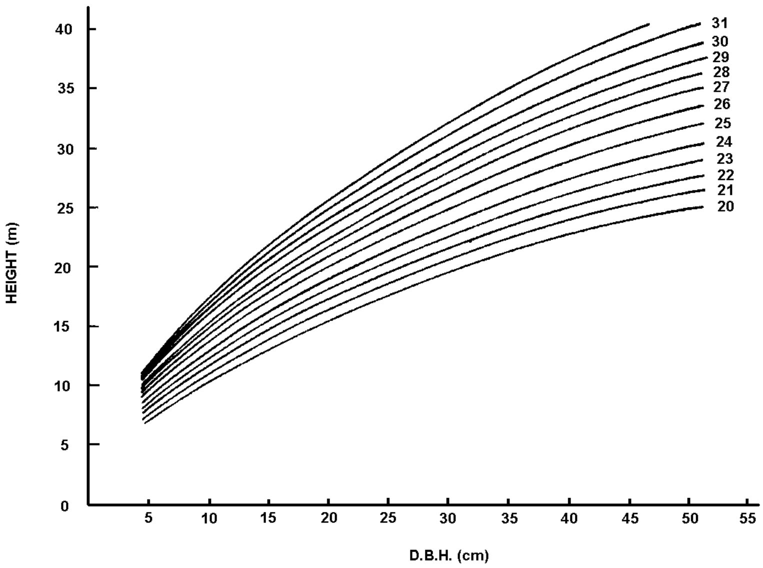

Figure 3: Site Index Curves for Spotted Gum - Ironbark Stands
(after Grimes and Pegg)

The approach is not known to have been tried in the N.S.W. Spotted Gum stands.

7.6 Size and Longevity

Spotted Gum trees, particularly under wet sclerophyll forest conditions, can grow to large size: several are among the largest known trees in N.S.W. A number of these outstanding trees have been specifically recorded, and are reserved. Details of these trees are shown in Table 15.

The ages of such trees are not known, though it is difficult to imagine their being much under 400-500 years. Should any such giants die or be blown over, efforts should be made to obtain heartwood samples for radio-carbon dating.

Table 15

OUTSTANDING SPECIMENS OF SPOTTED GUM RECORDED IN N.S.W.

LOCATION	HEIGHT (m)	DBH (m)	NOTES
Bodalla S.F., cpt. 5	52	2.37	Vol. 23.2 m^3
North Brooman S.F. (off 4 mile Rd)	70	2.70	Vol. 58.9 m^3
Currambene S.F., cpt. 40	51	2.08	Vol. 17.0 m^3
Olney S.F. (Yambo Rd)	34	2.00	
Coffs Harbour M.A., cpt. 6	55	1.81	Vol. 45 m^3
Bagawa S.F., cpt. 70	66	2.67	In 1260 Forest Preserve
Bagawa S.F., cpt. 77	65	1.82	
Richmond Range S.F., cpt. 32	58	3.66	

Note: *Trees from Richmond Range, and possibly those from Bagawa S.F., are the narrow-leaved form, "var. grayi."*

8. DAMAGE TO OLDER STANDS

The Spotted Gum types, and particularly Spotted Gum itself, are relatively little affected by the main agencies that can severely damage other eucalypt forest communities. As previously noted (Section 4), one of the major effects of damage to Spotted Gum is the production of gum veins and pockets, and these represent the main defect of Spotted Gum. They can be caused by fire, insect attack, mechanical damage or the production of epicormics, and their formation is well discussed and illustrated by Jacobs (1955, para. 145-157 - one of the few references to Spotted Gum in this outstanding text).

Fire is of course the major damage agency of these types, though Spotted Gum shows remarkable resistance to fire, in part at least because of its thick, smooth bark. Furrer (1971) examined the recovery of Spotted Gum from various intensities of fire damage on Wandera S.F. following the severe 1968 fire season. Trees selected ranged from those extremely heavily damaged (crown removed by fire; leaves and small twigs consumed by fire) to those lightly damaged (crown unaffected, forest floor burnt as under hazard reduction burning). After 2½ years the trees were assessed for recovery in 5 classes:

Dead
Severe: damage still evident; branches dead; epicormics on bole
Heavy : smaller branches dead; epicormics on larger branches
Light : evidence of dead twigs
Nil: no evidence of damage seen.

Nine percent of the extreme damage class only had died, and 5 per cent were classed as "severe"; otherwise all stems were classed as "heavy" or better.

One effect of the fire had been to promote bark shed, and 2½ years after initial measurement all damage classes still showed overbark DBH's less than immediately after the fire. However bark thickness measurements showed that all classes had in fact increased their underbark diameters since the fire. By contrast H. Dowden (pers. comm.) has noted that measurements following a fire in a Spotted Gum stand on the Mid North Coast showed that the bark thickness of the Gum was very variable, both within and between trees. In this instance bark thickness of Spotted Gum could not be reliably estimated by gauge, even though the same instrument gave good results with other species in the stand (Grey Ironbark, White Mahogany and others).

Furrer noted that the usual pattern of recovery following complete crown scorch was from epicormic shoots arising on branches larger than 5cm in diameter. Stem epicormics are unusual in Spotted Gum.

Jacobs (para. 150; figs. 76-79) notes that fire in cool weather will thin the bark on smooth-barked trees, but may not damage the cambium nor produce gum veins; a similar fire under warm conditions is likely to cause the bark to split through to the cambium, producing severe gum veins. Such cracks are often very apparent in Spotted Gum after severe fire. Though Furrer observes that in one Wandera stand, heavily damaged by the 1968 fires, no gum formation was subsequently found, and he speculates that there may have been inadequate moisture in the stems during the prevailing drought for kino production.

Furrer suggests that the fire may actually have stimulated the under-bark diameter increment of the burnt trees, and a similar comment was made by Henry (1961) in relation to controlled burning in the Maryborough district. Though he notes that the effect lessened after several burns: he surmises that it may have been due to the release of nutrients held in the litter. The Queensland studies showed that annual burning was practicable in sites with a continuous grass cover, but more difficult in sites invaded by dense Lantana and Brush Box except under conditions likely to damage the more valuable species. Nonetheless annual prescribed burning helped to reduce this weed problem. Serious damage from the burns was restricted to stems under about 3m in height.

Hoare (1982?) has given a preliminary report on some South Coast studies into the effects of prescribed burning at less regular intervals. Fine fuel loads averaging about 12t/ha were present before burning, and were reduced to about 1-2t/ha after fire. They appeared to take about 10 years to reach the pre-burn level, but the rate of accumulation varied appreciably from year to year. Hoare indicates that the communities in the study area (Mogo S.F.) seemed well attuned to frequent fire, and he urges a rather flexible approach to the timing of prescribed burning. on the mid North Coast, H. Dowden recorded fine fuel loads in unburnt Spotted Gum stands averaging about 9t/ha, the value varying from year to year and ranging from 6.8 to 10.4t/ha over time. Fuel loads after low intensity prescribed burning (mostly between 20 and 350 kW/s/m) were about 4t/ha, and pre-burn fuel levels were reached in about 6 to 7 years. Plots in which fuel was removed by raking took a similar time to reach equilibrium weight.

Turnbull & Pryor (1978) record Spotted Gum as being *"relatively resistant to pests and diseases."* It is highly resistant to the **fungal disease**, *Phytophthora cinnamomi*, and no significant foliar diseases have been observed in N.S.W. It is susceptible to the canker fungi, *Cryphonectria gyrosa* and *Cytospora eucalypticola*, both of which occur throughout the tree's range in N.S.W. On older trees these fungi are associated with annual bark cankers and perennial wound cankers; on coppice regeneration they are sometimes associated with the death of coppice stools and shoots. Both fungi are common in wounds exuding kino. Heartrots caused by *Phellinus* spp. are not uncommon, the fungi usually entering through branch stubs or wounds.

With respect to **insect** pests, younger specimens of Spotted Gum rarely show signs of termite attack, although senescent trees are more prone to infestations. Longicorn beetles sometimes severely attack individual trees, to the extent that the trees may be ringbarked and killed, and cockatoos seeking the beetle larvae may make worse the damage to heavily attacked stems. Standing trees may also be attacked, sometimes severely, by platypodid beetles. Jacobs (para. 151, fig. 81) mentions small wasps causing galls in the bark of Spotted Gum and producing gum veins in the wood beneath.

Spotted Gum logs may at times be prone to heavy attack by bostrychid borers, and at times log sprays may be necessary to prevent extensive damage to the sapwood. This is particularly so if logs are being seasoned prior to pressure impregnation of a preservative.

The starch-rich sapwood of seasoned Spotted Gum is highly susceptible to powder-post borer of the family *Lyctidae*.

Spotted Gum, and probably more commonly some of its associates, are occasionally infested with **mistletoe. Native Cherry** is very common in some South Coast Spotted Gum stands. As a root parasite it almost certainly has some effect on growth, though its influence is rarely apparent.

Other damage agencies occasionally appear in Spotted Gum types. A severe **hailstorm** on Camira S.F. in 1981 defoliated trees over a significant area; recovery has been as for crown damage from fire.

9. PRESERVATION

Spotted Gum types are represented in a number of national parks, including Mimosa Rocks, Murramarang, Washpool and Wallaga Lake, and in the Yarravel and Banyabba Nature Reserves. Several of these occurrences were previously well managed as productive State Forest.

The types are well represented in the Commission's Native Forest Preservation programme, with 12 Flora Reserves (total area 4 000 ha) and 7 Forest Preserves (total area 900 ha) carrying examples of these types. These preserved areas are listed in Appendix 5, and between them they provide a good sampling of the occurrence of the types in N.S.W.

As noted previously, the individual trees of outstanding size, listed in Table 15, have been preserved for their natural lives.

10. MANAGEMENT ASPECTS

10.1 Objectives

The policy of the Forestry Commission towards the management of forest areas that include the Spotted Gum types is expressed as follows (Forestry Commission of N.S.W., 1976):

> *"The accessible forests of the coastal plain should be managed for sawlog and miscellaneous round timber production and for recreation. This management should aim to maximise sawlog production in the next 30 years, consistent with sustained yield concepts. This will involve the retention of all thrifty stems of merchantable or near merchantable size for further increment. In most cases, this means that some good growing stock will be grown to diameters larger than may have been envisaged in former yield calculations. Where regeneration needs occur, they are to be met by natural means where possible. Where necessary they may be supplemented by artificial techniques such as clearing and jiffy pot planting to obtain a full stocking of the fastest growing commercial species suitable to the site."*
>
> *"The more mountainous and less accessible forests behind the coastal plain should be logged for sawlogs to the limit of economic accessibility. Sound vigorous advanced growth should be retained. In most cases, logging will create a need for regeneration or stand rehabilitation. Regeneration should be obtained by natural methods, generally without the assistance of any silvicultural treatment apart from what logging can accomplish, even though the presence of cull trees may reduce the regeneration stocking. In types such as moist hardwood where regeneration establishment is difficult, a continued acceptable forest environment should be sought, either through promotion of regeneration by burning techniques or the retention of an adequate forest cover of defective and smaller trees of the original stand. The essential feature of post-logging management of these areas is to obtain an acceptable forest cover preferably of commercial quality. Where this would require additional investment, any forest cover should be accepted as an alternative."*

Most of the Spotted Gum stands are among *"the accessible forests of the coastal plain",* though in a few cases they extend into more hinterland sites. In general, the policy requirements do not pose any major problems for the silviculture of most Spotted Gum stands.

10.2 Management Practices and Problems

Spotted Gum types are fairly simple to manage. Sawlog production stands are usually harvested under a selection system, though in some cases the level of logging is such that the results approach a clearfelling with seed trees. Small timber can be obtained from thinning in the sawlog stands or, in some generally low quality forests, from regular harvesting in stands maintained by coppice, with a few stems retained as standards to grow to larger size.

As with any forest there are problems in the management of the Spotted Gum stands, but these are usually not of fundamental silvicultural significance. One, of local importance, concerns difficulties in ensuring the regeneration of Spotted Gum on some South Coast sites: it is a problem that warrants further trial and study, but fortunately it does not seem to be of wide concern. Of more general application is the need for more information on the capacity of subdominant or other poorly crowned trees to recover if released and retained after logging: the consensus, probably well justified, is that any recovery is limited, and that the trees will be more prone to gum rings and pockets, termite attack and other internal defect. Need also exists for more quantitative data on the coppice stands managed under selection systems for mining timber production.

Probably of greater moment under current conditions are the more strictly management problems, such as maintaining commitments to industry whilst preserving the scenic beauty of many Spotted Gum stands.

10.3 Guidance Points

From the material outlined and reviewed in these Notes, some reasonably general guidance points can be made. They should, however, be regarded as just that - guidance points; they are not intended as directives or prescriptions, and they should be interpreted and applied in the light of more detailed knowledge of local forest conditions. Silviculture always primarily depends on knowing the bush.

Among the points that should be stressed are:

1. Spotted Gum stands are usually uneven-aged, and the types seem well adapted to management that maintains this condition. Stands that are obviously even-aged are unusual in the Spotted Gum forests.

2. Although flowering is irregular, an adequate seed source seems usually to be available in the crowns of the Spotted Gum trees.

3. Unless there is evidence to the contrary, local seed sources should be employed in any artificial regeneration treatments, though there is still scope for further trials using other provenances.

4. Regeneration is usually readily obtained, normally from the release of an established lignotuber pool, occasionally directly from seed.

5. Replenishment of the lignotuber pool usually occurs following the occasional fire.

6. Lignotubers can be rapidly lost from the pool under conditions of heavy shade.

7. Large openings in the stand are needed for optimum lignotuber response; within a fairly wide edge around existing trees or stands, growth is retarded.

8. Grazing and trampling by cattle and wildlife may also hold back lignotuber response.

9. Regeneration problems on parts of the South Coast - and these should not be overestimated - relate in part to the paucity of the lignotuber pool. Where this is the case efforts should be made to promote its establishment through progressive stand opening and appropriate use-of fire.

10. Coppice is a very effective means of regenerating stands of Spotted Gum types being used for small-wood production, and has been employed, apparently satisfactorily, both as the traditional clearfelling system and as periodic selective harvesting with Coppicing of the stumps of the felled stems. Early growth of coppice is very rapid.

11. As with any coppice system, stump height should be kept as low as possible; where this has not occurred a follow-up treatment to reduce stump height may be warranted.

12. Under favourable conditions, even seedling Spotted Gum growth can be rapid.

13. Subsequent growth is substantially affected by stocking, with significant restrictions on the growth of even the better stems in the stand at BAs exceeding say 20 m^2/ha, though this level will almost certainly vary in relation to the quality of the stand.

14. Individual stems show considerable variability in growth rates, but crown classifications appear to provide a useful guide as to the comparative growth of different stems in a stand.

15. At this stage the removal of small, poorly crowned stems of sub-quota size appears to be well warranted on silvicultural grounds, even though their removal may appear to conflict with desire to conserve potential quota logs for harvesting in 20 to 30 years.

16. Spotted Gum is relatively resistant to most damage agencies, including fire, though fires in the hot season (along with other forms of damage) can result in substantial gum ring information.

17. Too frequent fires can prevent the establishment of regeneration (especially that needed to replenish the lignotuber pool), while in the moister sites fires can promote the growth of weeds.

10.4 Further Research

Reviews such as this inevitably reveal gaps in our knowledge and understanding of the communities being considered, and this is certainly the case with the Spotted Gum types.

Among fields where further research or study would appear warranted are:

- The general ecology of the Spotted Gum types, particularly in relation to the factors determining their occurrence.

- Continued evaluation of the taxonomy of the Spotted Gum group, including further and more comprehensive examination and analysis of the existing provenance trials.

- Study of the regeneration establishment mechanisms of Spotted Gum in the moister sites, including the Richmond Range Spotted Gum types.

- Assessment of the extent of the South Coast regeneration problem, and the extension of previous work to determine its cause.

- The relative growth rates of coppice and lignotuberous regeneration over an extended period of time.
- Quantitative information on the effectiveness of the selective coppice system widely employed for mining timber production.
- The capacity of subdominant and poorly crowned trees to respond to release.
- A comparison of the effectiveness of existing systems of crown classification in predicting stem behaviour and response.
- Information on the stocking, density and size class relationships in uneven-aged stands, as a basis for determining optimum thinning and harvesting schedules.

Just a short list to improve any subsequent version of these Notes!

11. ACKNOWLEDGEMENTS

As in previous cases, these Notes are the result both of studies carried out by various researchers and of the experience of a large number of Foresters and others. Among the former, attention must be drawn to the work carried out within the Commission by R.A. Curtin, A.G. Floyd and B.J. Furrer, to the characteristically high standard studies performed by N.B. Henry and various colleagues of the Queensland Department of Forestry, and to the continuing efforts of R.G. Florence and various associates from the A.N.U.

The latter are too numerous to mention individually, but the following warrant special mention for their very constructive and useful comments on an earlier draft of these Notes:

D. I. Bevege	H. Dowden	V. Hervert
J. Bruce	R. Eldridge	B. Peick
R. A. Curtin	B. J. Furrer	G. D. Pople
H. Drielsma	D. I. Hamilton	J. Simpson

To all who have so willingly given of their knowledge and experience the compilers of these Notes offer their sincere thanks and appreciation.

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APPENDIX 1

PLANT SPECIES MENTIONED IN TEXT

Common Name	Botanical Name	
Apple, Smoothbarked	Angophora costata	AAADA
Ash, Silvertop	Eucalyptus sieberi	MAKED
Bangalay	E. botryoides	SECAD
Blackbutt	E. pilularis	MAIAAA
Bloodwood	Eucalyptus belonging generally to the subgenus of Pryor & Johnson.	
Pink	E. intermedia	CAFID
Red	E. gummifera	CAFUF
Box, Brush	Lophostemon confertus	
Grey	Eucalyptus moluccana	SUL:B
Steel	E. rummeryi	SUAAA
Brown Barrel	E. fastigata	MAKCB
Burrawang	Macrozamia communis	
Cherry, Native	Exocarpos cupressiformis	
Cypress Pine. White	Callitris columellaris "inland form"	
Goodenia	Goodenia ovata	
Gum, Blue. Sydney	Eucalyptus saligna	SECAC
Grey	E. punctata SECED or E. propinqua SECEA	
Mountain	E. cypellocarpa	SPIFE
Lemon-scented	E. citriodora	CCC:A
Maidens	E. globulus ssp. maidenii	SPIFI
Red, Forest	E. tereticornis	SNEEB
Slaty	E. glaucina	SNEEC
Spotted	E. maculata	CCC:B
Broadleaved	E. henryi	CCC:C
Richmond Range	E. maculata "var grayi"	
Ironbark, Broadleaved	E. fibrosa ssp. fibrosa	SUP:AA
Grey, Northern	E. siderophloia	SUP:I
Queensland	E. drepanophylla	SUP:E
Southern	E. paniculata	SUV:D
Narrowleaved	E. crebra	SUP:S
Squarefruited	E. tetrapleura	SUV:H
Ironwood	Backhousia myrtifolia	
Lantana	Lantana camara	
Mahogany, Red	Eucalyptus resinifera SECCC or E. pellita SECCA	
White Broadleaved	E. umbra ssp. carnea	MAG:AB
Narrowleaved	E acmenioides	MAG:C
Marri	E. calophylla	CAFUA
Messmate	E. obliqua	MAKAA
Palm, Pineapple	Macrozamia moorei	
Peppermint, Sydney	Eucalyptus piperita ssp. piperita	MATHAA
Soldier Vine	Kennedia rubicunda	
Stringybark, Blueleaved	Eucalyptus agglomerata	MAHCG
White	E. globoidea	MAHEF
Yellow	E. muellerana	MAHAA
Tallowwood	E. microcorys	SWA:A
Turpentine	Syncarpia glomulifera	
Wattle	Acacia spp.	
Black	A. mearnsii	
Woollybutt	Eucalyptus longifolia	SECGA

APPENDIX 2

CLIMATIC AVERAGES FOR SPOTTED GUM

TABBIMOBLE SF **Latitude** 29^{0}12'S **Longitude** 153^{0}16'E **Elevation** 18m

Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Total
Daily Maximum Temperature (Cº) - Mean												
31.4	32.4	31.6	29.5	26.4	23.7	23.1	24.1	28.0	29.2	31.6	31.2	28.5
Daily Minimum Temperature (Cº) - Mean												
22.8	23.5	21.2	18.8	13.1	12.2	9.1	12.5	14.4	17.6	20.1	22.8	17.3
Rainfall (mm) - Mean												
173	232	229	149	103	134	93	82	55	90	89	152	1581

GRAFTON **Latitude** 29^{0}42'S **Long** 152^{0}56'E **Elevation** 10m

Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Total
Daily Maximum Temperature (Cº) - Mean												
29.8	28.6	28.0	26.7	23.0	21.2	20.3	22.0	23.9	26.3	28.0	29.3	25.6
Daily Minimum Temperature (Cº) - Mean												
19.5	19.4	17.4	14.0	10.4	7.6	5.4	7.3	9.5	13.6	15.2	17.7	13.1
Rainfall (mm) - Mean												
186	107	97	39	40	97	47	61	41	121	87	106	1029
Raindays (No.) - Mean												
21	19	15	8	9	8	7	8	9	12	12	13	141

CASSILIS **Latitude** 32^{0}1'S **Longitude** 149^{0}59'E **Elevation** 402m

Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Total
Daily Maximum Temperature (Cº) - Mean												
28.9	27.5	28.3	25.6	19.1	16.7	15.8	16.5	20.2	23.9	27.3	29.7	23.3
Daily Minimum Temperature (Cº) - Mean												
14.3	16.1	13.1	6.5	4.0	4.5	0.0	1.6	2.6	7.7	8.7	12.3	7.6
Rainfall (mm) - Mean												
69	66	52	40	38	45	40	43	42	51	52	61	599
Raindays (No.) - Mean												
6	6	5	5	6	7	7	7	6	6	6	6	73

MUSWELLBROOK **Latitude** 29^{0}15'S **Longitude** 150^{0}53'E **Elevation** 144m

Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Total
Daily Maximum Temperature (Cº) - Mean												
28.4	28.6	27.6	24.9	19.9	17.8	17.4	19.1	20.0	25.3	25.9	29.1	23.7
Daily Minimum Temperature (Cº) - Mean												
16.1	16.7	14.1	9.7	6.5	4.5	1.8	4.2	5.8	9.9	12.2	14.9	9.7
Rainfall (mm) - Mean												
70	64	54	45	42	51	45	40	41	48	52	66	618
Raindays (No.) - Mean												
7	6	6	6	6	8	7	7	6	7	7	7	80

RAYMOND TERRACE **Latitude** 32^{0}38'S **Longitude** 151^{0}52'E **Elevation** 12m

Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Total
Daily Maximum Temperature (Cº) - Mean												
28.1	27.5	26.4	23.6	19.5	17.4	16.3	17.4	21.4	23.2	25.9	25.4	22.7
Daily Minimum Temperature (Cº) - Mean												
16.3	16.2	14.0	10.9	6.7	5.5	3.1	4.4	6.9	10.9	12.6	14.2	10.1
Rainfall (mm) - Mean												
130	122	138	92	87	132	64	86	62	82	70	95	1160
Raindays (No.) - Mean												
10	12	11	9	9	9	9	8	7	10	9	9	112

PROSPECT DAM **Latitude** $33^0$49’S **Longitude** $150^0$55’E **Elevation** 61m

Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Total
Daily Maximum Temperature (Cº) - Mean												
26.7	26.6	25.6	23.2	19.6	16.6	16.2	18.0	19.8	22.5	24.0	25.9	22.1
Daily Minimum Temperature (Cº) - Mean												
17.2	17.5	16.0	13.1	9.8	7.8	6.3	7.1	9.3	12.2	14.0	15.9	12.2
Rainfall (mm) - Mean												
92	89	93	74	72	78	64	52	48	58	67	77	864
Raindays (No.) - Mean												
10	11	10	9	8	9	7	8	9	9	9	9	108

ULLADULLA **Latitude** $35^0$22’S **Longitude** $150^0$29’E **Elevation** 9m

Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Total
Daily Maximum Temperature (Cº) - Mean												
24.3	24.3	23.6	22.6	19.1	17.2	17.1	17.7	18.8	22.1	22.3	23.0	21.0
Daily Minimum Temperature (Cº) - Mean												
16.7	17.0	15.4	12.8	10.5	9.1	7.2	8.1	8.5	11.3	13.1	14.7	12.0
Rainfall (mm) - Mean												
98	116	116	120	129	143	68	90	79	109	96	102	1266
Raindays (No.) - Mean												
15	16	12	6	6	4	3	5	3	5	10	17	102

NAROOMA **Latitude** $36^0$13’S **Longitude** $150^0$8’E **Elevation** 26m

Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Total
Daily Maximum Temperature (Cº) - Mean												
23.9	24.2	23.1	21.4	18.2	15.8	15.4	16.3	17.9	19.5	20.9	22.6	19.9
Daily Minimum Temperature (Cº) - Mean												
15.4	15.8	14.8	12.1	8.8	6.7	5.7	6.7	8.2	11.0	12.1	14.2	11.0
Rainfall (mm) - Mean												
98	116	116	120	129	143	68	90	79	109	96	102	1266
Raindays (No.) - Mean												
10	10	11	9	8	10	7	8	9	12	11	11	116

BEGA **Latitude** 36^0 40’S **Longitude** 149^0 50’E **Elevation** 13m

Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Total
Daily Maximum Temperature (Cº) - Mean												
26.1	26.7	24.9	23.2	19.3	16.7	16.6	17.6	19.6	21.7	22.6	24.8	21.7
Daily Minimum Temperature (Cº) - Mean												
14.0	14.6	12.2	7.8	4.4	2.0	0.7	2.6	4.2	8.1	10.1	12.3	7.8
Rainfall (mm) - Mean												
86	91	89	69	76	85	55	56	52	66	65	81	871
Raindays (No.) - Mean												
8	7	8	6	7	7	5	6	7	8	8	8	85

Appendix 3

PROPERTIES OF MAJOR TIMBER SPECIES: SPOTTED GUM TYPES

(Derived from K. R. Bootle: "Wood in Australia")
Abbreviations: L-S, Lyctid susceptible; G, green; AD air-dried (re density)

Common Name	**Blackbutt**	**Bangalay (Southern Mahogany)**	**Gum, Sydney Blue**	**Bloodwood, Red**
Botanical Name	Eucalyptus pilularis	Eucalyptus botryoides	Eucalyptus saligna	Eucalyptus gummifera
General Properties	Light brown. Coarse texture, straight grain. Hard, strong and tough, but not difficult to work	Reddish brown; medium and even texture. Grain interlocked.	Pink to red. Grain straight. Moderately coarse texture. Gum veins common. Easy to work, fix, dress and finish	Dark pink to red. Coarse texture, often interlocked grain. Numerous gum veins.
Density kg/m³	G: 1100 AD: 920	G: 1180 AD: 920	G: 1070 AD: 1020	G: 1150 AD: 900
Durability	2	2-3	3	1
Strength	S2	S2	S3	S3
Sawlog Group	B	B	B	D
Uses	Poles, sleepers, flooring, building framework.	General structural flooring.	General building purposes, cladding, flooring, panelling boat building. Potential for heavy furniture, structural ply.	Poles, piles, posts, decorative panelling.
Other Notes	Care needed in drying to avoid surface checks. Regrowth liable to spring, bow, collapse. Fair for bending; poor base for paint.	Slow in drying, end splitting, some collapse.	Easy to dry but susceptible to surface checks. Easy to work.	Little shrinkage in drying, but gum veins may open

PROPERTIES OF MAJOR TIMBER SPECIES: SPOTTED GUM TYPES

(Derived from K. R. Bootle: "Wood in Australia")
Abbreviations: L-S, Lyctid susceptible; G, green; S, seasoned; AD air-dried (re density)

Common Name	Box, Grey	Box, Steel	Gum, Forest Red	Gum, Spotted
Botanical Name	Eucalyptus Moluccana	Eucalyptus rummeryi	Eucalyptus tereticornis	Eucalyptus maculata
General Properties	Pale yellowish brown. Fine, even texture. Grain usually interlocked. Seldom gum veins.	Pale brown. Similar properties and appearance to Grey Ironbark.	Red. Coarse, even texture; grain interlocked.	Pale to dark brown; wide sapwood. Mod coarse texture; grain variable - wavy grain gives common fiddleback figure. Slightly greasy. Gum veins common. Northern material usually slightly denser, stronger and more durable than southern.
Density kg/m³	G: 1170 AD: 1120	G: 1300 AD: 1130	G: 1200 AD: 1050	G: 1150
Durability	1	1	2	3(S)
Strength	S2	S2	S3	S2
Sawlog Group	A	A	B	B
Uses	Heavy engineering construction, brides, wharves, shipbuilding.	Girders, poles.	Heavy engineering construction, machinery bearing, poles.	Heavy engineering construction, piles, poles, agric machinery, shipbuilding, flooring, plywood. Main Aust. species for handles subject to high impact forces (e.g. axe handles).
Other Notes	Slow drying. Because of density, rather difficult to work.		Not hard to dry.	Needs care in drying to avoid surface checks. Not hard to work; satisfactory for bending when grain straight. Sapwood very susceptible to lyctid attack.

PROPERTIES OF MAJOR TIMBER SPECIES: SPOTTED GUM TYPES

(Derived from K. R. Bootle: "Wood in Australia")
Abbreviations: L-S, Lyctid susceptible; G, green; AD air-dried (re density)

Common Name	**Ironbark, Broadleaved (Red)**	**Ironbark, Grey**	**Mahogany, Red**
Botanical Name	Eucalyptus fibrosa	Eucalyptus paniculata Eucalyptus siderophloia	Eucalyptus resinifera Eucalyptus pellita
General Properties	Dark red. Texture moderately coarse, even. Grain often interlocked.	Varies - pale brown to chocolate to dark red. Texture even, moderately coarse. Grain often interlocked.	Dark red. Texture medium, even. Grain slightly interlocked.
Density kg/m³	G: 1210 AD: 1140	G: 1210 AD: 1120	G: 1150 AD: 950
Durability	1	1	2
Strength	S1	S1	S2
Sawlog Group	A	A	B
Uses	Heavy engineering construction, poles, sleepers, flooring, bridge-building.	Heavy engineering construction, poles, sleepers, flooring and decking, shipbuilding.	Flooring, cladding, panelling, general construction, sleeper, poles
Other Notes	Slow in drying. Hard to work because of density.	Slow in drying. Hard to work because of density.	Dries well. Easy to work. Paints well.

PROPERTIES OF MAJOR TIMBER SPECIES: SPOTTED GUM TYPES

(Derived from K. R. Bootle: "Wood in Australia")
Abbreviations: L-S, Lyctid susceptible; G, green; AD air-dried (re density)

Common Name	**Stringybark, White**	**Stringybark, Yellow**	**Woollybutt**
Botanical Name	Eucalyptus globoidea	Eucalyptus muellerana	Eucalyptus longifolia
General Properties	Pale brown. Texure medium, even. Grain interlocked.	Yellowish-brown, pink tinge. Texture medium, even. Grain often interlocked.	Red, like Sydney Blue Gum. Texture medium, even. Grain is interlocked. Dressed surface with waxy sheen.
Density kg/m³	G: 1100 AD: 820-900	G: 1100 AD: 870	G: 1120 AD: 1050
Durability	2	2	2
Strength	S3	S3	S2
Sawlog Group	B	B	C
Uses	Building framework, treated posts and poles.	Building framework, sleepers, poles, piles, crossarms, flooring.	Building framework, sleepers, poles, posts.
Other Notes	Needs careful drying; some collapse. Unsuitable for steam bending.	Dries readily, but care needed to avoid checking and splitting. Some collapse. Unsuitable for steam bending.	Slight collapse in drying.

Appendix 4

CROWN ASSESSMENT SYSTEM

(after Grimes, 1978)

Crown Position:

5 - All crown open, both upper surface and sides
4 - Upper crown surface entierly exposed, some side competition
3 - Part of upper crown exposed, mostly side light
2 - Some side light only
1 - No side light

Crown Size:

5 - Perfect	Wide, deep roughly circular
4 - Good	Slight faults, lop sided etc.
3 - Satisfactory	Satisfactory silviculturally
2 - Poor	Removal in thinning
1 - Very poor	Useless

Crown Density:

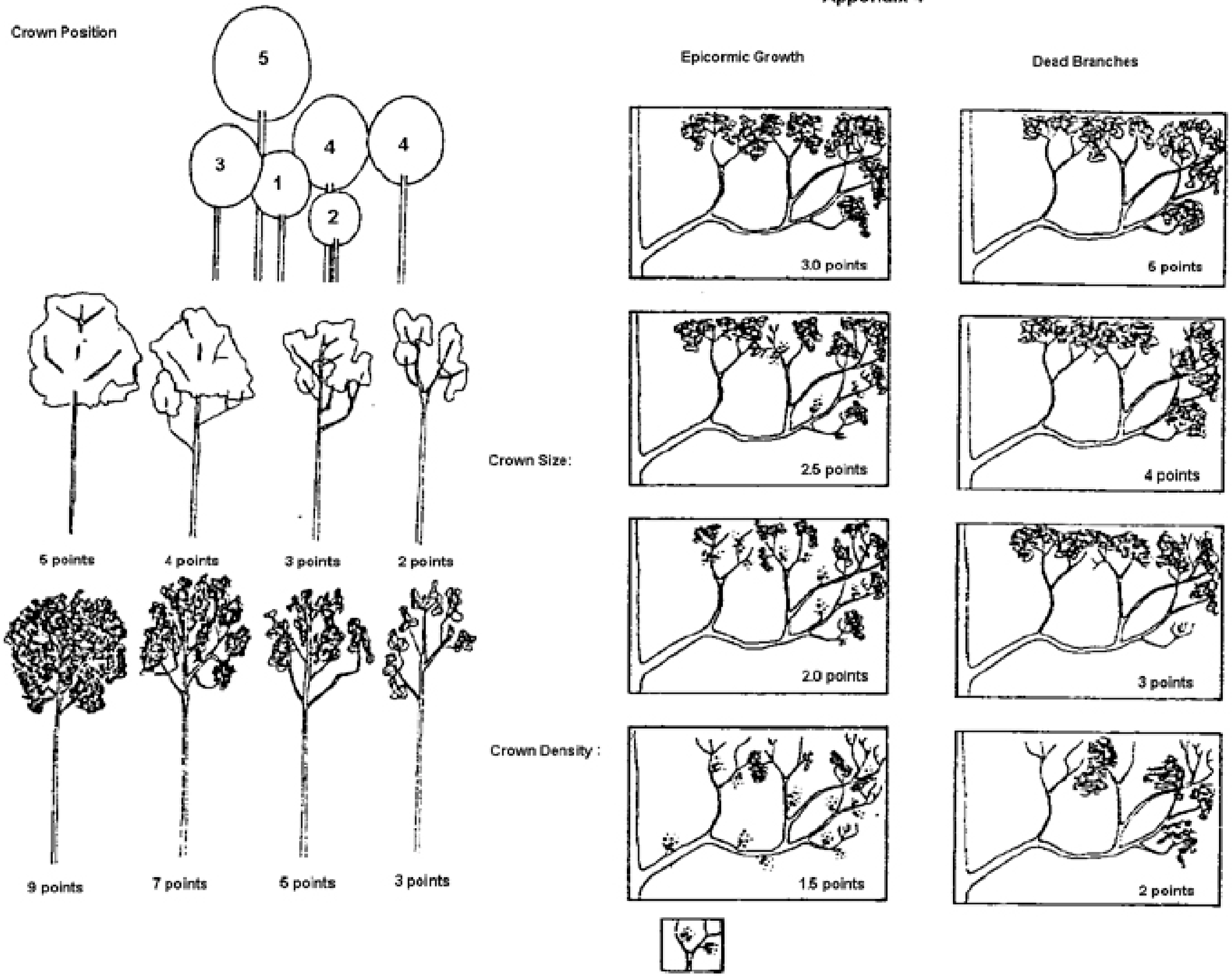
9 - Very dense
7 - Dense
5 - Average
3 - Sparse
1 - Very sparse

Dead Branches

5 - Nil
4 - Branches dead
3 - Small growing branches dead
2) - Main growing branches dead
1) -

Crown Epicormic Growth:

3 - Nil limbs clean, growth concentrated in branch extremities
2.5 - Slight
2 - Moderate
1.5 - Severe on crown or stem
1 - Severe on crown and stem



APPENDIX 5

FORESTRY COMMISSION PRESERVED AREAS CARRYING SPOTTED GUM TYPES

Flora Reserves

Durras Lake Flora Reserve No. 79943. Kioloa S.F. 105 ha. A good example of South Coast Spotted Gum types with little disturbance.

Mt. Dromedary F.R. No. 79948. Bodalla S.F. 1 255 ha. Includes some Spotted Gum types on its margins.

Glenugie Peak F.R. No. 79972. Glenugie S.F. 105 ha. Includes area of Spotted Gum (broadleaved form, *E. henryi)* with Grey Box and the rare Squarefruited Ironbark (*E. tetrapleura).*

Madmans Creek F.R. No. 80001. Conglomerate S.F. 92 ha. Spotted Gum included among a wide range of eucalypt types.

Wallaroo F.R. No. 80008. Wallaroo S.F. 28 ha. Spotted Gum occurrence on lower North Coast.

Cambridge Plateau F.R. No. 80009. Richmond Range S.F. 870 ha. Stands of the narrowleaved Richmond Range strain of Spotted Gum ("var. *grayi").*

Mallanganee F.R. No. 80013. Cherry Tree North S.F. 222 ha. Includes area of Richmond Range Spotted Gum type.

Shannons Creek F.R. No. 80015. Boundary Creek S.F. 245 ha. Excellent example of good quality virgin Spotted Gum.

Chandlers Creek F.R. No. 80018. Marara S.F. 980 ha. Spotted Gum above an understorey of the Pineapple Palm, *Macrozamia moorei.*

Pokolbin F.R. No. 80019. Pokolbin S.F. 90 ha. Spotted Gum included in an area with a number of rare species and unusual occurrences.

Steel Box F.R. No. 80022. Mt. Pikapene S.F. 20 ha. includes small area of Richmond Range Spotted Gum type.

Grange F.R. No. 80024. Grange S.F. 58 ha. Good quality Spotted Gum-Ironbark type.

Forest Preserves

1. **Peach Tree Gully Forest Preserve.** Currowan S.F. 17 ha. Excellent stand of South Coast Spotted Gum with Burrawang understorey.

132. **Broad Gully F.P.** Yadboro S.P. 16 ha. Pure stand of Spotted Gum close to western limit of occurrence in area.

150. **Mogood F.P.** Clyde S.F. 188ha. Particularly good example of a range of Spotted Gum types, close to altitudinal limit on South Coast (370 m).

174. **Twelve Sixty F.P.** Bagawa S.F. 305 ha. Includes Spotted Gum types.

193. **Sailors Hill** F.P. Boundary Creek S.F. 194 ha. Spotted Gum adjoining dry rainforest.

198. **Selection Flat** F.P. Myrtle S.F. 141 ha. Good examples of types dominated by the broadleaved form of Spotted Gum *(E. henryi),* and including the rare Slaty Red Gum *(E. glaucina).*

200. Curryall F.P. Curryall S.P. 37 ha. Westernmost known natural occurrence of Spotted Gum in N.S.W.