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

4. BLACKBUTT TYPES

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APPENDICES

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4. BLACKBUTT TYPES

1. INTRODUCTION

Blackbutt[1] is the single most important native timber tree in N.S.W. In recent years this species alone has provided about 15 per cent of the native hardwood log cut from Crown-timber lands in coastal and tableland districts of N.S.W.; including associated species, the Blackbutt types probably provide in excess of 20 per cent of the cut, while the large areas of developing regrowth of Blackbutt and its associates give promise of a proportionately still higher contribution in the decades ahead.

Whilst not without its problems, Blackbutt has long proved a most amenable species for forest management. It occupies significant areas of the coastal and adjacent escarpment districts of both the North and South Coasts, occurring particularly in the hill sites that have been less sought for, and hence better preserved from, agricultural and pastoral use; it is one of the most vigorous and fastest growing native species in N.S.W.; it is a tree that can reach very large size; in most situations it regenerates readily and reliably; it has proved very suitable for plantation use; it has a reasonable tolerance of fire, particularly in the older and larger sizes; though by no means producing one of the finest hardwoods, it provides a good, general purpose timber that for a very long time has been the mainstay of the State's building industry.

Because of its importance both to the timber industry and to forest management, Blackbutt as a species and the more broadly based Blackbutt types have been the subject of a reasonable level of silvicultural research, and of a much higher level of applied silviculture, extending over many years. These notes represent an effort to bring together and summarise much of the resultant information in what is hopefully a convenient form.

2. FOREST ECOLOGY

2.1 The Types

The Blackbutt types, as the term is used in these Notes, are characterised by the occurrence, and usually by the clear dominance, of the tree, Blackbutt. Blackbutt, as understood here, covers two very closely related and similar-looking species - Blackbutt itself, sometimes differentiated as “Coastal Blackbutt” *Eucalyptus pilularis* (Pryor and Johnson code MAIAAA), and Large fruited Blackbutt, formerly identified as a variety of Blackbutt and now classified as a distinct species, *E. pyrocarpa* (MAIAAB). Together these two species constitute the informal subseries *Pilularinae* of the series *Pilulares*, subgenus *Monocalyptus* (Pryor and Johnson, 1971). Large fruited Blackbutt often occurs close to stands dominated by Blackbutt, but there is usually little mixture of the two in the one stand; it can be distinguished from the more common and widespread species by its larger and more pyriform fruit, its very glaucous twigs, and its narrower and more pendulous leaves.

Aspects of the ecology of Blackbutt have been studied by Florence (1961), who wrote (with a slight updating of terminology):

> *"In its narrow coastal, but latitudinally attenuated range, Blackbutt occupies a considerable diversity of habitats. In spite of this the species is characterised by a remarkable universality of dominance, and unlike most other species, is rarely found occupying a generally subordinate position in the crown canopy.*
>
> *Blackbutt's most outstanding distributional characteristic is best illustrated by examining its relationship to other members of its own interbreeding group (subgenus Monocalyptus)). If Blackbutt could be divorced from consideration, the composition of the East Coast eucalypt forests - as far as Monocalyptus is concerned - would be in substantial agreement with the principle that interbreeding (Eucalyptus) species occupy distinctly*

[1] Botanical names of species mentioned are given in Appendix 1.

different ecological situations. For example, the Stringy barks, the White Mahoganies, Sydney Peppermint and Scribbly Gums occupy site situations differentiated by geographic, altitudinal, or contrasted edaphic criteria. Blackbutt, however, cannot be regarded as a species differentiated in a like manner; its occurrence is best illustrated as one superimposed on the distinctive site situations of each of the above Monocalyptus. With each site situation Blackbutt may either cohabit marginally with the inter-fertile species, or may have that species as an occasional component of the community, but in all situations, Blackbutt will form communities in which it is the outstanding, and in many instances only, dominant.

This wide habitat amplitude, and its relationship with interbreeding species raise important questions of ecotypic variation within Blackbutt - both morphologically and in physiological adaptation to differing climatic and edaphic phenomena."

The Forestry Commission of N.S.W. (1965), in developing its classification of forest types, recognised this wide ecological range, the common clear dominance of Blackbutt, and the variety of associates. It identified two types where Blackbutt occurs as the dominant, but with a large number of possible associates; one dominated by Large fruited Blackbutt; and four, of rather specialised occurrence, where Blackbutt is co-dominant with certain named species. These 7 types form the Blackbutt league, which is described in the following terms (again slightly updated):

"This is undoubtedly the most valuable and important league occurring in N.S.W., and it consists of a number of types in all of which Blackbutt (or Large fruited Blackbutt) is present and comprises 20 per cent or more of the stand. The league occurs throughout the coastal districts of the State, usually at relatively low altitudes though it ascends in northern areas commonly to 750m and rarely to over 900m. It requires a moderate rainfall, ranging from over about 900mm on the South Coast to over about 1 100mm an the North Coast, and it shows a preference for rather siliceous soils.

Blackbutt can be associated with a very large number of the other eucalypts found in eastern N.S.W. On this basis very many separate types could be recognised. However, in this list it has been felt better to recognise only a few of the more widespread and characteristic types, and to lump the remainder into two moisture phases of a broad Blackbutt type, which may vary from pure Blackbutt to stands in which Blackbutt makes up a relatively small proportion of the stand. Within this broad type, additional sub-types can, if necessary, be recognised. However, such splitting is usually unnecessary for management purposes."

The 7 types described are:

36. Moist Blackbutt and

37. Dry Blackbutt. Together these cover most of the commercially important Blackbutt stands, from the central South Coast northwards into Queensland. Blackbutt usually makes up over 50 percent of basal area, but may be as little as 20 per cent, and can occur either alone or with one or usually more of a large number of associates, including Tallowwood, White Mahogany, Red Mahogany, Grey Gum, Turpentine, Sydney Blue Gum, Bloodwood, Grey Ironbark, Stringybarks, Rough-barked and Smooth-barked Apples, Woollybutt, Mountain Grey Gum and others. Forest Oak is a common understorey associate, being replaced by Black She-oak on the less fertile soils. The two types grade into each other, but at one extreme the Moist Blackbutt type may occur as wet sclerophyll forest up to 60m high, and at the other extreme Dry Blackbutt type forms a dry sclerophyll forest of from 30 to 40m height. The main differences lie in the nature of their understoreys - mesic in Moist Blackbutt, xeric in Dry Blackbutt, though even here repeated fire can produce an essentially xeric understorey in a Moist Blackbutt type. Moist Blackbutt occurs in the more favoured and sheltered sites, with the more widespread Dry Blackbutt type occurring on ridges and more ex-posed slopes.

38. Large fruited Blackbutt. Resembles Dry Blackbutt type in structure, forming stands up to about 35m in height, dominated by Large fruited Blackbutt, with Grey Gum, White Mahogany, Bloodwood and other species as associates. Usually occurs on rather exposed, shallow-soiled sites, with a scattered occurrence from the Kendall district north to Casino.

39. Blackbutt - Spotted Gum. Both named species present, and others may be associated. Usually resembles Dry Blackbutt type, though it may also occur in the moister phase, particularly on the South Coast. It is found throughout the coastal zone often where moisture is becoming limiting for Blackbutt, and forms a link between the Blackbutt and Spotted Gum leagues.

40. Blackbutt - Scribbly Gum. Dry sclerophyll forest up to 30m high, occurring on soils of low fertility from upper South Coast into Queensland. Associated species may include Needle-bark Stringy-bark, Bloodwood, Red Mahogany and various Stringy-barks. Black She-oak is usually common in understorey.

41. Blackbutt - Bloodwood/Apple. A common type in sites close to the coastline, often though not invariably confined to deep sand deposits, and varying in form from open woodland, typically with spreading, heavily branched trees, to dry sclerophyll forest up to 35m high. Both Red and Pink Bloodwood, and Rough-barked and Smooth-barked Apple, may occur as associates. Usually of limited commercial interest for timber production.

42. Blackbutt - Sydney Peppermint - Smooth-barked Apple. A common gully and lower slopes community of the sandstone areas of the Central Coast. Other associates may also be present. Can vary from dry sclerophyll to wet sclerophyll forest, with a height range from 20 to 40m.

Various attempts have been made to classify the Blackbutt- dominated forest communities in broad ecological surveys. Pidgeon (1942) recognised two major groups of communities that could contain Blackbutt, one wet sclerophyll forest and the other dry sclerophyll forest; the first she termed the Sydney Blue Gum - Blackbutt Association[2] and the second the Blackbutt - Red Mahogany - Bloodwood Association. Specht et al (1974), following Hayden (1971), recognised the Sydney Blue Gum - Red Mahogany - Blackbutt Alliance, but noted that Blackbutt could also be a constituent of a number of other coastal Alliances.

From a forestry viewpoint, both approaches seem to lack practicality. More recently Beadle (1981), in a comprehensive review of Australian vegetation, has recognised a Blackbutt Alliance containing 8 sub-alliances.

- Blackbutt: soils of intermediate fertility; Blackbutt often sole dominant.
- Blackbutt - Tallowwood: moister and more fertile sites, north of 33º.
- Blackbutt - Pink Bloodwood - (Northern) Grey Ironbark: usually lower fertility sites, north of 31^0.
- Large fruited Blackbutt.
- Blackbutt - Sydney Blue Gum - (Southern) Grey Ironbark: especially on Wianamatta Shale soils.
- Blackbutt - Red Bloodwood: low fertility, sandy soils.
- Blackbutt - Sydney Peppermint: Hawkesbury Sandstone gullies.
- Blackbutt - Smooth-barked Apple: deep sands behind coastal dunes.

This appears a more realistic and understandable approach - possibly because Beadle notes that his classification of the better quality East Coast eucalypt forests is based on that of the Forestry Commission of N.S.W. (1965).

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[2] Most ecological writers in fact used botanical names, but their common name equivalents are used here for consistency. Pidgeon’s Association is the equivalent of the 'Alliance' of more recent workers.

2.2 Environment

The ecology of Blackbutt, as a species, has been studied in some detail by Florence (1961), and major aspects of his thesis have been subsequently more widely published (Florence, 1963, 1964 a and b), and go far towards explaining some of the more puzzling aspects of Blackbutt occurrence, and hence of the occurrence of the Blackbutt types.

Climatic details from various stations typical of Blackbutt occurrence are given in Appendix 2. General features of the climatic conditions include:

- Warm to hot summers and relatively mild winters (cold in the higher altitude sites, eg. Clouds Creek).
- Occasional winter frosts likely in open sites in most, if not all, localities, with their frequency increasing with altitude.
- Rainfall generally well in excess of 1 000 mm a year, though somewhat lower towards the southern limit (Merimbula).
- Rainfall seasonally distributed with a summer - early autumn maximum and a winter - spring minimum.

Florence (1961) has commented that Blackbutt is restricted to the eastern coastal strip with the lowest variability and maximum effectiveness of rainfall, being limited in the north by increasingly severe winter - spring drought, and in the south by the change from summer to winter dominant rainfall.

Blackbutt types occur on a wide range of soils, from coarse sands derived from sandstone, coastal sand deposits or granites to clays derived from shales and sandstones. The types are, however, almost invariably absent from soils derived from basalt or similar alkaline igneous rocks, and they avoid poorly drained soils.

Florence (1961, 1964a, 1968) looked closely at the soil conditions associated with Blackbutt occurrence, and his major findings include:

- Blackbutt is in many cases associated with a rock high in quartz content, and absent from fine-grained rocks low in quartz.

- It is certainly not restricted on heavy textured soil, but occurs only where the soil is well aggregated and bulk densities are moderate.

- The distribution of Blackbutt tends to be limited by physical properties of the soil that restrict aeration, moisture permeability or penetration of roots to depth. Such soil properties vary with the mineralogy of the parent material, its geological history and the landscape pattern. White Mahogany tends to replace Blackbutt on such soils.

- Blackbutt occurs on soils showing a wide range in fertility status; combined with the effects of soil moisture availability these changes in fertility are correlated with gradients from open dry sclerophyll forest (eg. Dry Blackbutt type) to wet sclerophyll forest and towards rainforest (eg. Moist Blackbutt type).

- Although firm evidence is lacking, it appears that Blackbutt may be increasingly restricted from soils at the higher fertility levels by the interactions of other organisms, both microbial and higher plants, creating conditions unfavourable for Blackbutt establishment and survival. Blackbutt's own interaction with its environment may contribute to this effect.

- Blackbutt soils consistently show favourable soil moisture characteristics, with a wide range of available soil moisture and with moisture levels commonly approaching Field Capacity.

Florence's explanation of the role of soil conditions on the occurrence of Blackbutt and associated communities is summarised in Fig. 1, taken from his 1964 paper. (Note, however, that in practice the boundaries between occurrences involve considerable overlap).

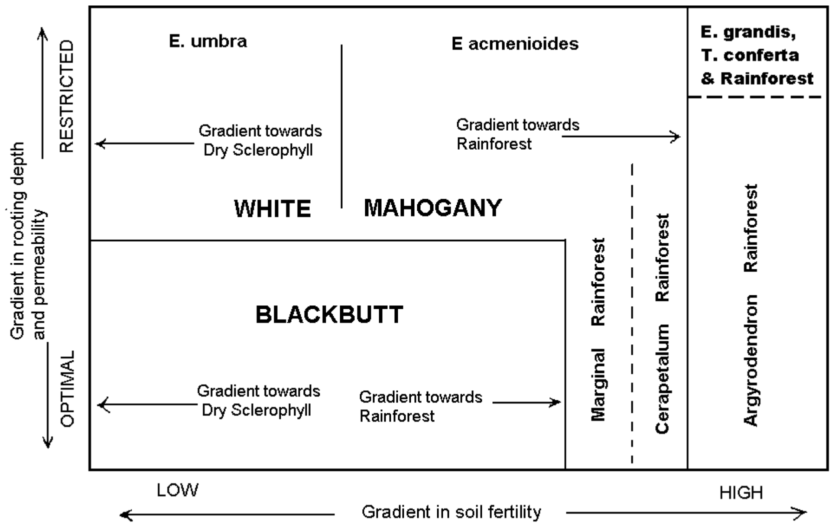


***Figure 1:** Diagrammatic illustration of relationship between soil conditions and occurrence of Blackbutt and other forest communities.*

(from Florence, 1964a)

Although it does not appear to have been the subject of any study, Largefruited Blackbutt, within its zone of occurrence, often occurs on shallow and heavily drained soils of low fertility. It would thus tend to substitute In part for Broadleaved White Mahogany in Fig. 1.

An early recognition that Blackbutt soils are often of relatively low fertility, particularly by agricultural standards, has been important in retaining many Blackbutt sites under forest cover - not only those under Crown ownership, but also frequently those on freehold lands.

Blackbutt types commonly show a distinct response to topographic changes. One common North Coast pattern is Blackbutt slopes, giving way to Flooded Gum or Brush Box gullies and to Grey Gum-Grey Ironbark-White Mahogany type on the ridges; another pattern produces Moist Blackbutt type on the lower slopes and Dry Blackbutt on the higher and more exposed sites. These topographic responses are readily explained by Florence's model, through the influence of topography on soil conditions. As previously noted Blackbutt types avoid sites that show poor drainage.

Biotic influences play their part in the distribution and occurrence of Blackbutt types. Florence and Crocker (1962) demonstrated the strongly inhibitory effect of Blackbutt litter on the growth of Blackbutt seedlings, and indicated that this effect was associated with microorganisms that are involved in the breakdown of litter - a process that occurs at a relatively rapid rate in Blackbutt soils - and the mineralisation of nitrogen from the litter. It was largely an extension of this effect that was suggested by Florence (1964a) as the cause of the restriction of Blackbutt from the more fertile soils.

There may be other microbial effects influencing the distribution of Blackbutt. *Phytophthora cinnamomi* has been shown to be widely, and apparently naturally, distributed throughout the area of occurrence of Blackbutt by Pratt and Heather (1973), who suggest that this pathogen may cause the restriction of certain trees and other plants from some sites. This could arguably apply to Blackbutt in its exclusion from apparently otherwise suitable moist, fertile sites.

Blackbutt types commonly, though not invariably, carry an understorey of she-oaks: Forest Oak on the better soils, Black She-oak on the poorer. These have long been regarded as a useful component of the forest stand (eg. Jolly, 1928), and are now recognised as being nitrogen-fixing plants. Whilst they probably do not influence the occurrence of the Blackbutt types, they may well contribute to the health and vigour of these types.

As with most eucalypt forest communities, fire is an important factor in the Blackbutt forest environment. Indeed it is the cause of the main species name from the black char that is a normal, and long lasting, feature of the rough, lower bark of Blackbutt trees.

At Cumberland S.F., half a century of protection from fire has succeeded in converting a fine regrowth stand into what might more appropriately be termed Greybutt. This, however, is unusual, and it is evident that in Nature fire is a regular feature of Blackbutt stands, probably being frequent but of usually moderate intensity in drier stands and less frequent but more severe in the moister ones. Fire itself significantly affects the facies of the stands, and there many North Coast examples where a mid-slope road divides Dry Blackbutt, with and understorey of Blady Grass, on the regularly burnt top side, from Moist Blackbutt, with an infusion of rainforest species and Lantana, on the rarely burnt lower slopes. In the usual pattern the fires will injure some trees, deliver the coup de grace to some of the weaker stems, remove much of the understorey and litter, and create suitably open conditions for the establishment of patches of regeneration. Without fire, some of the moister Blackbutt sites would gradually lose their Blackbutt component in favour of more shade tolerant species.

A further factor - **selective logging** - appears to influence the presence of Blackbutt on some of the more marginal sites where the species occurs as only an occasional tree, possibly utilising rare local microsites suitable for its growth. In a number of districts, sites once classified as Blackbutt type have been converted to non-Blackbutt stands by the removal of the scattered Blackbutt trees and their failure to regenerate. Conversely, of course, **planting** (particularly during the 1960s) and, to a lesser extent, **direct seeding**, have been responsible for extending Blackbutt beyond its natural range in various North Coast areas. Some of these 'off-site' plantings appear to have been highly successful, particularly on certain of the more mesic sites, but there have also been failures, and the long-term development of the off-site stands must be regarded with some caution - a point that has also been stressed by Florence (1968).

2.3 Other Ecological Aspects

There are several other ecological aspects of the Blackbutt types that should be noted as relevant to the management of these stands.

Blackbutt is a wide-ranging species, extending along the East Coast for about 1 700km, and in altitude from sea level to 600m, and rarely to 1 000m. Not surprisingly, it is also a rather variable species, showing considerable differences in crown, bark, leaves, capsules and other features. Some of these features are fairly consistent in a particular region or locality, but others may vary within a stand (Florence, 1961,1969). Blackbutt hybridises with other Monocalyptus eucalypts, including White Mahoganies, Stringybarks, Needlebark Stringybark and Sydney Peppermint (Burgess, 1975), and some of the variation has been attributed to hybrid introgression, though Florence found little evidence of this, and suggested instead that *“the variation pattern results from adaptive environmental selection on the species of widely heterogeneous genetic make up.”*

This genetic variation is reflected in considerable provenance differences within the species. Burgess (1975) has reported on a Blackbutt provenance trial, drawing on seed lots from throughout the species range, and planted on a number of different sites (some off-site for Blackbutt) in N.S.W. The results showed considerable differences in performance, but with batches from certain high quality sites (and including two batches of Large fruited Blackbutt) being the best performers in all locations. Burgess suggests that this indicates that the genotype x environment interaction is small or absent. He also points out that, averaged over all planting sites, the difference in height growth between the best (Ellis S.F.) and worst (Fraser Is.) sources would represent an improvement of 90 per cent by selection for the best. While these plantings in general continue to demonstrate the same trends described in 1975, there have been some changes; for example at the Cascade (Wild Cattle Creek S.F.) site, the Large fruited Blackbutt provenances have lost their early advantage.

Fauna in Blackbutt types has been studied fairly intensively in the Kendall district, looking at both undisturbed (or little disturbed) stands and stands subject to various histories of logging and treatment (Milledge, 1979a and b). The study covered the range of plant communities in the area, with Blackbutt types being the most significant, and Milledge (1979b) provides a list of vertebrates recorded from the Blackbutt communities (BRB), with their relative abundance, in his Appendix 2. This shows 14 amphibians, 23 reptiles, 94 birds and 24 mammals as having been observed in the Blackbutt communities.

All of these are animals, which are also found in adjacent eucalypt forest types; none is exclusive to the Blackbutt types. Many of these animals are dependent on a forest environment, with a minor, but significant, proportion of these being dependent on the occurrence of larger tree hollows. Such hollows are more common in trees capable of reaching the larger sizes, like Blackbutt. Milledge has provided a useful, though still incomplete, inventory of vertebrates in this area, but some of his comments and conclusions have subsequently been shown to be incorrect.

2.4 Ecological Relationships

The Blackbutt types occur closely associated with a number of other distinct forest types.

As already noted, on the North Coast they are commonly found with the Grey Gum - Grey Ironbark-White Mahogany type on the ridges, and with Narrowleaved White Mahogany, Flooded Gum or Brush Box types in the gullies; similar, though somewhat different, associations occur on the South Coast. These provide a repetitive pattern that is difficult to portray with any accuracy on other than fairly large-scale maps.

Elsewhere, particularly in areas where rainfall is below the optimum for Blackbutt development, it is replaced by Spotted Gum types on soils of heavier texture or poorer structure. Higher moisture availability and more fertile soils see it replaced by Tallowwood - Sydney Blue Gum or similar types, while reduced fertility results in Scribbly Gum, Bloodwood and other species taking over from the Blackbutt types. A portrayal of this pattern has been provided by Baur (1962; fig. 6).

The presence of Blackbutt itself provides a strong unifying feature in the stands dominated by this species. Despite their plasticity in some respects, these stands are distinctive in the field and share many characteristics in common. As such, they appear to justify being regarded as a good ecological, as well as silvicultural, entity.

3. OCCURRENCE

The distribution of Blackbutt as a species serves to mark well the occurrence of Blackbutt types. Where the tree occurs, it normally dominates the stand to the extent that, by almost any standard, the community has to be recognised as a Blackbutt type.

The southernmost occurrence of Blackbutt is close to the town of Eden. From here it extends discontinuously northwards along the South Coast, essentially confined to the coastal lowlands. Though the tree is widespread through this zone, there are few extensive stands of Blackbutt type present. In the Sydney area Blackbutt occurs as a tree in some of the sandstone gullies, and originally dominated the vegetation on the eastern, and better-watered, part of the Wianamatta shale deposits. This land has largely been cleared, though remnants remain in such places as Cumberland S.F. and Dalrymple Hay Nature Reserve (formerly State Forest), and to a lesser extent in urban subdivisions and local parks. Maiden (1917) mused that it was “perhaps the best known of all the genus to Sydney residents, as it is so abundant”; a similar comment would hardly be made today, though it is far from rare.

It appears again in the Gosford-Wyong area and stands extend along the Watagan Range into Newcastle. Stands occur towards Port Stephens, and then in a more or less continuous belt northwards from Hawks Nest through part of Bulahdelah S.F., Seal Rocks, and Wallingat S.F. to Kiwarrak S.F. The first truly major region of occurrence occurs north from the Manning River towards the Macleay River, and including the Taree, Kendall and Wauchope Forest Management Areas. Here, as further north, it extends into the ranges to altitudes of 700 - 800m. Blackbutt is less prominent, though still widespread, through the lower Macleay valley, but again becomes a dominant feature of the forest vegetation from near Macksville to north of Woolgoolga, and including the Macksville, Urunga, Bellinger, Coffs Harbour, and Dorrigo M.A.s and parts of Ellis and Clouds Creek S.F.s. Again its importance diminishes through the lower Clarence River basin, though It is common on light-textured soils in eastern parts of the valley, both north and south of the river, and extending north on similar sites towards the Richmond River. It is largely absent from the Richmond and Tweed valleys except for a rather limited, but important, occurrence on acid volcanic outcrops northeast of Lismore - Whian

Whian, Nullum and Mooball S.F.s. An isolated occurrence, at the highest altitude known for the species (about 1 000m), is on granite soils on former Dandahra Creek S.F., northwest of Grafton.

The species extends into Queensland, occurring through coastal and adjacent upland districts as far north as Fraser Island (about 25^0 S lat.)

The occurrence of Blackbutt is portrayed, with somewhat questionable precision, on the 1:4 000 000 Forest Types map of N.S.W. (Forestry Commission of N.S.W., 1978). This tends to overemphasise some stands (eg. lower Clarence) and to omit or under emphasise others (eg. South Coast, parts of Wauchope district), at least in part because of the intimate association of Blackbutt with other types.

An inventory carried out by the Forestry Commission in 1971-72 (Hoschke, 1976) indicated a total State area of some 391 000 ha of Blackbutt types, of which 199 000 ha were on State Forest: representation on other tenures at that time included National Park, 13 000 ha; vacant Crown land, 39 000 ha; leasehold, 20 000 ha; essentially freehold, 112 000 ha.

4. UTILISATION

Certainly for most of this century, Blackbutt has been the major hardwood timber producer in N.S.W. - the "bread and butter timber of the North Coast", as Dr. M.R. Jacobs used to call it. Together with its main associates it provides that great stand-by of the N.S.W. timber merchant, 'North Coast Hardwood". In recent years over 40 percent of the hardwood sawlogs produced from Crown-timber lands in eastern N.S.W. have come from Blackbutt and species associated with it, though probably only half this volume has in fact come from Blackbutt types.

As noted, Blackbutt may also occur with a large number of other associates, and the timber properties of some of the more important of these are summarised in Appendix 3, using data derived from Bootle (1971). They include some of what are widely recognised as Australia's finest hardwoods.

Blackbutt Itself is usually not regarded as an outstanding species for its timber properties, yet it is almost invariably the preferred species of any sawmiller with a choice in the matter. Reasons for this include: its availability; its defects generally being of the type that can be readily boxed out of the log; its easy and amenable sawing characteristics; and its fairly consistent quality and ease of handling as sawn timber. Like most eucalypts, however, young, regrowth logs of Blackbutt and its associates can prove most refractory: approaches towards overcoming the resultant problems have recently been studied and reported by Krilov (1980, 1981 a & b 1982).

Besides sawn timber, the types yield a range of other products, including poles, piles, girders, sleepers, case and pallet timber, orchard and vine poles and mining timber: in most districts markets exist for most of the wood produced. In addition sawmill residue from most species can be used as woodchips for paper manufacture, though Bloodwood, Turpentine and, on the South Coast, ironbark are not accepted at the time of writing.

The types within State Forests are commonly used for grazing under lease or permit. They are not highly regarded for honey production, though they are used by beekeepers to some extent. Particularly in some of the more elevated areas of occurrence, the Blackbutt types have a valuable catchment protection role.

Many of the stands, again especially in upland sites, have recreational appeal by virtue of the location where they occur (eg. Mt. Boss S.F., Whian Whian S.F.) or of the presence of stems of particular majesty (eg. Middle Brother S.F). However, beyond this, mixed aged regrowth stands, containing some trees approaching maturity, may also have high recreational appeal in their own right, and stands such as those traversed by the Pacific Highway on Burrawan, Newry and Pine Creek S.F.'s are widely recognised as contributing to some of the most attractive sections of the highway. Blackbutt Itself is prone to the dropping of long, dead, spear-like branches, and recreational sites within Blackbutt stands need to be chosen and managed with caution.

5. HISTORY OF USE AND MANAGEMENT

The Blackbutt types have a history of use for timber production going back to the earliest years of European settlement. Some of the associated species, eg. Tallowwood and Grey Ironbark, were recognised at an early date as some of the finest hardwoods, while Blackbutt itself, though less highly regarded for its properties, provided a good timber, and was available in quantity from large trees on accessible land.

The stands undoubtedly varied considerably from place to place, though many old reports, some now becoming legend, indicate that considerable areas carried rather widely spaced large trees, with an open understorey apparently maintained by regular Aboriginal burning (eg. Forestry Commission of N.S.W., 1957; p.42. A crown plan of such a stand is illustrated by Jacobs, 1955, fig. 114) The same legends suggest that at a somewhat later stage these stands were peopled by stockmen, endlessly galloping their horses through the open forest (Jolly, 1928; Fisher, 1978). Probably usually finished off by fire, overmature trees in the stand would die and fall, creating local gaps sufficiently large for clumps of young Blackbutt and its associates to become established when the fire regime permitted: though primarily consisting of the large trees, these stands must always have carried scattered patches of smaller stems. As Aboriginal tribal use of the forests disappeared the burning pattern altered, and certainly in some areas this allowed regrowth to become more widely established, to produce a two-aged forest - large and scattered old stems in a matrix of younger trees dating from the latter half of the 19th century, eg. Mt. Boss S.F. (A-Tree Preserve), Yessabah S.F. (Anderson’s Lease area); Wild Cattle Creek S.F. (Cascade area). Elsewhere, understorey shrubs started to appear more prolifically in the undergrowth. Either way, the stockmen's gallops were becoming impeded.

Logging, as it occurred, was highly selective, with the best stems only being removed. Again because of their size these trees, singly or several close together, created gaps large enough for the light-demanding Blackbutt to regenerate, the clumps of regeneration supplementing those present following natural mortality. One selective operation, loosely controlled by girth limits, was almost invariably followed by others - a progressive picking over of the forest, each operation producing further clumps of regeneration so that the once seemingly regular forest was transformed to a decidedly irregular one, made up of remnants of the old- growth forest and scattered and generally small stands of regrowth of varying ages (Jacobs, 1955; para 320).

This pattern of repeated selective logging was widespread in the more accessible coastal forests, particularly though not exclusively in the Blackbutt types. Subsequent silvicultural treatment, including culling, freeing, thinning and sometimes regeneration treatment, often performed under the catch-all name of timber stand improvement (T.S.I.), was carried out from about 1910 onwards, and helped to produce forest areas that to-day are both most attractive and increasingly highly productive, but usually with few remnants of the old-growth stands still in evidence.

During and after World War II operations moved from the coastal forest areas into the more remote and often rugged hinterland stands, such as Bellangry and the Horseshoe area (Urunga district). Changed economics, improved logging equipment, the effects of topography and increased timber demand meant that In these cases harvesting was no longer selective, but essentially a clearfelling in which usually only scattered unmerchantable stems and occasional clumps of regeneration were retained. These operations have produced large areas of even-aged regrowth that currently provides one of the major utilisation challenges of native forest management in N.S.W.

The history of logging in the Blackbutt types has thus resulted in the development of two different classes of stands. In the coastal areas they essentially carry a mosaic of usually relatively small patches of even-aged regrowth, the age of the patches varying from about a century to recent regeneration, but usually skewed towards the younger half of this range. Some larger even-aged patches occur - old bullock-paddocks that regenerated when mechanised logging arrived; stands heavily damaged by fire and then salvaged, such as the 1942 Eastbank Road regeneration on Orara East S.F.; areas given heavy silvicultural treatment, particularly culling, following logging, eg. the 1917 regeneration on Lower Bucca S.F. Nonetheless, the overall pattern in these more accessible forests is of mixed-age stands with management aiming towards a group selection system.

By contrast the more remote and frequently more rugged areas tend to carry diminishing areas of old-growth forest with extensive areas of even-aged regrowth, mostly dating since the 1950s, often with scattered old-growth trees standing above it - these trees were often considered unmerchantable at the time of logging, and were retained as a seed reserve, though sometimes better quality trees were deliberately kept as seed trees. In some areas such old-growth trees were subsequently removed in silvicultural treatment, while more recently still they have tended to be retained for wildlife or aesthetic reasons.

Particularly in the coastal districts, the Blackbutt types dominate those forests that have some of the longest histories of active and successful management in the State. Rule (1928) gives an interesting account of a visit through such stands (Coopernook, Lansdowne and Burrawan S.F.) over half a century ago. It is areas of this type that offer probably the finest opportunities for sophisticated management of native forests in N.S.W.

6. REGENERATION REQUIREMENTS

6.1 Seeding Habits

Information on the flowering and subsequent seed availability of various eucalypts has been summarised by Boland et al. (1980), and the figures relevant for major species in the Blackbutt types are shown In Table 1.

Table 1

FLOWERING AND SEED COLLECTION TIMES: BLACKBUTT TYPES

SPECIES	FLOWERING TIME	SEED COLLECTION	DURATION	NO. CROPS	NOTES
Blackbutt	Sep-Mar	Dec-Feb	+++	+	
Blackbutt Largefruited	Jan-Mar	Dec-Feb	+++		1
Bloodwood, Red	Jan-Apr	June-Mar	++		2
Gum, Grey (Smallfruited)	Jan-Mar	Nov-Mar	++		
Gum, Sydney Blue	Jan-Mar	Dec-Feb	++		
Mahogany, Red	Oct-Feb	Aug-Sep	++		3
Mahogany,White (Narrowleaved)	Oct-Feb	Dec-Feb	+++	+	
Tallowwood	Aug-Dec	Feb-Sep	++		

***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) Heavy seed years usually out of phase with those of Blackbutt.
(2) Only 6 - 8 weeks elapse between budding and flowering.
(3) Fruits more frequently towards N. of range; geographical variation in good seed years.

This table shows that most of the species present are summer-flowerers. Moreover, flowering tends to be much more variable than the table infers. Florence (1961, 1964b) gives details of flowering in a number of stands, mostly with peaks in late spring though one stand continued to produce flowers through to the autumn. At Pine Creek S.F. Floyd (1962) recorded flowering as regularly from September-November each year with occasional sporadic light flowerings reported by some workers in autumn, while later, working at Kendall, he found that *"November to March is the period of major flowering with an occasional very light flowering in June to August"* (Floyd, 1975). The off-season flowering is not necessarily as light as Floyd infers: C. Mackowski reports heavy flowering of Blackbutt on Candole S.F. in March, 1981, and conversely a heavy flowering of Largefruited Blackbutt on Conglomerate S.F. in November, 1980. Nonetheless the normal flowering times for these two closely related, and sometimes physically close, species are sufficiently separated to be a major factor in preventing hybridisation. By contrast with the North Coast stands, Blackbutt at its northernmost occurrence on Fraser Is., Qld, has peak flowering in mid-winter (Florence, 1961).

Flowering and fruit development for Tallowwood and Sydney Blue Gum were summarised in No.1 of these Notes: Moist Coastal Hardwood Types. Though specifically relating to the Tallowwood - Blue Gum type, the information is equally valid for these species in the Blackbutt types. Florence (1961) has recorded the flower development sequence for Blackbutt:

About Jan	year N	Initiation of flower buds
April	year N	Shedding of bracts surrounding inflorescence
Oct-Dec	year N+I	Shedding of opercula (ie. flowering)

Note that nearly two years elapse between the initiation of the flower buds and the time of flowering. Florence observes that the time for the capsule to mature is variable, but may be up to a year later, and that remnants of the previous year’s crop may survive for a further year. Thus evidence of four year’s seed crops (ie. immature buds, mature buds, main seed crop, previous seed crop) may occur on a tree at the one time.

Information on the seed characteristics of major species from the Blackbutt types is given in Table 2, again derived from Boland et al. (1980), while again, also, further information relating to Tallowwood and Blue Gum is discussed in No. 1 of these Notes.

Florence (1961) notes that, for Blackbutt itself, it is very difficult visually to separate fertile seed from sterile particles. (The figures in Table 2, as in usual practice, relate to the normal collection mixture of seed plus chaff). Floyd (1962) found an average of about 2½ viable seeds per capsule, out of a total of about 31 seedlike particles; he also found that, during seed collection, the viable seeds tended to remain in the capsules until towards the end of seed shed, so that seed collected over the first part of seed shed provided a lower proportion of viable seed than that from the last part. In his study, 17 days were required for virtually all seed to be shed from the capsules. Floyd also found remarkable similarity in the numbers of viable seed present in different batches of seed, collected over five years, though all from the Coffs Harbour - Urunga area. In four different batches the range was from 80 000 to 85 000 viable seeds per kilogram. Florence, working over a much wider geographic range, found considerably greater variability. Most seed was in the range 20 000 - 70 000 viable seeds/kg, but extremes can from 6 000 to 114 000. Florence found that some Queensland batches tended to carry substantially greater numbers of viable seed/kg than north Coast seed.

Florence and Floyd also both examined the patterns of seedfall in Blackbutt. Floyd followed one stand on Pine Creek S. F. over a period of three years, and concluded: *“The time of Blackbutt seedfall is … most flexible and could occur in any month of the year provided dry conditions are experienced for at least two weeks in summer and somewhat longer in winter.”* By contrast wet periods virtually stopped seedfall, so that in normal seasons little seed falls during the summer - a fact conflicting with local 'bush' opinion that most seed is shed in January and February. Time of flowering had little effect on the time of seedfall, as seed could remain on the tree for 12 months after maturity if weather conditions so dictated, and Floyd observed that some viable seed is carried in the crowns of Blackbutt at all times. Indeed in a later study, which generally con firmed the seedfall pattern reported from Pine Creek S.F, Floyd (1975), recorded *“nine periods of seedfall in the 2½years from late 1969 without any flowering to replenish the seed supply”.*

Florence followed seedfall in a number of sites for about 20 months, and reached conclusions somewhat different from Floyd's. He writes *"…following a general (heavy) flowering a substantial seed cast with a well defined peak occurs in the spring and summer …Where the flowering has been light, there is no clearly defined seed cast, but rather a series of small peaks are possibly influenced by varying climatic conditions”.* Florence does not appear to have endeavoured to examine the seedfall/weather relationships as Floyd did, and it is likely that the peaks he records are in fact no less a response to dry spells that permit the capsules to open and shed all or some of their seed.

Both Florence and Floyd refer to variations from season to season in the level of flowering and subsequently in the availability of seed, but neither followed their stands through for sufficient time to determine a pattern in the occurrence of good and poor seed years, while Van Loon (1971) has observed that it 'is well known that good seed years in Blackbutt stands occur infrequently'. C. Mackowski is currently involved in a long term study on the variability in Blackbutt flowering, and he notes that *"some trees flower as individuals and as groups sporadically (every 3-4 seasons), others frequently. There can be periods of two years without flowers on both Blackbutt species. Variation appears to be geographic ie. occasional departures from normal in different populations/localities".* In addition to this variability, severely fire damaged trees appear to go for lengthy periods, presumably until their crowns are adequately restored, with virtually no flowering.

Table 2
SEED FEATURES : BLACKBUTT TYPES

Species	No. viable seeds/kg		Germination		
	Mean	Highest	Temp (1) (C°)	1st Count (2) days	Final Count (2) days
Blackbutt	59 000	195 000	20;25	7	21
Blackbutt, Largefruited	28 000		(25)	7	21
Bloodwood, Pink	80 000	212 000	(25)	5	14
Bloodwood, Red	77,000	102 000	(25)	5	14
Gum, Grey (Smallfruited)	443 000	910 000	(25)	5	21
Gum, Scribbly (Northern)	99 000	210 000	25	5	15
Gum, Sydney Blue	538,000	1 540 000	25		14
Ironbark, Grey (Southern)	419,000	1 320 000	(25)		21
Mahogany, Red	215 000	790 000	25	5	21
Mahogany, White (Broadleaved)	54 500	119 000	20 (25)		21
Mahogany, White (Narrowleaved)	140 000	336 000	(25)	7	21
Tallowwood	205 000	770 000	(25)	5	14

Notes: (1) Temperatures recommended for germination tests. Where figure is bracketed, eg. (25), this temperature is satisfactory, but others have not been tested, where two figures are given, eg. 20;25 both have been found satisfactory.
(2) 'Count' figures relate to laboratory tests, but give a relative measure of the speed of germination.

Fire-damaged trees apart, it appears that Blackbutt trees will normally carry sufficient seed to provide adequate regeneration under reasonable conditions.

6.2 Regeneration Establishment

Regeneration in the Blackbutt types is usually obtained by natural means, though artificial regeneration utilisinq both direct seeding and planting seedlings has been used and is examined in section 6.7.

Natural regeneration ultimately depends upon the establishment of seedlings, but there are less directly seedlings-produced sources of regeneration, such as coppice, advanced growth and lignotubers, that can be of considerable significance in the regeneration of some Blackbutt stands, and these are discussed in section 6.6.

Seedling establishment requires the presence of three factors - a seed source, a suitable seedbed for germination, and the presence of factors allowing the young germinates to survive and grow.

6.3 Seed Source and Germination

As noted above, Blackbutt trees normally carry seed in their crowns, though the quantity available varies from season to season. Most of the associates in the Blackbutt types share this attribute, though perhaps less markedly than Blackbutt itself. Nonetheless, at any time a reasonable quantity of seed for seedling regeneration should be available in Blackbutt stands.

Florence (1961, 1964 b) does not give the total seed production from his seed tray collections in six Blackbutt stands, but his figures illustrating the rate of seed production at six-weekly intervals (1964b, figs. 4(i) and 4(ii)) allow estimates to be made. Two stands, selected as being about average for the two relevant figures (Coopernook (podsol soil), Bellangry), both gave similar estimates in the order of 450 000 viable seeds per ha per annum, based on measurement periods of 90 and 84 weeks respectively. For the first 12 months of collection the respective production levels were about 110 000 and 220 000 viable seeds/ha/an; heavy seed fall in the succeeding period boosted the longer term averages considerably. By comparison, Floyd (1962) recorded an average of about 75 000 viable seeds/ha/an over a longer period from trays located in openings in Blackbutt stands: his lower figure clearly reflects the greater average distance of his trays from trees shedding, compared with Florence's trays which were under a fairly complete canopy.

In nature, seed for regeneration comes from the standing trees. However, following logging operations, seed may come either from remaining seed trees or from the heads of felled trees. The distinction between these may be significant. Seed trees are a continuing source that will release seed when conditions are suitable (i.e. drying weather to open capsules) and, within limits, allow the seed to be spread widely. Heads from logging are a once-only source of seed, releasing what may be very large quantities over a short period after logging; most of the seed is concentrated within the area occupied by the head, though there is some movement of seed associated with logging activity (when, for example, some branchlets with capsules may be smashed off and moved about by tractors) and subsequent rain wash. Post-logging burning may destroy most of the seed released from logging heads, but may promote seedfall from retained trees. Depending upon the circumstances of logging and subsequent treatment, either may be the more Important source of seed for regeneration.

Floyd (1962) examined the dissemination of seed from a Blackbutt seed source. As previously noted, he found that a period of two weeks' dry weather in summer, and somewhat longer in winter, is needed to produce seedfall. In his near-coastal sites, seedfall was usually associated with the prevailing winds - north-easterlies to south-easterlies in the late spring and summer, and south-south-westerlies to westerlies in the autumn, winter and spring. From his seed-trays, Floyd recorded a surprisingly short distance of dispersal from seed trees. Sterile seed was recovered up to 36m from seed trees, but no fertile seed (which is heavier) was collected more than 8m from the butt. Using the occurrence of germinates as an indicator, Floyd found that effective seed dispersal was limited to a radius of 6m from the crown edge of 35m high Blackbutt, or about 10m from its butt. This is less than half the distance determined for Blackbutt in laboratory studies by Cremer (1977) - 21.1m from a 40m high tree in a wind of 10km/h. Over the years various foresters have expressed some reservation about Floyd's findings, which appear to underestimate and to conflict with common field experience of the distance to which seedlings may be found from seed trees. In an effort to check his earlier results A.G. Floyd in 1969 commenced a similar study in the Kendall district. This part of the study never seems to have been reported, but the field sheets show that seedling Blackbutt appeared up to 90m from an isolated ridgetop seed tree, though there is a suspicion that at least some of the seed may have carried over in the soil from logging nearly a year earlier. In the absence of more convincing evidence, R.G. Bridges' conclusion that adequate regeneration of Silvertop Ash can be expected within 40m of an unlogged boundary (see No. 3 of these Notes) would appear a realistic guide for the Blackbutt types.

Most eucalypt seed germinates rapidly. This applies to Blackbutt and its associates, which have no dormancy and which will start to germinate within a week of sowing when moisture and temperature conditions are favourable (Table 2). Floyd (1962) confirmed that seed shed at any particular time germinated on the first subsequent occasion that conditions were suitable, and over a 3 years' period he recorded six bursts of germination - three in the autumn, all with heavy germination, one in spring (light) and two In late spring-early summer (light to moderate).

There is no protracted build up of eucalypt seed in the soil, though the seed will survive for some months if conditions for germination do not occur (and if it is not removed by ants): Floyd (1957, 1962) has recorded germination in August of seed sown in the field in May.

6.4 Seed Bed

For seed to germinate and become established, it must fall upon a receptive and suitable seedbed.

Floyd (1962) carried out a comprehensive study into seed bed preparation on Pine Creek S.F., involving typical group selection openings, probably averaging about 70 m diameter, on a west-facing slope. Some were burnt after logging, some were mechanically cleared (or hand cleared in several cases), and one was left untreated. Treatments were carried out at different times of the year. While germination was superior on the burnt openings, and the seedling stocking remained better than on the mechanically cleared sites up to 3 years after treatment, the cleared areas provided more established seedlings, defined as those where the plants were free of domination by the undergrowth, and corresponding on the study site to a height of about 60cm. The untreated opening gave the poorest results.

A summary of the results is given in Table 3.

In the same study, Floyd studied the fate of Blackbutt seed sown on three different surfaces in a burnt opening - charcoal heap, ash bed and bare, unburnt ground. The ash gave the poorest result, though the one seedling that survived gave excellent growth; the charcoal gave marginally better survival than the unburnt ground.

Overall, Floyd concluded that mechanical site preparation was superior to burning, while either was to be preferred over no treatment in producing established seedlings. Floyd also suggested that site preparation from July to October provided the best results, since the, usual subsequent spring germination survives better than that of autumn.

The significance of mechanical clearing versus burning in relation of weed development was subsequently examined by Floyd (1965, 1966) for a moist eucalypt stand on Lower Bucca S.F. The stand was not Blackbutt type, though some Blackbutt was present, but the results would seem applicable to moist eucalypt stands generally. Burning promoted weed growth, either from seeds stored in the soil or from root stocks and coppice: 12 months after treatment, the burnt site carried 540 kg/ha of weed growth, whereas the mechanically cleared site only carried 160 kg/ha. In particular the weeds promoted by burning and coming from seed in the soil are those most likely to compete with and suppress eucalypt seedlings - Soldier Vine, Hopbush and wattles. Thus, as is common experience, burning in these moister sites may severely hamper eucalypt establishment, compared with mechanical clearing.

Table 3

BLACKBUTT SEEDLING ESTABLISHMENT WITH VARIOUS TREATMENTS

Pine Creek S.F. (from Floyd, 1962)
(Figures refer to no. plants/ha; final assessment 2½-3 years after treatment)

Post-logging Treatment	No. Germinated	No. Surviving	No. Established (1)
Burning	1730	1070	200
Mech. Clearing	1010	740	320
Untreated	300	148	0

Note (1): *see definition of 'No. Established' in text.*

Nonetheless some eucalypt seedlings will usually survive within such fire-induced weed growth, even under heavy vine growth as occurred following the1942 Eastbank fire on Orara East S.F. Often these surviving saplings are infested with vines that deform the leader; commonly the leader itself will die and the sapling will produce a new leader from a lower epicormic shoot.

Mackowski (1982) records that, in Moist Blackbutt type on the former Bellinger River S.F., a quarter of the Blackbutt regeneration showed such 'bayonet' growth.

Florence (1961) also demonstrated the superiority of prepared over untreated sites for seedling establishment. He used batches of sown seed and the planting of small seedlings under various conditions, and noted particularly the better initial health and growth of Blackbutt sown or planted on White Mahogany sites compared with those on Blackbutt sites.

This prompted the more detailed studies (Florence and Crocker, 1962), suggesting that microorganisms associated with the breakdown of litter in Blackbutt stands were antagonistic to seedling growth, inhibiting their development. In field practice this is probably of limited significance, since the disturbance associated with logging or fire usually seems sufficient to counter any antagonistic effect and to permit seedling development.

Both Florence and Floyd examined seedling germination and development in ground cover of ferns and grasses. Floyd found that quadrats carrying Kangaroo Grass had a higher stocking of Blackbutt seedlings than those with Blady Grass, and the growth in the Kangaroo Grass was better, though in both covers an adequate stocking of seedlings was established. Stocking was inadequate under fern, though growth was better than in the grasses.

Florence found that a continuous cover of Blady Grass or Bracken effectively reduced the number of seeds able to germinate and become established, but the barrier to regeneration was not complete - particularly under Blady Grass, seedlings do become established. He was impressed by the tenacity of the young seedlings, which could survive in dense grass and very low light availability. While most remained weak and spindly, some would grow through the grass and assume active growth indeed, regardless of the ground cover, Florence noted that once established in the soil, Blackbutt seedlings have a high potential for survival, and can tolerate both low light intensity and intensive competition, though their early stages of development are characterised by slow growth or intense inhibition in all situations.

Floyd also looked at the effects of light intensity, and found generally better stocking and early growth where shade was greatest. He noted that this was important in practice, as the grassy undergrowth tends to be poorly developed under the heavier shade, providing better conditions for eucalypt germination and establishment. Often, of course, the shaded site is the cooler and moister site, where seedlings are less likely to suffer from desiccation.

To summarise, these reported studies tend to confirm common field experience. Blackbutt regeneration is promoted by some seedbed preparation (which may be merely the soil disturbance associated with logging), with mechanical disturbance probably to be preferred over burning, particularly on the moister sites where burning promotes heavy and aggressive weed growth. Establishment close to standing trees may be retarded and inhibited by microorganisms associated with litter decay, but certainly in the early stages some shading appears beneficial for Blackbutt germination and establishment. Although not a preferred seedbed, some seedlings will establish in Kangaroo and Blady Grass cover, but they are less successful in ferny undergrowth.

6.5 Seedling Establishment

Establishment is that phase of the regeneration process extending from germination until the plant is able to assume dynamic growth or to survive the likely range of climatic extremes.

Blackbutt, virtually alone of its usual associates, does not produce lignotubers; it can, however, produce a carrot-like swelling near the root-stem junction, and this apparently acts as a food storage organ for the young seedlings (Jacobs, 1955, para. 19; Curtin and King, 1979). The lignotuberous associates probably have some advantage during the establishment phase, and certainly they have a degree of persistence that favours their build up as advanced growth in many forest stands, as Floyd (1962) noted in his study.

Nonetheless, despite their absence of lignotubers, young Blackbutt seedlings show a remarkable tenacity, with their ability to survive for lengthy periods in dense grass, as noted above, and to tolerate periods of hot, dry weather while still in their cotyledonary state (Floyd, 1957).

The period taken by a seedling until it can be regarded as adequately established varies considerably. Germinating on a suitable seedbed, with favourable subsequent weather conditions, the seedling may never cease active growth. The extreme example of this is shown by nursery seedlings planted out under conditions of intensive cultivation Mackowski et al. (1981) report planted Blackbutt with heights up to 4.2m in less 2 years from germination. Under more typical field conditions, Floyd (1962) recorded an average period of about 19 months from germination until he could regard the plants as established with a height of 60cm, while only about 10 months were required for the plants then to double their heights (i.e. 29 months from germination to reach 1.2m). The best plant in Floyd's study reached 60cm in 12 months and 2.1m in 2 years. At the other extreme Florence (1961) reports seedlings surviving for at least 21 months In dense Blady Grass, yellow green In colour and less than 5 cm high, but still surviving. It is some seedlings such as these, probably rather stronger in growth but subsisting in the undergrowth, that form the pool of advanced growth present in many Blackbutt stands (see section 6.6).

Despite its slow start, Floyd showed that the growth of Blackbutt seedlings was on a par with that of White Mahogany, and faster than any of the other species present as seedling regeneration during the duration of the study (about 2½ years) only Blackbutt and (Broadleaved) White Mahogany seedlings became established, with mean heights of 1.2 and 2.8m respectively for the oldest regeneration, though Floyd notes that by that stage the Blackbutt *"was steadily overtaking the white Mahogany".*

Whilst on most sites Blackbutt and its associates produce adequate seedling regeneration when a suitable seedbed is available, there are some sites where difficulties exist. The weed problem on moist sites has already been mentioned, and can be overcome by avoiding immediate post-logging burning. Perhaps more intractable are some of the stands on light, sandy soils that dry out rapidly after rain, as in come of the areas north and south of the Clarence River (eg. Bungawalbin and Doubleduke S.F.'s). Regeneration establishment here probably depends on the conjunction of receptive seedbed and adequate seedfall being followed by a lengthy period when the soil is kept moist, allowing the young seedlings to survive and develop a strong root system. Such conditions may only occur once in a decade, and periodic burning (likely in any case to eventuate in these dry forests) may be needed to ensure that some seedbed receptivity is maintained to take advantage of the conditions when they do occur.[3]

6.6 Other Sources of Natural Regeneration

Ultimately seedlings are the source of all eucalypt regeneration. However it is not necessarily seedlings from recent logging that provide much of the regeneration that forms the regrowth crop. Rather this is often provided by suppressed advanced growth, lignotubers and coppice. Thus Floyd (1962) records that, at the end of his Pine Creek study, the regeneration openings carried an average stocking of 1970 seedlings per hectare (870 Blackbutt, 1 100 other species) and 2 020 stems of advanced growth (300 Blackbutt, 1 720 other species). The advanced growth, benefiting from its established root system, was growing generally much faster than the seedlings, and was well ahead in size - whilst the average height of Blackbutt seedlings was 1.2m, much of the Blackbutt advanced growth was in excess of 3 metres.

Coppice is probably rarely of much significance in the regeneration of Blackbutt stands, though it is often a feature of young stands after thinning. However some occurs, often from small stems knocked over during logging operations or in some cases from small, malformed trees deliberately cut low to produce a potentially useful tree from the existing root system. Van Loon (1971) suggests that blackbutt stems larger than about 20 - 25cm DBH are unlikely to produce useful coppice.

Lignotubers form the basis for the advanced regeneration of species other than Blackbutt, and particularly in the drier, mixed Blackbutt stands they can be present in substantial numbers. Floyd's figure of over 1 700 such stems per hectare is probably typical; his range of values from 9 separate treatment openings was 820 - 2 760/ha. The plants themselves exist in different forms. Many may be

[3] This is one explanation of the 'Tabbimoble Problem', but there are others. At least one forester who has worked in this area and studied the problem is convinced that the lack of regeneration is due to unreported frequent burning. He states that there is plenty of evidence of seedling establishment after logging, but subsequent searches would almost invariably show the sites to have been burnt afterwards.

little more than the woody lignotuber with some weak shoots within the level of the grass layer; others 'will have spindly stems, poorly foliaged, subsisting within the taller undergrowth; some, benefiting from local openings, may have assumed more active growth. The lignotubers develop from seedlings that have become established as previously discussed, probably usually following earlier seedbed preparation by fire, logging or silvicultural treatment, and have been able to survive but not to maintain active vertical growth. They can survive for lengthy periods: Jacobs (1955, figs. 116 and 117) illustrates a Tallowwood lignotuber which had existed for 14 years under dense shade from wattles, and then assumed active growth when the wattle competition was removed, but this probably goes nowhere near approaching the survival limits of these plants. In the moister stands they may be less common, though where hazard reduction burning is practised their numbers may build up. (Some would undoubtedly contradict this statement, considering that lack of burning is responsible, for example, for the great increase in Turpentine stocking in parts of Pine Creek S.F. In this case establishment of the Turpentine almost certainly resulted from earlier burning, but the subsequent development of this very shade-tolerant species has been promoted by the absence of burning). Jacobs (para. 169) suggests that lignotubers of Tallowwood (one of the more shade-tolerant eucalypts) can survive for many years under one-fortieth of full sunlight, but at one percent of full sunlight they will disappear after a few years, and this undoubtedly is a major factor in lignotubers being less common in the more densely understoried moist stands.

Floyd's 1962 paper appears to be the first public recognition of the importance of Blackbutt advanced growth, Jacob’s comments on advanced growth relating primarily to lignotuberous species. The phenomenon was subsequently studied elsewhere, and Curtin (1966a) has described this non-lignotuberous advanced growth from the Taree area:

> *“Subsequent investigations have shown that these advance growth Blackbutt stems occur normally throughout large areas of mature and over-mature forest. In this state they tend to remain dormant, lying partially concealed in the Blady Grass understorey, with a few unhealthy juvenile leaves on the sterns, which show signs of repeated dying back and subsequent regeneration. The age of this advanced growth is not known, but they can obviously survive in this state for many years. However, on release by logging operations these stems quickly assume dynamic growth and grow much faster than germinates which arise as a result of seedbed preparation. It has become obvious that this advance growth in probably the major source of regeneration arising from the group selection management of these forests”.*

More recently, Curtin and King (1979) have described the characteristics of Blackbutt advanced growth regeneration:

(a) “It is typically difficult to see, being concealed in the understorey and appearing unthrifty with sparse juvenile foliage and evidence of repeated dieback of the shoots.

(b) It behaves like a lignotuberous seedling before assuming dynamic growth. The root stem junction becomes swollen like a carrot, presumably serving as a storage organ for food reserves.

(c) It is capable of extremely rapid growth on release from overhead competition. However, a wide range of growth rates does occur and not all individuals assume dynamic growth.

(d) It is plentiful in some forests but rare in others. Although its occurrence is not fully understood, it will tend to become established as a result of disturbance through logging or fire. It is found in the virgin forest but is more frequent in a forest subject to frequent cutting cycles.

(e) It is long-lived and can remain in the dormant state for a number of years.

(f) It is not plentiful on marginal Blackbutt sites.

(g) *Light prescribed fire may cause considerable damage to advance regeneration under 3 metres in height. Aerial shoots are often killed back to ground level and are replaced by coppice from the base of the original shoot. Depending on fire Intensity and tree size, up to 50% may be killed outright."*

Curtin and King, in their paper, refer to a stand on Lansdowne S.F. that had been selectively logged and silviculturally treated (some ring-barking, felling of dense Forest Oak understorey) in 1955-56. Much Blackbutt regeneration became established following this treatment, but its development was suppressed by vigorous Oak coppice regrowth and its presence was not noticed. A further selective logging was carried out in 1966-67, followed by the felling of oak coppice. In the process much of the still unnoticed Blackbutt advanced growth from 50cm to 3m in height was knocked over and pinned down by the Oak: its presence came to notice when the prostrate saplings started to produce epicormic shoots along their stems. The development of the prostrate stems was then followed for 10 years. Ninety percent of them survived, in each case with the strongest epicormic shoot present in 1968 being the one that survived and grew. These shoots varied in distance from 8 to 144cm from the root base of the original sapling, and by 1978 they had formed apparently stable stems from 2.5 to 22m in height and from 1.4 to 17.5 cm DBH. In no case had the surviving section of the original sapling layered, despite its horizontal position and close contact with the ground. The study says much for the persistence of this advanced growth, and for its ability to respond under even very adverse conditions.

As previously noted, advanced growth, whether lignotuberous or not, responds to stand opening much faster then seedling regeneration. Growth rates in Floyd's study showed similar relative values to those of the seedlings, with Blackbutt and White Mahogany faster than the other associates. Apart from the White Mahogany, Floyd believed that the growth rate of Blackbutt would allow it to assume dominance in the regrowth patches despite its relatively low stocking In comparison with the lignotuberous advanced growth, but he considered White Mahogany could be considered a rival to Blackbutt if present in my quantity. In practice, however, this seldom seems to be the case.

While not always present or significant, advanced growth is frequently a major source of regeneration in the Blackbutt types.

6.7 Artificial Regeneration

Although Blackbutt types normally regenerate well and reliably, artificial regeneration has been used with Blackbutt on a moderately large scale In N.S.W: as at 31st March, 1991, Blackbutt plantations covered over 4 200 ha on State Forests In N.S.W. (Forestry Commission of N.S.W., 1981). Plantations were initially used to regenerate some of the moister Blackbutt sites, where strong weed growth sometimes created problems in regeneration establishment, and also to re-establish Blackbutt on sites that were being brought back to forest after a period of use for farming or pasture - a practice that was extended and developed by a private company, A.P.M. Forests Pty Ltd., operating an the North Coast (Pryor and Clarke, 1964). Subsequently, and particularly during the 1960's when eucalypt planting was in particular vogue[4], it was used to establish Blackbutt on sites where the tree did not naturally occur, prompting some warnings about the risks of off-site planting by Florence (1968). At this time planting was also used on some sites where there would not appear to have been any real problem in obtaining adequate natural regeneration. More recently, planting has largely reverted to a technique for establishing Blackbutt on some of the more difficult sites, using both complete clearing and the extension of snig tracks to create suitable planting sites.

Blackbutt planting was reviewed by the Forestry Commission of N.S.W. (1966). Although there appear to have been some prior efforts, the earliest recorded planting was carried out on Whian Whian S.F. in 1939, using seedlings raised in standard metal tubes. During the late 1950's planting, which had only ever been on a small scale, was supplanted by direct spot sowing in prepared sites, following a technique that had been very successfully developed for Flooded Gum. The sowing rate used was between about 550 g and 1.1 kg per hectare, applied from a shaker to spots 2.4m apart, i.e. about 1 700 spots/ha, each receiving from 300-600 mg of seed or roughly 50 viable seeds. The seed normally was treated with a fungicide (TMTD) and an insecticide (dieldrin) to protect it prior to germination. Despite some conspicuous successes, it was obvious that planting gave more reliable

[4] Because of Pinus envy, according to one silvo-psychologist.

results on the moist sites, and with the development of a cheaper planting technique involving peat pots ("jiffy pots"), planting again largely replaced sowing.

The planting technique has undergone much improvement over the succeeding years, and the associated nursery operations have been described by Holmes and Floyd (1969), and more recently by Horne (1979c). Planting is usually associated with fertiliser application, using a 25 g starter pill (13:11:0:25 N:P:K:S) inserted in the soil about 20-25cm upslope from the seedling. The fertilising was originally intended as a 'starter' dose, giving the young seedlings a further edge in growth over weeds, but it has been found to provide the seedlings with a more lasting advantage. Horne (1978), reviewing a fertiliser trial on Lower Bucca S.F., notes that at age 10 years the fertilised trees had a 6 per cent increase in tree height, a 30 per cent increase In BA, and a 40 per cent increase in volume compared with unfertilised counterparts, while the effects of early increased mortality among the fertilised trees had been largely lost by subsequent mortality among the unfertilised trees. Weed control has also been shown to improve growth (Mackowski et al., 1981). The importance of seed source in Blackbutt planting has already been mentioned (Section 2.3). Not only does provenance affect yield, but there is also evidence in some areas that poor form in plantation trees can be attributed to seed collected from low and heavily branched parents.

Blackbutt planting has produced some extremely impressive stands on the North Coast, many of them now yielding merchantable timber. Planting has a role in the management of the Blackbutt types, though in most stands natural regeneration is more than adequate for the restocking of logged areas, while the temptation to try and extend Blackbutt beyond its natural occurrence (and in some cases into areas where its natural occurrence was fairly occasional) needs to be watched: as previously discussed (Section 2.2), there can be good reasons why areas are "off-site", to Blackbutt. Successes with off-site Blackbutt plantings there have undoubtedly been, but there have also been failures, particularly on poorly drained sites and sites subject to excessive droughting. The condition of existing off-site plantings warrants continued monitoring.

6.8 Regeneration Damage

Blackbutt and, to a large extent, its associates are normally relatively free of damage agencies in their young stages. However, they are not immune, and damage can at times be serious.

In the pre-regeneration stage, seed can be lost to ants. This can probably be of significance in the drier sites if a lengthy period elapses seedfall and germination, and was the reason for adding dieldrin to Blackbutt seed that was to be direct sown.

Blackbutt is rather more susceptible to frost damage than are most of its associates: R. Horne has reported a study where temperatures of -2.5 to -3.0ºC killed Blackbutt seedlings, whereas Sydney Blue Gum survived at temperatures below -5ºC. This has been of some significance where heavy logging operations have created local frost-hollow clearings in some of the higher altitude Blackbutt areas.

The role of **weeds** has already been mentioned. Particularly in the moister, and potentially higher quality, sites, slash burning can lead to a massive germination of weed seeds that have lain in the soil, sometimes for periods of many years (Floyd, 1965, 1966). The resultant weeds include various shrubs and small trees, with very rapid early growth (eg. wattles such as Two-veined Hickory Wattle and Black Wattle; Hopbush; Brush Kurrajong), and perhaps most damaging of all, Soldier Vine that can blanket the ground in a smothering tangle approaching a metre in depth. By contrast, weeds following mechanical site disturbance are usually species of much weaker growth, often annual herbs. There are undoubtedly many excellent regrowth stands that have become established through dense fire weeds, often aided by the development of bayonet shoots on the vine-entangled saplings (see Section 6.4); there are also more than a few severely understocked regeneration areas where either most of the eucalypt seedlings have succumbed to the weed competition or else where the eucalypt component, suppressed by the woody weeds, exists as advanced growth - potentially useful if released, but not currently contributing to the future tree crop. Stands in the drier sites usually face less of a weed problem, though again dense wattle may often be present, while Lantana becomes an increasingly competitive weed, particularly in areas not subject to frequent burning. C. Mackowski has suggested that some of the most common regeneration associates of the Blackbutt type, namely wattles and she-oaks, may play different roles, depending upon site conditions - on poor sites they are beneficial to the eucalypt regeneration, whilst on the better sites they become savage competitors.

Grass swards can prevent seedling germination or early survival, and for this reason such areas (eg. old pasture lands) are usually planted following ploughing or other site preparation: this also helps break the compaction that is often a feature of land formerly used for cattle grazing. Even then growth may be severely retarded by re-establishment of the sward, with the young trees' growth being checked (and in the process the trees often being unduly subject to insect attack) until finally they are able to establish sufficient crown cover to start to control the grass below. At this stage the planted trees usually assume active vertical growth, but in the meantime five or so years' growth may have been lost.

Browsing can also damage young regeneration. Domestic stock is often attracted to regeneration openings, where seedlings are trampled on or (probably accidentally) grazed. Soldier vine sites seem particularly attractive, thus accentuating the damage caused by the weeds themselves - the, more so as browsing tends to promote the new growth of Soldier Vine leading shoots and tendrils.

The significance of browsing by native animals on natural regeneration does not appear to have been examined for Blackbutt types, though signs of browsing on young regeneration are often evident. The damage is usually regarded as of minor significance, but may in fact be of rather greater importance in some sites:

- How (1968) recorded browsing on Blackbutt and Tallowwood germinates and plants up to 1.2m in height at Wingham;

- Van Loon (1971) has remarked on the "repeated browsing by marsupials" being a factor in the poor growth of Blackbutt germinates from spot-sowing on a fire-damaged site at Lansdowne S.F.

- B.J. Furrer recalls that fenced plots on Benandarah S.F. in the 1960s became islands of regeneration in areas that were generally deficient in regeneration.

- Similarly, fenced control plots in a study on wallaby-browsing in a Flooded Gum plantation at Timmsvale (Wild Cattle Creek S.F.) are reported by C. Mackowski to be the sites where Blackbutt regrowth became established.

On the other hand planted seedlings are commonly attacked and virtually destroyed by wallabies, with Blackbutt Itself being a particular favourite. At Batemans Bay, up to 50 per cent of enrichment planted Blackbutt seedlings were destroyed (Baur, 1958) and on Lansdowne S.F. over 70 per cent were damaged (Van Loon, 1971); heavy damage occurred to planted seedlings on former grazing blocks within Pine Creek S.F. in the 1950’s, though the occasional natural seedlings present appeared unattacked; and in the Watagans the level of damage to planted Blackbutt was a major factor in substituting the seldom-attacked Blueleaved Stringybark for Blackbutt in the local plantation programme. Similar experience has been widespread. Horne (1975) examined the problem in eucalypt plantations on the eastern Dorrigo Plateau, and found that browsing was widespread and deleterious to growth. It was worst within 100m of the plantation edge, and was most frequent on plants under 60cm high at the onset of winter. Horne's suggestions for minimising damage included shaping planting coupes to avoid excessive edge effects, and planting early and fertilising so as to produce plants taller than 60cm before winter.

Besides seed-depredation by ants, other **insects** may attack Blackbutt seedlings, though the level of attack appears much less than with Flooded Gum seedlings. Mackowski et al. (1981) have observed that chrymoselid beetles and lepidopterous larvae are the insects most commonly associated with foliage destruction in Blackbutt plantations, but their significance does not appear great. As noted above, stands retarded by heavy grass competition appear more prone to insect attack.

As with most, if not all, eucalypt forests, the major cause of damage to regeneration is fire. Van Loon (1971) made a particularly comprehensive and interesting review of the effects of fire on young Blackbutt, using five fires, both wild and prescribed, to follow through the subsequent growth and survival of Blackbutt regeneration. The complete report is recommended for holding and reading in any Blackbutt district, and many others as well: the situations it deals with will be familiar to most. Van Loon's main findings were:

1. Unexpectedly for a non-lignotuberous species, young Blackbutt shows a remarkable ability to survive fire.

2. Small advanced growth in two areas had its numbers reduced by about 30 per cent following low intensity hazard reduction burns. In one case the stems studied were all under 1.5m high, with an average of about 70cm, and in the other heights ranged from under 60cm to about 6m. In the latter case mortality tended to be highest in the smaller plants. Van Loon stresses the importance of this advanced growth in Blackbutt regeneration (see Section 6.6), and warns of the risks of prescribed burning immediately ahead of logging and silvicultural treatment in stands where it is present.

3 A winter wildfire occurred in a 6 months old Blackbutt plantation, fully or partially scorching the seedlings. All the partially scorched, and 60 per cent of the fully scorched, plants recovered, either from basal sprouting (70 per cent) or stem epicormics. Most of the damage was caused-by radiation from debris heaps that caught alight in the tractor-cleared site, which was still fairly clear of weed growth. Little long-term impairment to the seedlings' subsequent growth was recorded.

4. In all cases where larger actively growing plants were damaged, recovery was found to be better than was expected following an early assessment of damage. It frequently takes 4 to 5 months after the fire before the extent of the damage can be accurately assessed.

5. In severe fires, causing total defoliation, stems smaller than about 12cm DBH will generally recover from Coppice shoots originating at or near their base. The number of shoots present on any stem rapidly decreases, and height growth of the strongest shoot is commonly in the order of 2 - 2.5 m a year. Early reduction of the numbers of shoots to one per stem will increase the diameter of the coppice, though the extent of the response is probably not worth the expense.

6. Stems larger than 12cm DBH in a severe fire, and smaller stems in a less severe fire, tend to recover by epicormic clusters along the trunk or in the crown. Such stems tend to exhibit a range of fire-induced defects for a long period, and their ultimate merchantability is doubtful.

Based on these findings, Van Loon suggested that the appropriate action where actively growing young Blackbutt is severely burnt should be:

1. Delay any action for 4 to 5 months after the fire, because the full extent and nature of the recovery may not be clear until then.

2. If all or nearly all stems coppice at or near ground level, there appears to be no need for any treatment.

3. If an adequate number of stems coppice from ground level, while a substantial number of larger epicormic recoverants are also present, the latter stems may be removed at any time.

4. Only if an inadequate number of stems coppice from ground level can it be justified to cut all other stems back to ground level. However, there is almost certainly an upper size limit at which Blackbutt can coppice satisfactorily from a low stump. This upper limit probably lies in the 20 - 25cm DBH class.

With one proviso these appear to remain valid guidelines for the treatment of young fire-damaged Blackbutt, and probably for many other eucalypts as well, and they have been essentially confirmed by various subsequent studies (eg. King, 1979). The proviso relates to the period during which any action should be delayed until the extent of recovery is apparent. This will vary with weather conditions following the fire. In the light of some subsequent slow, but ultimately adequate, recoveries it appears that any rehabilitation treatment might wisely be left for at least 12 months after the fire, unless it is apparent that the new stand will be dominated by the larger, dead-topped and obviously defective stems.

6.9 Early Development

As has been discussed, there is rarely much difficulty in obtaining Blackbutt regeneration, whether from seedling establishment or, as is frequently the case, from advanced growth already present in the undergrowth. The growth response of the regeneration can be extremely variable and some figures, mostly from sources already discussed, are given in Table 4.

This variability of course reflects a range of growing conditions, from the best (Wild Cattle Ck., age 1.8 years) to the poorest (Coopernook, same age). However, it should be noted that great variability can exist within a stand, under apparently identical growing conditions. Florence (1961) refers to one quadrat at Coopernook with one seedling 47cm high and four less than 10cm, and to an enrichment planting area on the same forest with some plants up to 4.5m in height, and adjacent ones under a metre. He mused whether it might be due to soil conditions, but considered a strong environmental selection within the species no less likely. This variation, however, often seems to be associated with rather marginal or adverse growing conditions, and micro-site changes should not be ruled out.

Table 4

GROWTH FIGURES FOR YOUNG BLACKBUTT

AGE (yr)	**HEIGHT** (m)	**DBH** (cm)	**STAND DETAILS**	**REFERENCE**
1.0	0.6	-	Pine Ck: Log, Treat. Best Seedling	Floyd, 1962
1.7	0.6	-	Pine Ck: Log, Treat. Average Seedling	Floyd, 1962
1.8	0.05	-	Coopernook. Heavy Blady Grass	Florence, 1961
1.8	4.2	-	Wild Cattle Ck. Best - Analog Expt.	Mackowski et al, 1981
2.0	2.1	-	Pine Ck: Log, Treat. Best	Floyd, 1962
2.0	3.0	-	Dingo: Fire recovery	Van Loon, 1971
2.4	1.2	-	Pine Ck: Log, Treat. Average	Floyd, 1962
2.4	3.0+	-	Pine Ck: Advanced growth release	Floyd, 1962
4	1.9	-	Lansdowne: Snig Track extn.	Van Loon, 1971
5	9.9	7.3	Lansdowne: Coppice after fire	Van Loon, 1971
5	10.1	9.3	Lansdowne: Coppice (thinned to 1 shoot)	Van Loon, 1971
6	12.2	-	Pine Ck: A.F.S. Growth Plot	-
10	(2.5	1.4)	Lansdowne: Released Adv. Growth	Curtin and King, 1979
	(22.0	17.5)		
10	22.5	23.2	Whian Whian: Thinned Plantation	For. Comm., 1966

Other things being equal, plants in an open situation, whether of seedling or advanced growth origin, usually will respond and grow well. However, regardless of its tolerance, perhaps even preference, for shaded conditions in the establishment stage, Blackbutt ultimately requires open conditions and plenty of light for growth into sapling size and beyond. Good hard data is lacking, but there is much field experience to suggest that in small openings, particularly of a shaded aspect, Blackbutt does not respond well and is likely to be replaced by more shade tolerant species such as Tallowwood, Turpentine and Small fruited Grey Gum. Jacobs (1955; para. 325) considered gaps of from 400 to 1 200m² (1 to 3 sq. chains) to be "ideal" for obtaining regeneration, but most North Coast foresters to-day would tend to prefer larger openings, particularly if operating on the more sheltered aspects, while subsequent study by Florence (1970) has pointed to some of the other problems associated with the "conservative" treatment favoured by Jacobs at that time (see also Section 7.3).

Standing trees will have an inhibitory effect on nearby regeneration, and in the case of Blackbutt this may be accentuated by the antagonistic effect often associated with Blackbutt litter

(Florence and Crocker, 1962). Again quantitative data is lacking for Blackbutt types, though the inhibitory effect is clear to see in the forest, and is probably of a similar order to that demonstrated by Incoll (1979) for Silver-top Ash, where it is of significance for about twice the crown diameter from the stem. This inhibitory effect underlies the culling operations that have been carried out in these stands since 1910. Combined with freeing and the extension of regeneration openings this provided the basis for the timber stand improvement (T.S.I.) operations that were equally widely applied. One measure of the effect of this type of stand opening on Blackbutt advanced growth is provided by Van Loon (1971) from Burrawan S.F., where on plots receiving no logging or T.S.I., selected advanced growth plants grew from 0.7m to 1.4m over 5 years; over the same period on a logged and treated plot similar stems grew to 3.5m in height: for active response, Blackbutt needs open conditions.

It is interesting to note that, after 5 years, the advanced growth stocking had fallen by 26-27 per cent in both Van Loon's plots. In the logged and treated area the decrease was almost entirely associated with logging losses, whereas in the untreated area there was a fairly constant mortality, averaging 5 per cent a year: this may be a reasonable indication of the advanced growth attrition rate, and suggests an average survival period of about 20 years for these small, suppressed, but clearly responsive plants.

7. GROWTH AND YIELD

7.1 The Virgin Forest

Before examining data on growth and yield, and the aspects of associated treatments, in Blackbutt forests under management, a brief look at some stands In their virgin condition (or at least with minimal logging disturbance) is useful. Today such stands are rare in the more accessible areas, but Jacobs (1955, fig. 114) has reconstructed such a stand on Pine Creek S.F. from the occurrence of old stumps and heads remaining after past logging, Mackowski (1982) has described stands of both Moist and Dry Blackbutt types in the former Bellinger River S.F., while plots in preserved areas on Mt. Boss and Lorne S.F.'s provide information on other areas. These stand details are summarised in Table 5. An extract from Mackowski's report is attached as Appendix 4, and Mackowski has summarised the features of these stands as follows:

> *"These forests are dominated by trees over 100cms dbhob. The structure of the forest is governed by the canopy they provide with their massive crowns. These massive crowned trees occur at between ten and twenty five stems per hectare, and each of their crowns covers between one thirtieth and one fifteenth hectare (20 to 30 metres crown diameter).*
>
> *The forests show a very wide distribution of sizes, for the dominating species, indicating an uneven-aged forest. On site inspection reveals the size classes and crown age/morphology classes to be clustered, representing even-aged groups, within an uneven-aged overlapping mosaic of even-aged groups.*
>
> *Regeneration of sclerophyll species is already present in all types of unlogged sclerophyll forest in this area."*

Table 5

STAND DETAILS FROM VIRGIN BLACKBUTT

Stand	Stems/ha	BA (m^2/ha)	Mean DBH (cm)	Gross Vol (m^3/ha)
Pine Creek	-	35	-	280
Mt. Boss	227	60	58	610
Lorne (50cm+)	50	36	88	-
Bellinger R. Moist (10cm+)	456	61	41	-
Bellinger R. Moist (50cm+)	65	48	98	335
Bellinger R. Dry (10cm+)	342	49	43	-
Bellinger R. Dry (50cm+)	61	34	84	135

The Mt. Boss figures apply to a specially selected, and rather atypical, plot, and would represent the upper levels of the stand range, while the Pine Creek, Bellinger River and Lorne figures would be more typical of wider areas of high quality Blackbutt type: similar figures have come from recent logging on Yessabah *S*.F., yielding up to 300 m^3/ha. Trees in such stands are of course growing: Forestry Commission of N.S.W. (1957) recorded a DBH PAI of 5mm, and a volume PAI of 6.6 m^3/ha, for the Mt. Boss plot over the period 1954-57.

However, such figures have little if any relevance to the managed forest, and volume (and B.A.) growth figures in fact tend to represent fortuitous fluctuations in a stand that is dynamically stagnant: gains such as were recorded over 1954-57 are ultimately balanced by mortality, maintaining stand parameters within a not-so-wide plateau range.

Stand tables exist for the Lorne and Bellinger River areas, and are summarised in Table 6 for stems over 50cm DBH in contrast with some virgin stands (including the Mt. Boss plot), which show two tree populations (see Section 5), these have typical reverse-J stem distributions, indicative of uneven-aged stands. As Mackowski has pointed out in the quotation above, they in fact probably represent *"an uneven-aged overlapping mosaic of even-aged groups".* (The larger size classes in stands such as the Mt. Boss plot could be expected to have a similar structure, though the smaller size classes apparently are more or less even-aged and result from regeneration that followed the cessation of Aboriginal burning in the 19th century).

Table 6

STAND TABLES: VIRGIN BLACKBUTT STANDS (STEMS/HA)

DBH Class (cm)	Lorne		Bellinger R. - Moist		Bellinger R. - Dry	
	Blackbutt	All Stems	Blackbutt	All Stems	Blackbutt	All Stems
50 - 60	3	13	6	12	5	12
60 - 80	5	16	12	18	14	22
80 - 100	3	8	8	11	11	14
100 - 120	2	5	10	12	5	8
120 - 140	0	1	4	5	4	4
140 - 160	1	2	3	3	1	1
160 - 180	1	2	3	3	0	0
180 +	2	3	1	1	0	0
TOTAL	**17**	**50**	**47**	**65**	**40**	**61**

Some of the trees present in such virgin stands were very large, with DBH's quite commonly exceeding 2m, and with the largest trees having diameters of over 4m and volumes of over 100 m^3: see also Section 9. The ages of such giant trees are not known, but are possibly in the range of 400-500 years.

Except for the Dry Blackbutt type on Bellinger River, the stands represented in Tables 5 and 6 are all from high quality Moist Blackbutt type, and indicate stand conditions in sites particularly favourable for Blackbutt development. Much of the Blackbutt range was of course in stands much poorer in development than these, though these high quality areas appear to be typical of perhaps the majority of Blackbutt forest under fairly intensive management.

7.2 Growth and Tending in Even-aged Stands

Because Blackbutt types are managed both as even-aged and as irregular stands, with different ways of determining growth rates and with different requirements for treatment that may affect growth, the two stand types are here examined separately: for irregular stands, see Section 7.3.

Even-aged stands include both plantations and areas arising from natural regeneration (including released advanced growth). While most naturally regenerated stands now present have resulted from heavy logging operations followed by culling or other silvicultural treatment, some of the finest stands have been caused by severe wildfire with follow-up salvage logging, eg. Eastbank Road area, Orara East S.F.

The largest areas that have been harvested since World War II of even-aged stands tend to be in the somewhat more remote sites (eg. Mt. Boss S.P; Horseshoe area; outer parts of Wild Cattle Creek S.F.; Nullum S.F.). However, there are also substantial areas in the more coastal forests, which in general tend to be managed as irregular stands. These include plantations and natural regeneration, some of the latter dating back to before 1920 (eg. Lower Bucca S.F.). In addition, regeneration in the larger openings of irregular stands behaves essentially as an even-aged stand.

Seventy years ago Hay (1914) estimated the DBH MAI of Blackbutt as 1.7cm (0.68 inches) for trees up to 75cm DBH Though apparently based on measurements dating back to 1896, this figure, like many of the others presented at that time by Hay, was decidedly optimistic. Subsequent increments were based on intelligent estimates of the time taken to grow to sawlog size (60cm DBH), the rotation length usually being nominated as 70 years on the better sites and 90 years on the poorer (eg. Forestry Commission of N.S.W., 1957): this gave diameter MAI's of 0.85cm 0.67cm respectively.

While some growth plots had existed previously, but had mostly been abandoned or mislaid, during the 1950's a series of growth and treatment plots were established in even-aged Blackbutt stands. These were used by Curtin (1969) to produce a provisional yield table for Blackbutt, and this in turn was metricated and somewhat extrapolated by Borough et al. (1978). This table is reproduced as Table 7.

Table 7

YIELD TABLE FOR EVEN-AGED BLACKBUTT
(after Curtin 1969; Borough et al., 1978)

AGE (years) and condition	**STOCKING (stems per hectare)**	**MEAN DBH** (cm)	**BASAL AREA** (m^2/ha)	**TOTAL VOLUME** (m^3/ha)	**NUMBER OF STEMS BY DIAMETER CLASS** (cm DBH)								
					10-20	21-30	31-40	41-50	51-60	61-70	71-80	81-90	91-100
12 BT	989	19.3	29	89	591	398							
12 T	507	18.1	13	31	381	126							
12 AT	482	20.6	16	58	210	272							
20 BT	482	28.6	31	173	17	322	143						
20 T	193	25.7	10	52	52	188							
20 AT	289	30.4	21	121	12	134	143						
30 BT	289	38.7	34	251		20	160	104	5				
30 T	119	34.3	11	82		20	99						
30 AT	170	41.5	23	169			61	104	5				
40 BT	170	49.7	33	256			15	84	64	7			
40 T	67	43.6	10	76			15	52					
40 AT	103	53.3	23	180				32	64	7			
70	103	73.8	44	373					10	32	42	17	2

Total yield 614 m^3/ ha; annual increment 8.5m^3/ ha.
(BT - Before thinning; T - Thinned; AT - After thinning)

The table shows a Volume MAI of 8.8 m^3/ha (Borough's figure of 8.5 m^3 is a slight error), with the value peaking at about 11 m^3/ha around age 30 years. For comparison with earlier figures, the DBH MAI for final crop trees is 1.05cm, but the average PAI's for periods between thinning are of course lower, as discussed by Curtin:

Age (yrs)	**Subsequent DBH PAI (cm)**
12	0.96
20	0.86
30	0.81
40	0.66

More recently Horne (1975a) has reviewed unthinned plots in experimental areas of even-aged Blackbutt (essentially the unthinned segment of the same data used by Curtin). Horne recognised 3 major growth strata - fertilised plantation stands, unfertilised good sites (dominant height over 27m at age 20 years), and unfertilised average sites (height under 27m at 20 years). He also recognised several minor strata based on stocking, but notes that the data *"shows somewhat surprisingly that volume is mostly dependent on site quality, stocking within reasonable limits (is) not shown to be a significant factor".* He presents his review as a series of graphs, showing various stand growth relationships with age, and two of these graphs, showing bole volume with age and the decline in volume PAI with time, are reproduced in Figure 1a and b. The best old plot used in his review (Whian Whian, expt. H4/2.1, plot 6C; unfertilised good stratum) shows at 34 years:

Stocking	860 stems/ha	
Dominant Height	41.2m	
Mean DBH	27.8cm	: MAI 0.82cm
BA	56.9 m^2/ha	
Volume	545 m^3/ha	: MAI 16.0 m^3/ha

Excellent though this is, there are even better stands: plots in a 10 years old plantation on Middle Brother S.F. have shown a volume MAI of 25 m^3/ha at that age. These, however, are exceptional, and most stands fall in the average stratum of Horne.

During the 1950's and 160's, continuous forest inventory (C.F.I.) plots were established in a number of managed forests, many of which carried Blackbutt. These plots covered both even-aged and irregular stands. An early review of this programme for the Kendall district was provided by Hoschke (1973), and a review of similar plots established by the Australian National University on Pine Creek S.F. has been made by Vanclay (1977). Because of problems in maintenance, most of these C.F.I. plots (though not those at Kendall or Pine Creek) have been abandoned in favour of permanent growth plots, but analysis of the older series has provided much useful information on growth under more average field conditions, and this has been widely used in yield calculations for management. Such figures from several North Coast forests are given in Table 8.

Table 8

BLACKBUTT TYPE DIAMETER GROWTH - NORTH COAST
(cms)

BLACKBUTT

LOCATION	EFFICIENCY CLASS (1)		
	1	2	3
Kendall - Stratum 2(2)	0.90	0.74	0.25
Kendall - Stratum 3	0.85	0.69	0.34
Kendall - Stratum 4	0.59	0.43	0.25
Kendall - Stratum 5	0.79	0.81	0.43
Nambucca	0.68	0.53	0.36

LOCATION	EFFICIENCY CLASS			
	1	2	3	4
Coopernook, Lansdowne	1.00	0.85	0.75	0.62

	Dominant	Co-dominant	Sub-dominant	Suppressed
Pine Creek	0.89	0.88	0.54	0.45

OTHER SPECIES - PINE CREEK S.F.

SPECIES	Dominant	Co-dominant	Sub-dominant	Suppressed
Tallowwood	0.65	0.56	0.40	0.09
Bloodwood	0.59	0.39	0.19	0.08
Red Mahogany	-	0.46	0.17	0.05
White Mahogany	0.59	0.64	0.44	0.28
Grey Ironbark	0.88	0.46	0.43	0.34
Turpentine	0.26	0.27	0.18	0.19

Note:

1) Efficiency classes are based on a combination of dominance and crown quality.

2) Management strata used at Kendall are:

Stratum 2: Stands with a high proportion of mature or defective trees.

Stratum 3: Vigorous regrowth stands suitable for sawlog thinning.

Stratum 4: Mixed hardwood stands suitable for selective logging.

Stratum 5: Regeneration areas, 10-30 years of age.

Other species associated with Blackbutt have somewhat slower rates, commonly ranging from 50 to 90 per cent of the Blackbutt increment. Some values from Vanclay's study are shown in Table 8. Similar figures have been developed in Queensland by Fisher (1978). More recently an assessment of some of the larger areas of even-aged Blackbutt regrowth has been carried out as a basis for small wood marketing strategies.

Unlike natural regeneration, with plantations the forester has ready control over the stocking, and several experiments have been established on the North Coast, examining the effects of different espacements on Blackbutt growth. These do not appear to have been analysed and reviewed, but field inspection clearly indicates that the wider espacements, while associated with rapid diameter growth, produce heavy branching and poor form. Plantations of Blackbutt are commonly established at spacings of up to 4 x 4m (625/ha); although some favour spacings of up to 6 or 7 metres, such wider espacements should probably be regarded with caution unless heavy woody weed growth (eg. wattles) is expected, while on sites likely to re-establish a heavy grass sward a slightly closer spacing might be favoured, to allow for earlier control of the grass by the trees.

Thinning in Blackbutt regrowth has been examined in a number of experiments in both Queensland (Henry, 1956, 1960; Borough et al., 1978) and N.S.W. (Horne, 1979 b, 1981, undated), and general guidelines on the subject were provided by Curtin (1971).

Horne's 1979 paper reviews a rather comprehensive experiment established at age 10 years in a stand that regenerated following wildfire in 1942 on Orara East S.F. Curtin (1966), in an earlier reference to this study, had noted that the heavier thinnings (to below about 14 m^2/ha) had caused a loss in total increment without any corresponding gain in the growth of selected crop trees, and that this lack of response was attributed to competition from coppice that developed from the stumps in the more open stands. This effect has been noted elsewhere (e.g. Henry, 1958), and appears sufficient to justify the use of poison when young stands of Blackbutt or other coppicing species are being rather heavily thinned (see also Curtin, 1971). A light burn, 18 months to 2 years after thinning, has also been successfully used to control coppice in some stands.

In his review, Horne noted that a relationship existed between the soil phosphorus levels and the growth shown by plots of similar stocking, and that this relationship carried over into the response to thinning. Maximum response[5] to thinning in all stands occurred with quite low stockings at an early age - about 200 to 250 stems/ha at age 10 years, and continuing to fall with age. However, 80 percent of this response was still obtained at significantly higher stockings - in the same example, about 350 stems/ha at age 10 years. Horne also determined that soil phosphorus, or as an index of this value, dominant height, was a valuable criterion in the response to thinning. In stands with the higher phosphorous levels, greater response is obtained by the larger, and potentially, more valuable, stems in the stand. In stands of lower fertility the response tended to be spread more evenly between all stems, regardless of their ranking, unless the stands were thinned very heavily to a low stocking.

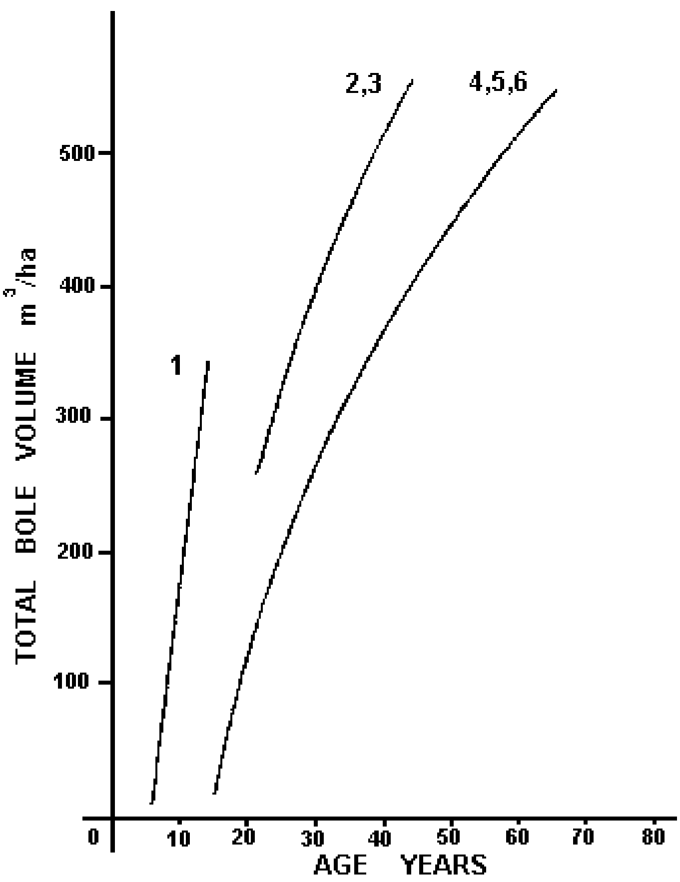
[5] The measure of response used by Horne involved the difference in B.A. growth of strata of ranked trees (e.g. best 50 in terms of DBH; best 100; etc) in thinned plots, compared with the same strata in unthinned plots. For details see Horne (1979 b; undated).

Horne's 1981 paper has developed these findings into more general prescriptions (Graphs 1 and 2, see Figures 2a and b):

"The response of Blackbutt to thinning has been found to be dependent on
(a) available soil phosphorus
(b) residual stocking
(c) age of thinning.
On high phosphorus sites, following thinning, a large response was found to accrue to the larger trees. Stands on sites with lower available P did not show this large response on bigger trees. However, Blackbutt fertilised at time of planting on poor sites has responded similarly to high quality sites after thinning.

For practical purposes, mean dominant height has been found to be an adequate index of available soil phosphorus, and that a dominant height/age graph indicates thinning potential.

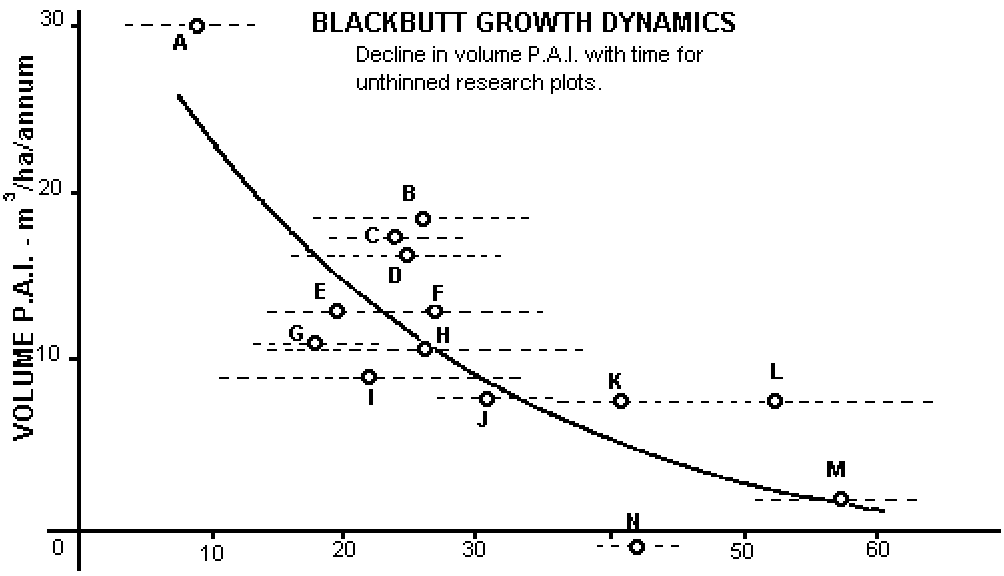
RESEARCH GROWTH PLOTS - UNTHINNED BLACKBUTT



KEY TO PLOT GROUPS	
1	**Fertilised Plantation** - **Dom. Ht. > 27m Age 20** - **Stocking > 1000 st/ha**
2	**Good site** - **Dom. Ht. > 27m Age 20** - **Stocking > 1000 st/ha**
3	**Good site** - **Dom. Ht. > 27m Age 20** - **Stocking > 1000 st/ha**
4	**Average site** - **Dom. Ht. > 27m Age 20** - **Stocking > 2000 st/ha**
5	**Average site**

	- Dom. Ht. > 27m Age 20 - Stocking > 500- 2000 st/ha		
6	Average site - Dom. Ht. > 27m Age 20 - Stocking Low < 500 st/ha		
LINE	**REGRESSION EQUATION**	**r**	**SIG**
1	Y = 39.57 x - 222.92	0.92	**
2,3	Y = 399.58ln x - 956.39	0.57	*
4,5,6	Y = 355.63ln x – 945.91	0.96	**

Figure 1a



LEGEND	
A	Kendall 1964 Ptn.
B	Whian Whian 1940 Rgn.
C	Bellangry 1945 Rgn.
D	Orara East 1942 Rgn.
E	Bellangry 1955 Rgn.
F	Peach Mtn. 1965 Rgn.
G	Bellangry 1956 Rgn.
H	Manning River 1940 Rgn.
I	Newry 1938 Rgn.
J	Craib 1943 Rgn.
K	Pinchgut 1932 Rgn.
L	Juhles Mtn. 1914 Rgn.
M	Burrawan 1897? Rgn.

Figure 1b

Graph 1 indicates high quality and average quality sites on a dominant height/age graph. 'High sites' will have the greatest increment on the largest trees and thinning from below is recommended for sawlog production.

Graph 2 illustrates the optimal residual stocking against mid thinning age for thinning high quality sites from below. A lower stocking will give a greater increment on larger trees at the expense of total production; a greater residual stocking will reduce this response but may be desirable if local markets exist for smaller diameter products and such a low BA *is considered undesirable. The graph also illustrates the lesser response with greater residual stocking, indicating the 80% optimum response.*

For example, if a stand is to be thinned first at age 15 and then at age 25, the 'mid thinning age' of 20 years is used. Applying the graph, the stand should be thinned to 160 stems/ha at the first thinning for optimum stocking for sawlog production. A stocking of 265 stems/ha may be desirable to produce more smaller diameter products, but this will give 80% of the optimum response for increase in basal area production."

This provides an extremely useful guide, which is being used to assist in thinning regrowth Blackbutt stands on the North Coast.

RESEARCH GROWTH PLOTS - UNTHINNED BLACKBUTT
GRAPH 1

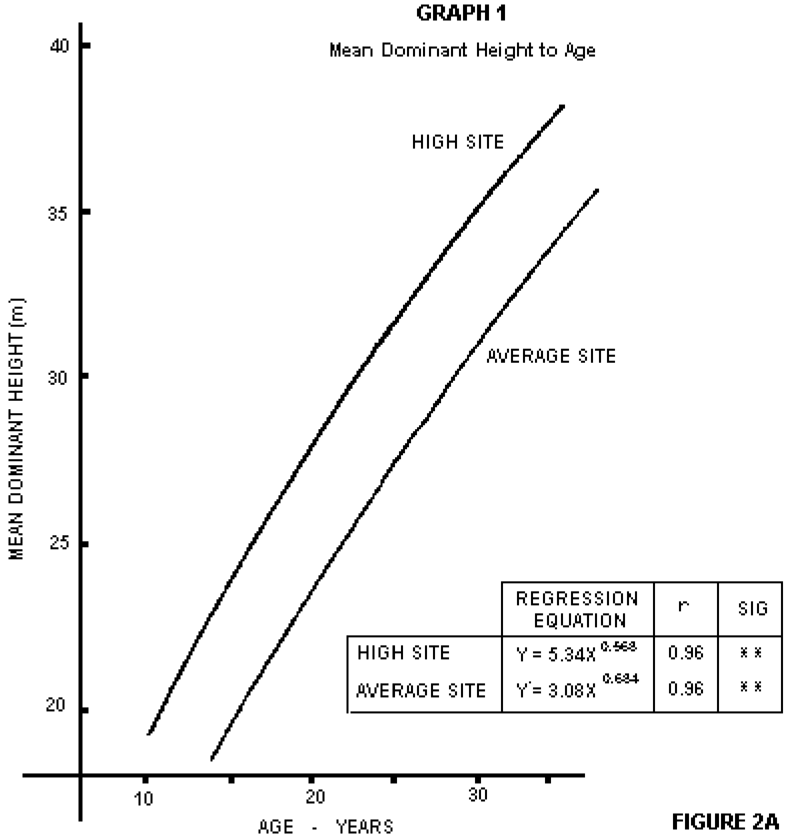


FIGURE 2A

BLACKBUTT - OPTIMUM THINNING RESPONSE

GRAPH 2

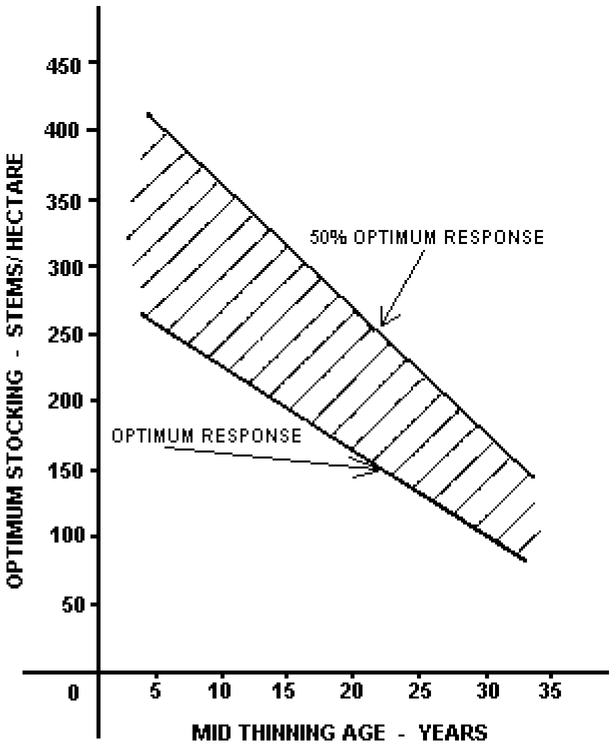


FIGURE 2B

Figure 2B:

Graph showing at what stocking optimum thinning response per hectare is gained on residual trees following thinning from below for an age, which is the mid point of the stocking plateau.

For example:
A stand thinned at age 15 years and is proposed to be rethinned at age 25 years, use 20 years mid point for stocking level.

7.3 Growth and Tending in Irregular Stands

Irregular stands, which make up much of the Blackbutt forests that have been under management for a lengthy period in the more accessible coastal districts, offer rather greater problems in the analysis of growth. Much of the information comes from continuous forest inventory or similar plots, measured several times and usually subject to selective harvesting during the period of measurement. The analysis of this information is basic to the successful management of these stands, and has largely been dealt with from its management, rather than its more strictly silvicultural implications (eg. Curtin, 1962 ; Turner, 1966; Vanclay, 1977; Hoschke, 1973).

Curtin (1962, 1963) used data from C.F.I. plots on Coopernook S.F. to develop an ideal stocking for irregular Blackbutt forests, and again Borough et al. (1978) have metricated and slightly extrapolated Curtin's figures to provide the yield table reproduced in Table 9.

Table 9

YIELD TABLE FOR IRREGULAR BLACKBUTT STAND: COOPERNOOK S.F.
(from Borough et al, 1978, after Curtin, 1963)

DBH class (cm)	Stocking (stems per hectare)	Stems harvested (per hectare)	Average tree volume (m³)	Total volume harvested over 15 years (m³/ha)	Annual Volume production (m³/ha)
10-20	58.8	-	-	-	-
20-30	40.0	18.8	0.25	4.6	0.31
30-40	27.2	12.8	0.61	7.8	0.52
40-50	18.5	8.7	1.18	10.2	0.68
50-60	12.6	5.9	1.85	10.9	0.73
60-70	8.6	4.0	2.66	10.6	0.71
70-80	S 9	2.7	3.48	9.4	0.63
80-90	40	1.9	4.6 1	8.8	0.58
90-100	2.7	1.3	5.74	7-5	0.50
> 100	0	2,7	7.10	19.2	1.28
Total		**58.8**		**89.0**	**5.93**

This ideal stand is based on the aim of the maximum sustained yield of sawlogs, and assumes that all stems are merchantable. The stand portrayed carries a BA of about 22m²/ha and a growing stock volume of about 170m³/ha, and the average stem takes 15 years to pass through each 10cm class (increment of 0.66cm/year). By comparison Jacobs (1955; Table 16) presents a table of stem distribution in a Blackbutt irregular forest, based upon well-stocked stands on Pine Creek S.F. Curtin's and Jacobs' distributions are not readily brought to the same terms. But if the attempt is made they appear to compare fairly well except for the largest classes (over 60cm DBH), where Curtin expects more than 20 stems per hectare, compared with only 10 expected by Jacobs. *A* major effect from this is that the BA of Jacobs stand, at 14 m²/ha, is much less than that of Curtin. Jacobs (para. 321) in fact referred to the presence of more large trees in such stands, noting that areas carrying over 30 stems/ha larger than 60cm DBH, and with BA's in excess of 35m²/ha, exist, but that they do not have the appearance of a healthy selection forest. Rather they look like stands being grown for clear cutting.

Curtin's Ideal stand shows an annual volume production of 5.9m³/ha. This is significantly above the Increments (net growth including ingrowth) actually recorded from C.F.I. plots for irregular Blackbutt stands on the North Coast. These show values ranging between 2.1m²/ha (Kendall, stratum 1) and 3.1 (Pine Creek, Moist Blackbutt type), while the size class distribution and merchantability of the stands usually means that even these figures cannot be directly translated into an available yield.

Elsewhere Curtin (1970) has shown that in fact even long managed irregular stands carry a significant number of stems that are not merchantable. For three forest areas that carry primarily Blackbutt types, Curtin showed the following percentages of useless stems and useless volume:

Coopernook	50% useless stems;	14% useless volume
Kendall	44%	35%
Lansdowne	68%	45%

"Uselessness" of course depends upon markets, but in this context it refers to those stems that would not be acceptable as sawlogs because of form or damage. Curtin stresses that such stands require continuing silvicultural treatment in the form of culling (or, if possible, of sale as low value products such as pulpwood) with each routine logging operation.

As previously indicated (Table 8), individual tree growth is strongly correlated with both dominance and crown quality, which for simplicity are frequently combined into a lesser number of efficiency classes. Subdominant and suppressed trees, and trees with poor crown vigour, make little contribution to stand growth, and in mixed Blackbutt stands species other than Blackbutt are slower growing and tend to contribute much less than the main species. The corollary of course is that dominant and co-dominant stems with crowns of good or medium vigour, especially if Blackbutt, are the trees that will most respond to retention. R. A. Curtin has pointed out that it should be realised that stand density also has an effect (negative) on individual tree growth even in the irregular forest: a fact that is often not appreciated.

Whilst Curtin (1970) has indicated that there is a strong correlation between yield and growing stock between forests, Florence (1970) has shown that a radical treatment of irregular Blackbutt forest has produced a much better response than more conservative treatment. Florence compared two similar areas on Pine Creek S.F., one logged and culled in 1949, with only stems of better quality being retained, and the other treated in 1955 with a deliberate effort to retain as much growing stock as possible: the latter stand is described by Jacobs (para. 322). These two stands are compared in Table 10.

Florence believes that the poorer diameter growth shown by the more conservative treatment is probably due to many of the trees retained having long been suppressed, and responding poorly to release, rather than to the higher stocking of this plot. Many of the stems, particularly in the other species, were in poor crown quality classes and these showed very low growth rates.

As Florence then points out, this problem of substandard growing stock is an important one in the management of irregular Blackbutt (and other) stands. Careful logging and silvicultural treatment can greatly reduce the difficulty, but management considerations may dictate that the corrective action should occur gradually; alternatively there is sometimes a strong urge to convert the whole stand to an even-aged condition. The problem is compounded by a continuing lack of data on the long-term response of formerly suppressed trees. It is almost an article of faith that the small but old tree, retained as growing stock, is incapable of worthwhile response. It has given rise to countless bush arguments about the age and status of small trees; it has provided the rationale for more than one conversion of irregular stands to even-aged. The presumption may well be true, but there is also the suspicion that, given time - possibly a decade or two - to re-establish a healthy crown, such trees may indeed have the capacity to resume active growth. Unfortunately, hard data either way still seem to be lacking, though a 16 years' study adjacent to Coopernook S.F. revealed very little recovery in stag-headed, poor crowned, suppressed Blackbutts retained after a logging operation on private property. In this particular case it has been suggested that the retained trees were near the end of the suppression spectrum and were most unlikely to recover. On the other hand Blackbutt itself may be less likely to recover from suppression than some other eucalypts, while even if it were to do so there is a misgiving that internal defect may be effectively negating the diameter growth (see Section 8.2).

Table 10

COMPARISON OF RADICAL AND CONSERVATIVE TREATMENTS
Pine Creek S.F. - from Florence, 1970

Treatment	**Radical**				**Conservative**			
Yr Logged	**1949**				**1955**			
Species	**Blackbutt**		**Other Species**		**Blackbutt**		**Other Species**	
DBH Class (cm)	**Stocking Increment (no./ha)**	**DBH Increment (cm/yr)**	**Stocking Increment (no./ha)**	**DBH Increment (cm/yr)**	**Stocking Increment (no./ha)**	**DBH Increment (cm/yr)**	**Stocking Increment (no./ha)**	**DBH Increment (cm/yr)**
20 - 40	3.6	1.16	10.4	0.76	20.5	0.84	85	0.48
40 - 60	7.9	1.40	2.0	84	12.3	0.74	29	0.46
60+	2.0	1.24	0.7	-	12.3	0.84	5.7	0.41

BA Increment (m^2/ha)	**1949**	**1967**	**1955**	**1967**
	4.4	17.7	16.6	24.2

	Radical	**Conservative**
	1949	**1955**
BA PAI (m^2/ha)	0.73	0.64
Vol.PAI (m^3/ha)	6.9	5.0
Blackbutt	3.5	2.4
Other Species	3.4	2.6

A final word on the make-up of irregular Blackbutt stands appropriately comes from Jacobs (para.322): *"It is stressed that the stockings given (in his stem distribution table) refer to the average of considerable number of small areas. The figures are not intended for application to very small areas, but they may give a useful lead as to the nature of the stocking of a compartment. Similarly a small experimental area of a few acres might still contain groups of big trees and groups of regeneration."*

The essence of the irregular Blackbutt forest is as a mosiac of small, overlapping and essentially even-aged stands.

8. DAMAGE TO OLDER STANDS

8.1 General

The Blackbutt types are subject to the same run of damage agencies that afflict eucalypt forests generally in eastern N.S.W. Two of these - termites and fire - are of particular concern and are considered slightly more fully below. Some of the others are briefly mentioned here.

Climatic events, especially those of an unusual nature may cause damage to stands. In June, 1958, an exceptional snowfall on Myall River S.F. caused considerable branch breaking and stem bending in regeneration of Blackbutt (Baur, 1972); hail storms may defoliate stands over usually relatively small areas. These tend to be exceptional. More common Is damage associated with strong wind, usually in slender regrowth stems: bending in the wind, the bark splits away from the stem on the windward side of the tree, ultimately producing a dry side in the area of the damage, usually at a height of about 5 metres. This damage, which was noted by Jacobs (para. 292), is fairly common with Blackbutt. Stands recently thinned are particularly prone if gale-force winds follow within a year or so. Under extreme winds regrowth stems may snap off, often within a few metres of the ground. This (damage, which effectively destroys the tree, is much less common than bark splitting, and usually occurs in local gullies, presumably under the effects of wind funnelling. Drought also will affect Blackbutt stands, and a youthful Baur (1952) has recorded that during the severe 1951-52 summer:

> *"Blackbutt particularly was affected. Where this species ascended from its usual hillside position on to the tops of rocky ridges, it lost its leaves and appeared to die on a face over appreciable areas. Since the drought broke many of these stems have recovered and have sent out a vigorous growth of epicormic shoots, similar to those formed after defoliation by fire. However, the loss in growth for the drought year, and the degrade in the timber due to the development of the epicormic shoots, will be considerable."*

Besides termites, Blackbutt is probably at all times supporting insects that feed upon various parts. However it appears much less prone to serious insect damage than many other eucalypts, and indeed is noted for its relative immunity to serious attack. Hadlington and Hoschke (1950) have recorded defoliation of Blackbutt on Tamban S.F. by a plague phasmatid, but note that this was the only occasion, in a number of outbreaks studied, where Blackbutt was attacked. Carne and Taylor (1978) similarly mention reports of damage to Blackbutt by leaf miners and longicorn beetles, but again with the inference that severe damage is unusual. As previously noted (section 6.8), young regeneration may attract insect defoliation, particularly when subject to grass competition.

Fungi appear of little significance to established trees except for wood-rot organisms, whose role has tended to be overshadowed by termites: alone or jointly. Wood rots and termites are responsible for the "pipe" that is a feature of most logs of Blackbutt and its associates, and that has been responsible for the development of complicated systems of log measurement and sales and for the loss of much timber volume.

Mistletoes are not uncommon in Blackbutt stands, but appear of limited significance. Their effects are greatest on weak and suppressed trees, whose contribution to stand growth is in any case slight.

8.2 Termites

Several species of termites attack Blackbutt and its associates, with the most important of these being *Coptotermes acinaciformis.* This species has been intensively studied by Greaves and various co-workers and reported in a series of papers between 1959 and 1967. The related *C. frenchii* also occurs in Blackbutt stands. It has broadly similar behaviour patterns, but its damage occurs more widely through the heartwood, rather than being confined to a central pipe.

These termites form large colonies, sometimes with in excess of a million insects. The initial entry by colony-founding pairs is through damaged stems, and the young colony needs decayed wood for its survival. A favoured entry point is a fire scar on the butt of the tree, whence it moves to the centre of the tree where a nursery is established in the pipe, which is gradually extended up and down the stem and is packed with mudgut. The nursery - essentially the heart of the colony is usually a metre or so above ground and may be up to 45cm wide and 75cm, long. The presence of the nursery is sometimes indicated by a swelling in the tree's stem, and usually by “ant-tits", where galleries extend to the bark of the tree through distinct protuberances which act as escape hatches for winged adults.

On suitable soils, which seem to include most Blackbutt soils, the termites will construct galleries through the soil, giving them access to dead branch-wood and stumps: it should not be forgotten that these insects play an important role in the breakdown and removal of forest debris. The galleries also provide access to adjacent living trees. Galleries may extend for distances of up to 45m from the host trees, and the termites can gain entry to other living trees from their galleries through sound wood and bark. Subsidiary breeding colonies may be established in other attacked trees. Clearly one colony can damage a number of trees: in one excavation up to 16 trees had been attacked. Colonies can survive even though the host tree is destroyed if the nursery remains undamaged. This is unusual with chain-saw felling from the ground, but was common in earlier days when trees were felled above the basal swelling from "boards", and active colonies may still exist in old stumps from those times. Similarly subsidiary colonies may allow damage to continue even though the host colony is destroyed.

Studies in Urunga district showed damage to be much more extensive in the virgin old-growth stands than in the regrowth stands of the more coastal forests. In both areas termites were the major cause of-timber -defect, though their significance was reduced in the regrowth stands of Pine Creek S.F.

A comparison of the two areas is shown in Table 11, with values expressed in 1966 terms. The high “decay, etc." cause of defect at Pine Creek was due primarily to poor form and kinks, and the termite damage was largely confined to formerly suppressed trees which had subsequently been released from competition; relatively few regrowth dominants showed signs of attack. This tended to confirm studies in Queensland showing that trees of good vigour were more resistant to attack than trees of poor vigour, and also the oft-quoted. But seldom seen report on laboratory studies by F.J. Gay in Canberra, showing that wood from dominant Blackbutt trees was much more resistant to termite attack than wood from subdominant or suppressed stems.

Termite colonies can be destroyed by applying appropriate insecticides, including arsenic trioxide and chlorinated hydrocarbons, to the nursery area.

Table 11

TIMBER LOSSES IN BLACKBUTT FORESTS
(after Greaves et al., 1967)

NATURE OF STAND	OLD GROWTH	REGROWTH
State Forest	**Scotchman**	**Pine Creek**
Vol. Sold	57.2m^3/ha	17.7
Vol. Lost through defect	56.8m^3/ha	3.5
% Vol. Lost	505	14
Cause of Defect – Termite	92%	64
Fire	2%	3
Decay, stem form, other	6%	33
Value of timber sold	$154/ha	107
Value lost through defect	$299/ha	38
% Value lost	66%	26

Termites have been among the most important and costliest damage agencies in east coast forests, and will undoubtedly continue to be present henceforth. However in a forest maintained in a healthy and vigorous condition their future significance should be much less, particularly if efforts are made to destroy any major nurseries that are found.

8.3 Fire

The other major damage agency to the Blackbutt forests is of course fire. Nonetheless Blackbutt itself shows fairly high resistance to fire, though accumulations of debris round or close to the butts of trees can cause fire scars to develop, and periodically to enlarge. (The fire scars can also provide points of entry for termite colonies - see above). Crown fires can occur under extreme conditions, particularly where the stand carries a tall understorey, and the more severe fires are likely to result in kino-vein formation.

Studies on the effects of fire in Blackbutt stands have been under way on the North Coast since the late 1960's, largely examining aspects of deliberate hazard reduction burning in regrowth stands.

As part of these studies, Van Loon (1970) examined litter fall in a number of Blackbutt stands. Over four years the rate averaged about 6t/ha/year (annual range from 4.9 to 7.7t/ha), while the weight of litter lying on the forest floor averaged about 16t/ha in the stands studied. Van Loon found that, although it took over 10 years to restore this equilibrium floor weight after its complete removal. The initial accumulation of litter (fuel) was rapid: 50 per cent of the equilibrium weight was restored in 1.7 years, 70 per cent in 2.9 years, and 90 per cent in 5.5 years.

Several studies have examined the effects of prescribed burning at regular intervals. The most documented of these, in even-aged regeneration from the 1940s on Lansdowne S.F., was described in detail at its inception (Van Loon, 1969) and has been mentioned in subsequent progress reports (Van Loon 1975, 1977; Dowden, 1981). Prescribed burning, not to exceed an intensity of 350 kw/m, has been carried out at 2- and 4- yearly intervals, and there are unburnt controls. No effects of the burning on growth have been recorded, but it was early noted that frequent burning tended to produce an open, part-like appearance, whereas the unburnt controls carried a mesic understorey with Lantana, Cheesewood, Breynia, Forest Oak and wattle.

In December 1979, the experimental area was mostly burnt by wildfire. Prior to the fire the 2-yearly burn sites carried much less fuel than the other sites, with less difference between 4-yearly and control. The 2-yearly burn plots suffered much less damages in the wildfire, and came through with generally good vigour; poorest vigour after the fire lay with the 2-yearly burn sites, which had developed a low but fairly dense shrub by understorey.

Prescribed burning does not, of course, aim to remove fuel from throughout the stand. Rather it aims to break it up, providing some belts where the fuel is low and fire control can more readily be carried out in the face of a wildfire. The Lansdowne study is particularly interesting in this regard.

Many districts have determined that prescribed burning can be safely carried out in Blackbutt plantations from about age 8 years. Naturally regenerated even-aged stands possibly should be left for several years longer, since these often carry much larger accumulations of debris from the harvesting operations that preceded regeneration, while the regrowth itself tends to be a couple of years behind plantation regeneration in terms of growth and development.

Burning in irregular stands has its own problems, largely associated with damage to regeneration (see section 6.8). The need for hazard reduction in such forests may be high, while the short cutting cycles can mean that, in any compartment, new logging may be under way before regeneration from the previous operation is old enough to carry an acceptable prescribed burn. While the lengthening of cutting cycles can help, this type of situation requires very careful planning and practice if hazard reduction burning is to be safely and effectively carried out.

The effects of fire apply not only to the vegetation, but also to wildlife. King (1981) has examined some of these effects on small mammals (one of the most vulnerable groups) in the Taree district, and has noted that early indications are that animals survive burning. But survival for a period following the fire is in lower numbers due to change in habitat or available food supply.

Fire in Blackbutt types is not just a damage agency or a tool in helping to reduce the risk of such damage. It is also, as earlier discussed, an important ecological factor in shaping the appearance of Blackbutt stands, sometimes in determining the occurrence of the main species, and in Nature usually in producing regeneration. We should be very wary of excluding fire from the Blackbutt forest completely, but as ever we should be careful in our use of it, and aware of the implications of its use.

9. PRESERVATION

Because of the accessibility of much of the area of Blackbutt types in N.S.W. and its long history of utilisation, the State has large areas of managed Blackbutt in the coastal districts, but few stands that have not been used for logging. However in the escarpment zone there has been greater opportunity to preserve samples of virgin Blackbutt forest, and these have been widely taken.

National Parks that include Blackbutt communities (though not necessarily without prior disturbance) include:

Ben Boyd (about southernmost occurrence)
Crowdy Bay — Royal
Washpool — Dorrigo
New England — Nightcap
Myall Lakes *(Blackbutt - Smooth-barked Apple on deep sand)*
Werrikimbe — Yuragir

To these might be added Dalrymple Hay Nature Reserve, which carries one of the better samples in the Sydney metropolitan area. Other nature reserves also carry Blackbutt.

Appendix 5 lists formal preserved areas within State Forests, and shows 17 Flora Reserves, with an area totalling over 1 200 ha, and 9 Forest Preserves with a total area of over 4 000 ha.

There are other preserved stands of Blackbutt, some controlled by the Forestry Commission (eg. A -Tree Reserve on Mt. Boss S.F.; Bird Tree Reserve on Middle Brother S.F.) and some by other bodies, including local Councils and the National Trust. Together these parks, reserves and preserves provide an extensive sampling of communities carrying the State's most important native timber tree, and those on State Forest in particular form a most useful baseline from which to assess the effects of management on other, nearby stands.

A number of notable individual trees have also been recorded and preserved within Blackbutt types on State Forests. These are listed in Table 12, and include several of the largest known trees in N.S.W.

Table 12
OUTSTANDING TREES RECORDED IN BLACKBUTT TYPES

SPECIES	LOCATION	HEIGHT (m)	DBH (m)	NOTES
Blackbutt	Middle Brother SF	69	3.58	"Bird Tree" Vol. 144m^3
Blackbutt	Middle Brother SF	64	4.10	"Benaroon" Vol. 126m^3
Blackbutt	Olney SF	34	1.73	
Blackbutt	Olney SF	44	1.97	
Blackbutt	Way Way SF	62	2.37	
Blackbutt	Mistake SF	58	1.78	
Blackbutt	Orara West SF	53	2.60	
Blackbutt	Orara West SF	58	2.27	
Bloodwood, Red	Burrawan SF	60	4.75	"Old Bottlebutt" Diam at 3m = 2.86m
Gum, Grey	Burrawan SF	40	0.93	Very good form
Ironbark, Grey	Mistake SF	48	1.68	
Ironbark, Grey	Ingalba SF	50	1.60	
Ironbark, Grey	Wild Cattle Creek SF	50	0.84	
Mahogany, Red	Burrawan, SF	40	1.02	
Stringybark, White	Queens Lake SF	43	0.99	
Turpentine	Middle Brother SF	37	1.57	

10. MANAGEMENT ASPECTS

10.1 Objectives

Referring to those areas where Blackbutt occurs as a significant component in the local forests, the N.S.W. Indigenous Forest Policy (Forestry Commission of N.S.W., 1976) states:

> *"In general, coastal forests should be managed to perpetuate the indigenous species that have occurred there. There should be only minor silvicultural manipulation to amend species proportions, rather than an attempt to change the species type itself.*
>
> *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."*

Hardly surprisingly, the Blackbutt types fit comfortably into the constraints set by this policy. Individual management areas normally require, in their objectives, the production of sawlogs and other products, maintenance of forest environment, conservation of soil values, protection of flora and fauna values, and provision for recreational use.

10.2 Management Problems and Practices

Blackbutt types are among the most straightforward in N.S.W. to manage. They are certainly not without problems, but these are often of the types that require more sophisticated and professional responses than occur in most of the native forests of the State. The types lend themselves to management as either even-aged or irregular stands; natural regeneration is usually readily obtained, though there are exceptions. Blackbutt itself is a particularly fast-growing species, while most of its associates fit readily into subordinate positions in the stand. Their timbers are well regarded for a range of uses; the trees show a good tolerance of fire damage. Blackbutt is less liable to insect and other damage than most eucalypts. While termites, the major pest, are likely to be of much less significance in regrowth stands than in the virgin state. In addition the forests provide a rich repository for wildlife, while their attractive appearance gives them high recreational appeal in all stages of growth, but particularly as irregular stands.

As previously noted, the more accessible and longer used coastal forests tend to be managed as irregular stands under some variant of the group selection system, while the more remote stands, largely used for timber production only since the 1940s, have generally produced large, even-aged coups of regeneration. In the long run neither approach need be permanent; progressive selective logging can bring an even-aged stand to an Irregular condition, while, with some sacrifice of growing stock, the reverse also can apply - and indeed has applied, eg. in the expansion of Blackbutt plantations during the 1960s.

The major problems facing the forester in Blackbutt types are usually of a management nature, eg. determining yield and balancing the cut, finding and maintaining markets for a range of products, deciding whether to cull now or to retain currently unmerchantable stems for possible future markets. Nonetheless problems more directly related to silviculture do occur and may concern regeneration establishment, use of fire, choice of silvicultural system, decision to use artificial regeneration, and other matters. Some guidance points on these and related issue are given in the succeeding section.

10.3 Guidance Points

The following points are not intended as instructions or prescriptions. Rather they should be regarded only as suggestions, covering some issues where problems have arisen in the past and putting forward possible solutions that may be valid under some circumstances. As always in forestry, and particularly in the management of native forests, solutions to silvicultural problems have to be based on a sound understanding of local conditions in the bush, coupled with appreciation of the silvicultural characteristics of the species involved. Notes such as these can help provide the second requirement; they can do nothing about the first.

1. The choice of silvicultural system or approach in Blackbutt types will usually be dictated in advance by past events and the resultant nature of the stand. The coastal forests, with a long history of selective logging and silvicultural treatment, normally present a mosaic of small stands that favour a continuation of the irregular forest conditions. On the other hand the more remote areas usually require or have received a heavy logging operation that removes virtually all merchantable trees. However, as noted above, the pattern is not immutable, and one approach can, if necessary, be altered to the other - as indeed is likely to occur, over a lengthy period, with at least some of the extensive even aged coupes.

2. The irregular forest undoubtedly requires a greater display of the forester's professional skills than do even-aged stands. It will also provide a somewhat lower yield than even-aged stands, though on the other hand it offers the opportunity to

grow stems to larger size, and greater value, than is likely to occur in the even aged stands. The antecedents of both approaches occurred in the virgin stands, and neither should be regarded as more "natural" than the other. Irregular stands provide more variety in appearance and probably in the provision of habitat, and as such there may be strong reasons for supporting them in the more populous and visited areas, while favouring the simpler even-aged stands in the more remote areas - essentially, the maintenance of the status quo.

3. Although some of Jacob's comments suggest that Blackbutt irregular stands can be maintained with the creation of small openings, in the forest such action usually seems to result in a progressive take-over by the more tolerant or persistent lignotuberous species, though the picture is complicated by the role of fire. Certainly the most successful examples of group selection in action appear to be those where regeneration openings approach a minimum of about 1 500 square metres, and usually rather more. The group is in fact a most integral part of the structure of these forests.

4. Except for a period following crown damage by fire, Blackbutt will usually carry adequate seed in its crown to provide regeneration after logging. Heavy seed fall is usually limited to areas within about 10m of the crown of seed trees, but sufficient seed to provide regeneration needs will normally fall over a much wider area. Nonetheless seed from the heads of felled trees may often be important as a source of regeneration. Post-logging slash burns or top disposal can destroy this.

5. Seedling establishment, to be effective, requires a suitable seedbed, usually provided by logging disturbance or fire. Fire is fine in the drier Blackbutt types, but in the moister stands it is likely to produce a dense, blanketing weed growth that can reduce or preclude effective regeneration. (Similarly, where planting is proposed, mechanical site preparation will usually be far more effective in moist sites than will burning.) Thus in the moister stands efforts should be made to avoid immediate post-logging burning; rather, as much mechanical disturbance as possible should be sought during logging.

6. In many Blackbutt stands there is a large component of advanced growth persisting inconspicuously in the undergrowth, and this is often the major source of regrowth following logging since the established advanced growth seedlings are mostly capable of rapid response when released. Although these plants have shown a reasonable tolerance of light fire, burning will reduce the number of Blackbutt plants, whilst probably not affecting the numbers of lignotuberous advanced growth. As far as practicable burning should be avoided in these situations both ahead of logging and for a period afterwards (unless confined to the disposal of scattered heads), so as to preserve and allow the active growth of as much of this regrowth source as possible.

7. Some excessively dry Blackbutt sites (eg. deep sands) provide problems in their natural regeneration (and, for that matter, in plantation establishment). This appears to be a poker-machine type of situation, where one has to await the suitable combination of seedbed, seed availability and appropriate weather conditions for establishment before one wins the jackpot. Weather conditions that maintain good soil moisture conditions for the first growing season are the hard card to pull, and in these situations it is necessary to have patience, and in the meantime probably to burn fairly regularly (first checking to ensure that in fact seedlings are not present) so as to maintain a receptive seedbed for when establishment becomes possible. And then, of course, to hold off burning for some years.

8. Artificial establishment has its major role in bringing back under Blackbutt sites that previously had been lost to forest use, eg. old farmlands. There is usually much less need for it in existing forest areas.

9. Planting and seeding have been used to extend Blackbutt into sites that do not naturally carry this species. This practice of off-site establishment should be regarded with some caution, as there appear to be very good ecological reasons why Blackbutt is absent from many such sites. Similar arguments usually also apply to efforts to increase the Blackbutt component of stands where it is naturally of very scattered occurrence - this may be due to purely historic reasons, but is more likely because most of the area does not have the capacity to support Blackbutt growth in the long term.

10. There are nonetheless situations where artificial establishment, particularly by planting, is the appropriate silvicultural treatment in Blackbutt types. This is especially the case in some of the moister areas where the Blackbutt stems have been removed, but regeneration has been unable to develop because of undergrowth or weeds, and it may be favoured in moist sites even where a natural seed source still exists.

11. In artificial establishment, attention should be paid to seed source. Either a local source or one from good quality stands (and in either case, from good quality trees) should be used. Wallaby damage should be anticipated, and efforts made to have well-established plants with good height growth present by the end of the first growing season by the use of early planting and fertilising.

12. Fire is a natural factor in Blackbutt ecology, and the tree has an above-average tolerance of fire though, as with other eucalypts, damage in the large sapling/small pole classes can be particularly undesirable by producing stems that possess a dead, spiky top and recover by stem epicormics. Efforts to fell such stems and allow their recovery by coppice may well be warranted. Smaller stems will usually coppice naturally, and larger ones will suffer less damage. Recovery after wildfire is usually better than first seems likely, and as a general rule the forester should be prepared to wait up to a year or so before taking any action to treat or replace burnt stands.

13. Blackbutt types, particularly in their less moist phases, lend themselves to prescribed burning, though it should be realised that the benefit in terms of hazard reduction may be largely lost within 3 or 4 years. Burning can help reduce the shrubby understorey and thus ease the establishment of regeneration when necessary, but it may also progressively reduce the stocking of advanced growth in such stands. As noted, fire should, if possible, be avoided in recently logged moist sites. Even-aged stands can usually be given a prescribed burn to reduce fire hazard from about age 8 years for plantations, and several years later for natural regeneration, with minimal damage to the stand.

14. Termites are a major source of volume loss in virgin stands by producing and enlarging pipe. One colony can infest trees up to 45m distant, with the less vigorous stems being most prone to damage. Regrowth stands, particularly if maintained in a healthy condition, are likely to suffer much less damage. Colonies can survive in old high stumps or infested trees for many decades, and if significant damage is noted in regrowth stands it is probably worth looking for the source and then poisoning it.

15. Good guidelines have been developed for thinning regrowth Blackbutt, and can be applied to plantations, even-aged coups or groups in irregular stands. Response to thinning is greatest in the higher quality stands, and in general these should receive priority in treatment. Heavy thinning in young stands often results in active coppice growth from the stumps of felled trees, and this can offer significant growth competition to the remaining stems. Coppice poisoning or light prescribed burning may be warranted under these circumstances.

16. As with other eucalypt types, large trees of doubtful merchantability can severely hamper the development of nearby regeneration or the growth of nearby trees, and their removal is silviculturally desirable. Such trees are sometimes retained as an

emergency seed source (which is probably in fact never needed) or for habitat purposes. In the retention of such trees we should be aware of what we are expecting to achieve, and what we are likely to forgo.

17. Logging in irregular stands should pay particular heed to the quality of retained trees, since those of poor crown quality or dominance class show poor growth response, at least in the short term; their longer term behaviour appears to need more study. By contrast some of the larger stems can maintain high growth rates under these conditions.

18. Almost as a corollary, irregular stands usually carry a number of stems of doubtful merchantability. Efforts should be made to remove these during harvesting operations or, if not possible, in a commercial operation, during a subsequent culling treatment unless specifically required for habitat or other similar purposes.

19. Except in regeneration openings, She-oaks should be regarded as a useful component in Blackbutt stands.

10.4 Further Research

Blackbutt types have been the subject of probably more detailed research than any other eucalypt forest communities in N.S.W., and this effort is reflected in size of these Notes: there has been a lot of information to include in what is, nonetheless, still only a summary.

Much of this research, particularly relating to stand dynamics and growth and to fire effects, is of a continuing nature, and improved information will continue to come forth from it, and hopefully will be widely disseminated.

This review has indicated some other fields where improved information would be very useful in the treatment of these very valuable and productive types. These include:

- Monitoring of the development and growth of Blackbutt planted in sites that did not originally carry Blackbutt types. What is the future of off-site plantings?

- Improved quantitative information on seasonal variations in flowering and seed availability for Blackbutt and its major associates.

- Determining the true value of large, isolated and virtually unmerchantable trees for habitat purposes in Blackbutt stands, and the effects of such trees on regeneration development.

- The longer term response of previously suppressed trees that are released and retained during logging in irregular stands.

- The most desirable characteristics of regeneration openings under various conditions in irregular stands.

Other points could be added here, including a number of management, rather than silvicultural, significance.

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Appendix 1

PLANT SPECIES MENTIONED IN TEXT

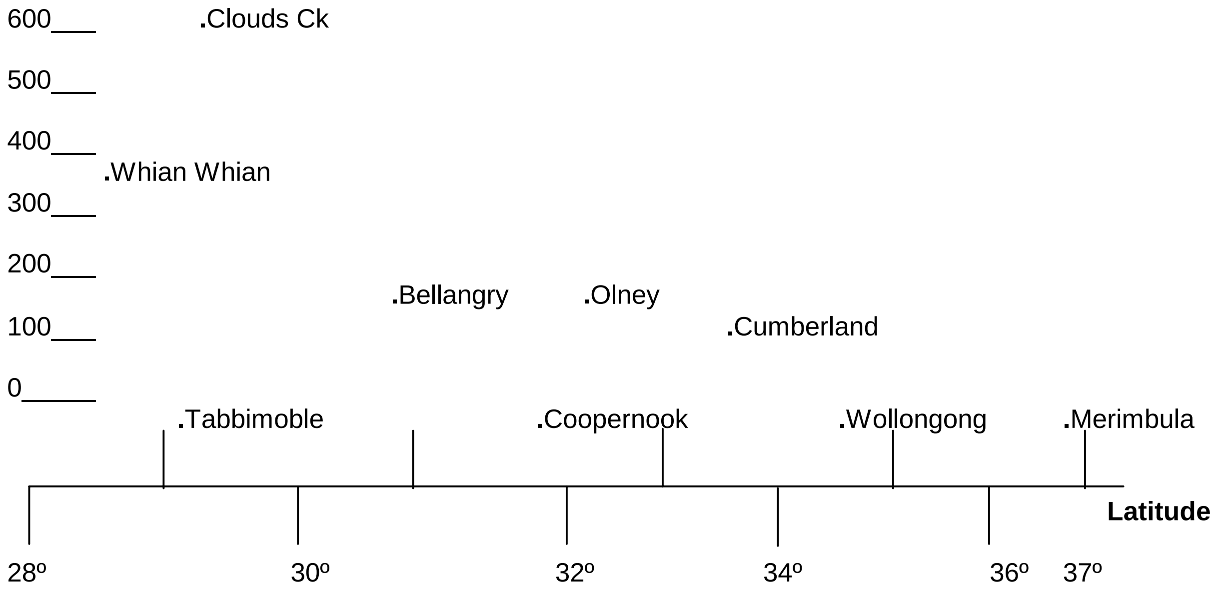
Common Name	Botanical Name
Apple, Roughbarked	Angophora floribunda
Smoothbarked	A. costata
Ash,Silvertop	Eucalyptus sieberi
Bangalay	E. botryoides
Banksia, White	Banksia integrifolia
Blackbutt	Eucalyptus pilularis
Largefruited	E. pyrocarpa
New England	E. andrewsii ssp. campanulata
Bloodwood (unqualified, usually Red Bloodwood)	
Pink	Eucalyptus intermedia
Red	E. gummifera
Box, Brush	Lophostemon confertus
Breynia	Breynia oblongiloia
Cheesewood	Glochidion ferdinandi
Fern, Tree	Cyathea spp.
Grass, Blady	Imperata cylindrica
Kangaroo	Themeda australis
Grasstree	Xanthorrhoea spp.
Gum, Grey (Smallfruited)	Eucalyptus propinqua
Mountain Grey	E. cypellocarpa
Scribbly (Broadleaved)	E. haemastoma
(Narrowleaved)	E. racemosa
(Northern)	E. signata
Sydney Blue	E. saligna
Hopbush	Dodonaea triquetra
Ironbark, Grey (Northern)	Eucalyptus siderophloia
(Southern)	E. paniculata
Kurrajong, Brush	Commersonia spp.
Lantana	Lantana spp.
Mahogany, Red	Eucalyptus resinifera
White (Broadleaved)	E. umbra
(Narrowleaved)	E. acmenioides
Oak, Forest	Allocasuarina torulosa
Pea, Prickly Shaggy	Oxylobium ilicifolium
Tree Bitter	Daviesia arborea
Peppermint, Sydney	Eucalyptus piperita
She-oak, Black	Eucalyptus littoralis
Soldier Vine	Kennedia rubicunda
Stringybark, Blueleaved	Eucalyptus agglomerata
Needlebark	E. planchoniana
White	E. globoidea
Tallowwood	E. microcorys
Turpentine	Syncarpia glomulifera
Wattle	Acacia spp
Black	A. irrorata
Two-veined	A binervata
Woollybutt	Eucalyptus longifolia

Appendix 2

CLIMATIC AVERAGES: BLACKBUTT SITES

Station Localities

Altitude (m)



WHIAN WHIAN **Latitude** 28°36'S **Longitude** 153°23'E **Elevation** 381m

Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Total
Daily Maximum Temperature (Cº) - Mean												
25.7	25.3	23.8	22.1	18.5	16.5	15.5	17.0	20.5	22.7	26.0	24.1	21.5
Daily Minimum Temperature (Cº) - Mean												
16.7	16.3	14.9	13.0	9.5	8.2	5.8	6.8	8.8	12.1	13.4	15.5	11.8
Rainfall (mm) - Mean												
352	382	318	189	155	194	146	103	74	149	135	191	2388
Raindays (No.) - Mean												
15	18	18	14	11	11	8	8	11	10	10	13	147

TABBIMOBLE S.F. **Latitude** 29°12'S **Longitude** 153°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

CLOUDS CREEK S.F. **Latitude** 30°6'S **Longitude** 152°36'E **Elevation** 600m

Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Total
Daily Maximum Temperature (Cº) - Mean												
26.9	26.4	25.4	23.6	19.8	17.5	16.4	17.3	20.5	23.8	26.2	26.7	22.5
Daily Minimum Temperature (Cº) - Mean												
14.8	15.2	11.8	8.7	5.0	2.3	-0.3	2.7	4.8	9.0	11.0	12.9	8.2
Rainfall (mm) - Mean												
228	188	172	83	62	89	62	68	49	109	122	165	1397
Raindays (No.) - Mean												
15	16	18	13	7	9	6	8	8	13	11	14	138

BELLANGRY **Latitude** 31^{0}20'S **Longitude** 152^{0}35'E **Elevation** 152m

Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Total
Daily Maximum Temperature (Cº) - Mean												
26.7	27.3	25.6	23.5	19.8	17.3	17.1	18.1	21.6	23.4	25.6	25.6	22.6
Daily Minimum Temperature (Cº) - Mean												
16.4	17.2	15.8	13.8	10.8	9.6	7.7	8.8	11.1	12.7	14.2	15.9	12.8
Rainfall (mm) - Mean												
168	255	181	129	78	114	51	89	58	112	96	129	1460
Raindays (No.) - Mean												
16	17	12	5	7	7	6	7	6	6	8	11	108

COOPERNOOK **Latitude** 31^{0}48'S **Longitude** 152^{0}39'E **Elevation** 30m

Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Total
Daily Maximum Temperature (Cº) - Mean												
28.3	28.2	28.1	25.6	21.9	19.5	19.0	20.2	22.2	24.4	26.0	27.3	24.2
Daily Minimum Temperature (Cº) - Mean												
16.8	17.6	15.7	11.9	8.6	5.8	4.6	6.2	8.0	12.0	13.6	15.0	11.3
Rainfall (mm) - Mean												
180	196	202	134	100	146	69	99	69	115	94	131	1535
Raindays (No.) - Mean												
15	15	12	6	8	10	7	7	7	12	13	11	123

OLNEY **Latitude** 33^{0}6'S **Longitude** 151^{0}15'E **Elevation** 152m

Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Total
Daily Maximum Temperature (Cº) - Mean												
26.5	26.3	23.5	22.7	17.2	15.4	14.2	15.4	19.1	20.1	23.2	23.6	20.6
Daily Minimum Temperature (Cº) - Mean												
14.0	16.4	13.4	11.5	8.1	7.1	5.0	6.3	8.5	11.5	12.7	15.1	10.8
Rainfall (mm) - Mean												
152	197	177	152	129	214	71	103	74	104	111	130	1614
Raindays (No.) - Mean												
12	12	12	10	7	9	8	7	8	9	8	10	112

CUMBERLAND S.F. **Latitude** 31^{0}45'S **Longitude** 152^{0}21'E **Elevation** 126m

Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Total
Daily Maximum Temperature (Cº) - Mean												
28.5	28.2	27.2	22.6	18.8	16.4	15.5	17.8	21.7	23.2	26.5	27.0	22.8
Daily Minimum Temperature (Cº) - Mean												
15.5	16.0	14.3	12.0	8.1	6.7	5.2	6.5	9.2	10.9	13.3	14.3	11.0
Rainfall (mm) - Mean												
121	159	119	76	88	137	67	77	59	87	96	93	1179
Raindays (No.) - Mean												
9	16	12	6	7	9	5	4	5	8	13	5	99

NORTH WOLLONGONG **Latitude** 34^{0}25'S **Longitude** 152^{0}53'E **Elevation** 18m

Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Total
Daily Maximum Temperature (Cº) - Mean												
24.6	25.2	24.2	22.7	19.6	17.1	16.8	17.8	21.0	22.1	22.1	25.5	21.6
Daily Minimum Temperature (Cº) - Mean												
17.8	18.6	16.8	14.1	11.3	9.4	8.7	8.7	10.5	12.8	14.1	16.7	13.3
Rainfall (mm) - Mean												
267	207	123	82	44	76	24	65	23	101	108	155	1275
Raindays (No.) - Mean												
16	18	16	8	8	7	7	9	5	12	13	11	130

MERIMBULA **Latitude** 33⁰54'S **Longitude** 149⁰54'E **Elevation** 2m

Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Total
Daily Maximum Temperature (Cº) - Mean												
23.8	24.7	22.8	21.4	17.8	16.2	16.0	16.5	18.2	19.8	20.1	23.2	20.0
Daily Minimum Temperature (Cº) - Mean												
15.3	15.7	13.3	10.1	6.9	4.5	3.4	4.6	5.7	9.3	11.1	13.2	9.4
Rainfall (mm) - Mean												
132	129	50	24	36	22	23	63	34	50	116	79	758
Raindays (No.) - Mean												
13	12	9	8	8	7	8	8	4	13	12	9	111

Appendix 3

PROPERTIES OF MAJOR TIMBER SPECIES: BLACKBUTT TYPES

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

Common Name	Blackbutt[6]	Bloodwood, Red	Gum, Sydney Blue	Gum, Grey
Botanical Name	*Eucalyptus pilularis*	*Eucalyptus gummifera*	*Eucalyptus saligna*	*Eucalyptus propinqua*
General Properties	Light brown. Coarse texture, straight grain. Hard, strong and tough, but not difficult to work	Dark pink to deep red. Very coarse; grain generally interlocked. Gum veins often large and extensive	Pink to red. Grain straight. Moderately coarse texture. Gum veins common. Easy to work, fix, dress and finish	Red. Rather coarse, uniform texture. Grain usually interlocked. Very hard, grub holes common.
Density kg/m³	G: 1090 S: 900 B: 720	G: 1140 S: 865 B: 740	G: 1150 S: 910 B: 690	G: 1235 S: 1075 B: 850
Durability	2	1 L-S	3 L-S	1 Seldom lyctus attacked
Strength	B/S2	B/S3	B/S3	A/S2
Sawlog Group	B	D	B	C
Uses	General building construction, flooring, poles, railway sleepers	Poles, sleepers, mining timbers, fencing; hard-board manufacture	General construction, flooring, cladding, panelling.	Heavy engineering construction, poles, sleepers
Other Notes	Rather slow to dry; back sawn surfaces prone to surface checking. Some collapse may occur. Bends moderately well	Tends to open at large gum veins	Rather slow to dry; may check on back-cut surface. Only fair for bent work.	Slow drying. Back sawn faces tend to check

[6] Largefruited Blackbutt *(E. pyrocarpa)* is marketed as Blackbutt. Its timber properties do not appear to have been specifically studied, but the tree is usually well regarded and sought after by the sawmilling industry.

PROPERTIES OF MAJOR TIMBER SPECIES: BLACKBUTT TYPES

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

Common Name	Ironbark, Grey	Mahogany, Red	Mahogany, Narrowleaved White (White Mahogany)
Botanical Name	*Eucalyptus paniculata, Eucalyptus siderophloia*	*Eucalyptus resinifera*	*Eucalyptus acmenioides*
General Properties	Sometimes dark red, usually light to dark chocolate. Interlocked grain, texture fine and uniform. Little figure. Hard to work, but turns to good finish	Dark red. Interlocked grain. Moderately coarse texture. Not difficult to work; takes good finish; holds paint well	Light yellow-brown. Gum veins. Fine texture. Grain often interlocked. Not difficult to work.
Density kg/m³	G: 1200 S: 1120 B: 900	G: 1155 S: 960 B: 785	G: 1180 S: 990 B: 780
Durability	1 L-S	2 L-S	1 Seldom lyctid attacked
Strength	A/S1	B/S2	B/S2
Sawlog Group	A	B	C
Uses	Heavy engineering construction, poles, sleepers, cross arms	Flooring, cladding, panelling, sills, general structural purposes	Heavy engineering construction. Poles, sleepers, cross arms. Flooring, cladding
Other Notes	Dry slowly to avoid surface checking.	Slow drying, but little degrade. Not prone to checking.	Slow to dry. Prone to check on back-sawn surface.

PROPERTIES OF MAJOR TIMBER SPECIES: BLACKBUTT TYPES

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

Common Name	**Oak, Forest (Rose She-Oak)**	**Tallowwood**	**Turpentine**
Botanical Name	*Allocasuarina torulosa*	*Eucalyptus microcorys*	*Syncarpia glomulifera*
General Properties	Dark red with large, coloured rays. Relatively fine texture.	Yellow-brown, greenish tinge. Moderately Course texture. Grain interlocked. Greasy nature. No gum veins.	Red-brown. Fine, uniform texture. Interlocked grain. Turns well. Takes high finish. Resistant to wear; does not splinter readily. Dulls cutting tools. Does not readily burn.
Density kg/m³	G: 1200 S: 930 B: 770	G: 1230 S: 990 B: 800	G: 1140 S: 910 B: 670
Durability	2-3	1 L-S	1 Seldom lyctid attacked. Very resistant to marine borers
Strength	A	A/S2	B/S3
Sawlog Group	D	A	D
Uses	Flooring, roofing shingles and shakes. Decorative turnery and woodware.	Heavy engineering construction. Sleepers, poles, cross arms. Sills cladding, flooring.	Marine piling, shipbuilding, wharf decking, flooring, bearings, mallets. General building construction.
Other Notes	Slow to dry. Prone to check on back-sawn surface.	Dries slowly. Some surface checking and warping. Not recommended for bent work.	Slow drying. Some collapse.

Appendix 4

DESCRIPTION OF VIRGIN BLACKBUTT STANDS - FORMER BELLINGER RIVER STATE FOREST

(from Mackowski, 1982)

1. THE BLACKBUTT TYPES

The Blackbutt types are a continuum from very high quality Moist Blackbutt to very low quality (almost non-commercial) Dry Blackbutt. The Dry Blackbutt type occurs as both low and high site quality forest with a further structurally obvious sub-division of the high site quality forest into predominantly average crowns (size and shape distribution of crowns similar to low site quality Dry Blackbutt) or predominantly very large crowns (size and shape distribution of crowns similar to Moist Blackbutt). For the purposes of this assessment the dry Blackbutt type with predominantly very large crowns is considered as structurally equivalent to Moist Blackbutt type.

(a) Dry Blackbutt

The Dry Blackbutt type is dominated by Blackbutt trees up to about 150cms DBH and up to a top height of 45 metres. New England Blackbutt, Tallowwood, and White Mahogany occur up to similar sizes but together make up less than 20% of biomass. Turpentine, Bloodwood, and Forest Oak are also associated species that occur in smaller sizes and are a minor component of biomass. The understorey layer is various grasses or continuous stands of either Tree Bitter Pea or Prickly Shaggy Pea indicating extensive fire regeneration 10-20 years ago.

The size distribution of the dominant Blackbutt and also associated tree species is fairly uniform but generally declining in number in the larger sizes, this reflects an uneven aged forest.

Also in terms of crown morphology there is a fairly even distribution of crown sizes by number. Crown biomass is concentrated in trees between 70 and 120cms diameter, thus the structure appears as dominated by crowns approaching maturity with relatively few senescent crown forms.

(b) Moist Blackbutt

The Moist Blackbutt type is dominated by Blackbutt trees up to over 200cms DBH and up to a top height of 60 metres. New-England Blackbutt, Tallowwood, Blue Gum, Brush Box, and White Mahogany occur up to similar sizes but together make up less than 25% of biomass. The understorey consists of Forest Oak as the major biomass component of a species mix including Blackwood, Grasstree, Tree Fern, and various small “rainforest" tree species, grasses and mesophyll vines.

The size distribution of the dominant Blackbutt and also associated tree species is fairly uniform but generally declining in number in the larger sizes, this reflects an uneven aged forest.

Although less than eight percent of trees over 50cms DBH by number are of senescent size and crown biomass is concentrated in trees between 70 and 150cms DBH about twenty percent of crown biomass is of senescent crown form. The forest structure is dominated by mature crowns with a significant proportion of senescent crown forms.

2. REGENERATION

Regeneration of dominating species is present in all forest types.

i) the Dry Blackbutt type regenerates (seedlings to small trees (30cms DBH of Blackbutt plus associated species) are generally found below gaps in the canopy, but also occur scattered throughout the stand. Regenerates of Blackbutt average 120 stems per hectare.

ii) the Moist Blackbutt type contains less regenerates per hectare than the Dry Blackbutt - averaging 60 stems per hectare of Blackbutt these occur both as groups below gaps in the overstorey and also beneath trees with senescing crowns. There is an apparent dominating single age group in this regeneration possibly resulting from a wildfire that was recorded in the area for 1965.

The mesophyll species in the understorey, especially the vines, are considered a hindrance to sclerophyll regeneration. in the Moist Blackbutt type subject to vine competition: all regenerates over 20cms DBH have beaten vines; 94 percent of regenerates 10 to 20cms DBH have beaten vines; and 86 percent of regenerates under 10cms DBH have beaten vines.

That vine competition has been substantial in the past is evident from the fact that one quarter of stems beating vines show obvious bayonet stems between one and five metre weight - this shows that the tree has shed its leader (and the vines that were strangling it) and has recovered a leading shoot and tree form from an epicormic shoot.

3. LIFE HISTORY STRATEGY

The life history strategy of a forest is the demographic interpretation of regeneration rates, mortality rates, growth rates and time of passage through size classes.

Regeneration of the sclerophyll dominants in all the species types is interpreted as being dependent on regeneration events, predominantly fire but also including cyclone damage, lightning strike, sheet erosion, and soil slumping. The uneven aged size distribution and the aggregation of tree size classes and crown morphology classes into groups means that the regeneration events are of variable and localised intensity such that the forest has not originated from one single cataclysmic event.

Mortality rates are difficult to estimate. Dead, dry sclerophyll stags are present in all size classes in all types of forest; they total 12% of standing stems over 50cms DBH in the Dry Blackbutt type and 18% of standing stems in the Moist Blackbutt type. Inference of mortality rate from stag counts is complicated by considerations of rates of decay, the absolute biomass of the stag to be decayed, and the incidence of fire; the evidence of the standing stags is that mortality occurs at all ages and is not concentrated in one particular size/age class. Estimates of mortality can be obtained using a forest growth simulation mathematical model and limiting stem numbers according to the existing distribution of sizes in each of the forest types. If this model uses growth rates for co-dominant stems then: Dry Blackbutt forest type has a moderate mortality of about 4.8% per annum until about 70cms DBH after which it declines to a low 1.8% per annum; Moist Blackbutt has a high mortality rate of 11.4% until about 60cms DBH then a moderate 2.4% per annum until 150cms DBH then a low 1.1% over 15cms.

Growth rates vary with dominance and diameter: Dry Blackbutt co-dominants average about one centimetre per annum increment in DBH up to 50cms DBH and about half a centimetre per annum over 50cms DBH; Moist Blackbutt co-dominants average well over one centimetre per annum up to 100cms DBH, and about half a centimetre per annum over 100cms DBH

Time of passage through the size classes is the reciprocal of growth rates. Co-dominant Blackbutt in Dry Blackbutt type would be 150cms DBH at about 240 years; Blackbutt in Moist Blackbutt type would be 150cms DBH at under 150 years of age.

The types each approximates a balanced uneven aged stand in the sense that they are not a succession stage between large-scale catastrophe and climax. This balanced uneven aged structure is reached by differing life strategies for the forest types. Speaking relativities these strategies are: for Dry Blackbutt regeneration is moderate, growth rate is moderate, and mortality is moderate; for Moist Blackbutt, regeneration is moderate, growth rate is high, and mortality is high.

(Although the Blackbutt regeneration is moderate to good in both Dry and Moist Blackbutt types, recruitment from seedling to small tree is very low while vigorous overstorey Blackbutts are present.)

Appendix 5

FORESTRY COMMISSION PRESERVED AREAS CARRYING BLACKBUTT TYPES

Bruxner Park Flora Reserve No. 73036. Orara East S.F. 57 ha. Typical North Coast ridge-gully transect, including Blackbutt. Logged in past.

Durras Lake F.R. No. 79943. Kioloa S.F. 105 ha. Includes good quality Blackbutt with Sydney Blue Gum and Bangalay. Some early logging.

Sugar Creek F.R. No. 79958. Wallingat S.F. 85 ha. Includes some Blackbutt types. Some past logging.

Bundagen F.R. No. 79960. Pine Creek S.F. 53 ha. Littoral area, including Blackbutt-Bloodwood type with White Banksia and Blady Grass.

Boogarem Falls F.R. No. 79963. Nullum S.F. 2 ha. Regrettably small area of Moist Blackbutt and Blackbutt-Scribbly Gum types on Koonyum Plateau at head of falls.

Rowleys Rock F.R. No. 79971. Bulga & Dingo S.F.'s. 146 ha. Includes areas of Moist Blackbutt type.

Moses Rock F.R. No. 79973. Wild Cattle Creek S.F. 61 ha. Very good examples of both Blackbutt and Largefruited Blackbutt types.

Mines Road F.R. No. 79974. Bellangry S.F. 20 ha. Sample of the Bellangry stands, including Blackbutt.

Edwards Plain F.R. No. 79976. Wild Cattle Creek S.F. 35 ha. Primarily a natural grassland, with Blackbutt stands among those that adjoin the “plain”.

Mobong Creek F.R. No. 79978. Wild Cattle Creek S.F. 14 ha. Small area of Moist Blackbutt type included.

Black Bull F.R. No. 79982. Wild Cattle Creek S.F. 47 ha. Typical of much of the original Blackbutt stands on eastern Dorrigo Plateau.

Lorne F.R. No. 79986. Lorne S.F. 179 ha. This is the finest example of little disturbed Blackbutt forest occurring in the more accessible lowland sites.

Minyon Falls F.R. No. 79989. Whian Whian S.F. 100 ha. Includes some Blackbutt-Scribbly Gum types near falls.

Big Scrub F.R. No. 79991 Whian Whian S.F. 196 ha. Mostly rainforest, but some Moist Blackbutt type on rhyolitic soils.

Boomerang Falls F.R. No. 79999. Whian Whian S.F. 24 ha. Includes some Moist Blackbutt type.

Madmans Creek F.R. No. 80001. Conglomerate S.F. 92 ha. Includes Dry Blackbutt, Blackbutt-Scribbly Gum and Largefruited Blackbutt types.

Six- B F.R. No. 80005. Broken Bago S.F. 28 ha. Primarily a good example of Largefruited Blackbutt type.

Tinebark Forest Preserve No. 19. Kippara S.F. 132 ha. Includes some very high quality Moist Blackbutt type.

Pyrocarpa P.P. No. 90. Doubleduke S.F. 59 ha. Sandstone area with Largefruited Blackbutt; Dry Blackbutt type also present below cliffs.

Killiecrankie P.P. No. 117. Oakes S.F. 126 ha. Includes Blackbutt stands.

Waihou, F.P. No. 143. Conglomerate S.F. 1 900 ha. Mostly sandstone plateau with dry sclerophyll forest, but Blackbutt stands in one valley.

Ringwood P.P. No. 166. Irishman and Gladstone S.F.'s. 65 ha. Carries some Blackbutt with rainforest understorey.

Twelve Sixty P.P. No. 174. Bagawa S.F. 305 ha. Contains areas of both Moist and Dry Blackbutt types.

Banda Banda F.P. No. 176. Mt. Boss S.F. 1 500 ha. Includes substantial areas of both Moist and Dry Blackbutt types.

Dingo P.P. No. 178. Broken Bago S.F. 59 ha. Mostly dry rainforest, with adjoining Dry Blackbutt type.

Needlebark F.P. No. 199. Gibberagee S.F. 47 ha. Takes in small area of Blackbutt - Bloodwood type.