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

8. DRY COASTAL HARDWOOD TYPES

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8. DRY COASTAL HARDWOOD TYPES

1. INTRODUCTION

Forest types that may be grouped together as Dry Coastal Hardwood (DCH) types are among the most widely distributed of all forest communities in the coastal districts of N.S.W. The types can contain any of a number of usually naturally durable hardwood species, but they are typically dominated by species of Ironbarks[1], White Mahoganies, Grey Gums and coastal Boxes in various combinations. They include communities that have, in the past, borne such names as “pole type”, “mixed hardwoods type” and “semi-moist hardwoods type”. As the last of these names infers, the “Dry” in the group name can at times be rather misleading, since in some situations the types can appear in a distinctly mesic (i.e. moist-looking) form.

Dry Coastal Hardwood types have generally been held in higher regard in the past, when there was greater need for naturally durable timbers, than they are today, though they are still by no means unimportant as producers of sawlogs and they remain among the more significant sources of poles. The types are characterised by species that coppice readily, tend to maintain a pool of lignotuberous regeneration in the understorey, and are among the more shade-tolerant of the eucalypts. In consequence the types are amenable to management under rather extensive selection systems.

One result of their somewhat limited economic significance and their ease of silvicultural treatment is that the types have been subject to relatively little detailed study.

2. FOREST ECOLOGY AND BOTANY

2.1 Forest

The forest types constituting the Dry Coastal Hardwoods belong to two leagues, as described by the Forestry Commission of N.S.W. (1965: “Forest Types in N.S.W.”), with a total of some 14 types. These leagues, which are closely related, are the Grey Gum-Grey Ironbark league and the Grey Box-Ironbark league.

The Grey Gum- Ironbark league is typified by the presence of one of the Grey Gums, one of the Grey Ironbarks, or both a Grey Gum and Grey Ironbark; it is distinguished from the related Spotted Gum league (see Silvicultural Notes No. 6) by the absence of Spotted Gum except as an occasional stem, and from the Grey Box-Ironbark league by the absence of coastal Boxes as ecological dominants and of Ironbarks other than the Grey Ironbarks. The league occurs mostly on rather excessively well-drained sites in otherwise high-quality forest, and is common on steep slopes (particularly those facing north and west) and on the ridgetops in areas where the more favoured sites support types from the Blackbutt or Sydney Blue Gum/Bangalay leagues. Six types are recognised in the league:

60. **Narrowleaved White Mahogany -Red Mahogany -Grey Ironbark-Grey Gum.** A type of very mixed composition, usually occurring as wet sclerophyll forest up to 45m tall, often with a dense understorey of rainforest plants. Other associated trees may include Tallowwood, Turpentine, Red Bloodwood, Stringybarks, Sydney Blue Gum and occasionally other species; Forest Oak is also commonly present. This type, which is found north from the Wyong district, represents the moist end of the spectrum of types within the Grey Gum-Grey Ironbark league, and is somewhat atypical in the league for this reason.

[1] For botanical names of species, see Appendix 1; see also section 2.2 for further discussion.

61. **Broad-leaved White Mahogany.** Usually rather gnarled or stunted stands, up to about 25m in height, occurring on steep, excessively drained slopes and ridges with a westerly aspect. Associates may include Grey Gum, Grey Ironbark, Smoothbarked and Roughbarked Apples, Stringybarks, Red Mahogany and Grey Box, and the understorey is usually sparse. Found at altitudes up to 600m on the Central and North Coasts.

62. **Grey Gum-Grey Ironbark** -**White Mahogany.** A common ridgetop and upper slopes type, with more productive forest communities occupying the lower slopes. This dry sclerophyll forest attains heights up to 35m and is found north from the upper South Coast. Depending on locality, either species of each of the three indicator trees may be present (i.e. Grey Gum may be ***E. punctata*** or ***E. propinqua***, etc.) Other associates may include Smoothbarked Apple, Red Bloodwood, Tallowwood, Spotted Gum, Blackbutt, New England Blackbutt, Red Mahogany, Sydney Blue Gum and other species. Smaller trees of Forest Oak (or sometimes of Black She-oak) are commonly present in the understorey.

63. **Grey Ironbark-Woollybutt.** This type tends to replace the previous one along much of the South Coast. Grows to a height of about 30m, with Apples, Stringybarks and Silvertop Ash among the more common associates.

64. **Grey Gum-Stringybark**. A widespread type on steep and exposed slopes in the drier parts of the coastal regions, but uncommon in State Forests. One or more of various species of Stringybark (White, Diehard, Thinleaved, etc.) may be present; other associates can include Forest Red Gum, Apples, Bloodwood, White Mahogany and New England Blackbutt. Rarely over 30m in height.

65. **Forest Red Gum-Grey Gum/Grey Ironbark-Roughbarked Apple.** A type found on the far North Coast on steep slopes leading to basalt-capped plateaus carrying rainforest, usually with grassy understorey. Associates may include Yellow Box in its rare coastal occurrences, Grey Box, Stringybarks, White Mahogany and Tallowwood. Height up to 35 m.

The Grey Box-Ironbark league is marked by the dominance of various coastal Boxes (Grey, Coastal Grey and Steel) and Ironbarks (Narrowleaved and Broad leaved). Spotted Gum is absent except as a very subordinate species, and Grey Ironbark is similarly rare or absent except in one type. The league most commonly occurs as a tall woodland, but may in certain types appear as wet sclerophyll forest. It typically occurs on rather heavy soils in the drier coastal districts of the State. Eight separate types are recognised in the league:

80. **Grey Ironbark-Grey Box**. This type occurs on the far North Coast on well-drained basaltic soils under a rainfall of 1 000 to 1 250mm a year. It usually grows as tall woodland, up to 30m tall. Associated species may include Narrowleaved Ironbark, Forest Red Gum, Yellow Box, Bloodwood, White Mahogany, Broadleaved Apple and Grey Gum.

81. **Grey Box-Northern Grey Gum**. Wet sclerophyll forest up to 45m tall, replacing the previous type under the influence of increasing rainfall. Associates may include Grey Ironbark, Stringy bark, Tallowwood and Brush Box, often with a rainforest understorey.

82. **Grey Box**. A widely distributed type in drier coastal areas, and extending to parts of the Western Slopes. Numerous associates may occur. Usually on relatively heavy textured soils, on the drier, ridgetop sites in coastal districts. Height can range from under 20 to over 35m.

83. **Grey Box-Ironbark**. Related to the previous type, but with various Ironbarks (Narrowleaved, Broadleaved, Red) occurring with the Grey Box. Other associates may occur. In some sites soils appear liable to occasional waterlogging. Heights up to about 30m.

84. **Narrowleaved/Broadleaved Ironbark**. Either or both Ironbarks occur, on fertile, well-drained soils under relatively low rainfall conditions (often under 750mm). Stands rarely over 30m tall. The stands often contain only the Ironbarks, but other associates may occur.

85. **Grey Box-Forest Red Gum**. Common in the lower rainfall coastal districts on rather heavy, periodically waterlogged sites, reaching 30m in height.

86. **Coastal Grey Box-Woollybutt**. A South Coast type, often occurring as wet sclerophyll forest up to 40 m high, but sometimes less tall and more open. Other associates may occur.

87. **Steel Box**. A type of limited occurrence on the far North Coast, usually found close to rainforest margins on fertile soils and often exceeding 40m in height. Craven Grey Box has a somewhat similar type of occurrence on the lower North Coast, while Rudders Box, another of the less common coastal Boxes, is found in rather drier hardwood types (often type 62) on the lower North Coast, with heights up to about 35m.

Of these 14 types, types 60 and 62 are by far the most important in terms of timber production and forest management, with types 63, 80, 81, 86 and 87 of more local significance. Most of the remaining types are more typical of pastoral holdings than of State Forest.

Other ecological workers have tended to recognise two alliances, or similar groupings, corresponding fairly closely to the two leagues used by the Forestry Commission. Thus Fraser and Vickery (1939), Pidgeon (1942), Specht et al. (1974, following Hayden, 1971) and Beadle (1981) all identify one major grouping dominated by Narrowleaved White Mahogany and one of the Grey Gums, with variously Thinleaved Stringybark, Tallowwood or Red Mahogany as a third dominant, and they identify a second major grouping dominated by Grey Box, either alone or with Forest Red Gum. In several of these classifications more detailed subordinate classification has produced a number of associations or types that again fairly closely match the types recognised by the Forestry Commission.

The communities making up the Dry Coastal Hardwood types, although occurring over a range of site conditions, are related to each other both in botanical composition (see 2.2) and certain environmental features. They occur with a number of other major forest types in various parts of their range. In inland N.S.W. they have their analogues in the Western Box and Ironbark types, with which they imperceptibly merge in the upper Hunter/Goulburn River valley. They often occur with Spotted Gum types in a mosaic fashion, with the factors responsible for the change from one community to the other being as yet not very apparent. At higher elevations in northern N.S.W. the ridgetop types give way to stands dominated by New England Blackbutt, while on the South Coast this role is largely taken over by Silvertop Ash types. They occur in many of the State's most important coastal forest areas, often being associated with Blackbutt and Flooded Gum stands in a discernible pattern reflecting changes in topography and soil conditions. Under conditions of lower soil fertility they tend to be replaced by some of the types associated with the Scribbly Gum-Silvertop Ash-Stringybark league.

2.2 Forest Botany

The Dry Coastal Hardwood types are marked by the presence, in various combinations, of species of White Mahoganies, Grey Gums, Ironbarks and Boxes, including in each group a number of species that are either very closely related or very similar in appearance - or sometimes both.

The White Mahoganies are represented by two species, Narrowleaved White Mahogany (***E. acmenioides*** MAG:C) and Broadleaved White Mahogany (***E. umbra*** MAG:A). Of the major species typifying the Dry Coastal Hardwood types, these are the only ones in the subgenus Monocalyptus of Pryor and Johnson (1971), though some of the other associated species (e.g. Stringybarks, Silvertop Ash, New England Blackbutt) also fall within this subgenus. ***E. acmenioides*** is normally a tall tree with rather thin leaves which are distinctly paler on the undersurface; *E. umbra* is usually a smaller tree with thicker, coarser leaves which are only slightly, if at all, paler below. Two subspecies of ***E. umbra*** are recognised: ssp. ***carnea*** (MAG:AB) is common on the North Coast on poor stony hillside sites, though not on sandstone; it has a somewhat bluish cast to its foliage, and the disc of the fruit is very narrow.

By contrast ssp., ***umbra*** (MAG:AA) has a more coastal distribution, often on sandy soils, with dark green foliage and a moderately prominent disc.

Like the remaining major species groups in the Dry Coastal Hardwood types the Gums are within the subgenus Symphyomyrtus. They form a distinctive subseries (Punctatinae) within the series Salignae, section Transversaria. Two species occur in N.S.W., Smallfruited Grey Gum (***E. propinqua*** SECEA) and Grey Gum (***E. punctata*** SECED), with the latter containing several subspecies: ssp. ***punctata*** (SECEDA), found on the Central and South Coasts; Largefruited Grey Gum, asp. ***canaliculata*** (SECEDC), with very large fruits, found in the Gloucester and nearby areas; and Northern Grey Gum, ssp. ***didyma*** (SECEDD), which was previously misidentified as ***E. major*** (e.g. Baur, 1962; Forestry Commission of N.S.W., 1965 - correctly ***E. major*** is a Queensland species) and which occurs as a large tree on parts of the North Coast. Although there is some overlap, in general the common Grey Gum of the Central and South Coasts is ***punctata ssp. punctata***, and on the North Coast ***E. propinqua.***

Also within the series Salignae, and occurring in the Dry Coastal Hardwood types, are the Red Mahoganies (***E. resinifera*** SECCC and ***E. pellita*** SECCA) and Woollybutt (***E. longifolia*** SECGA), the last partly overlapping in range with Grey Gum and tending to take its place in Dry Coastal Hardwood types on the lower South Coast.

The Boxes and Ironbarks all belong to the section Adnataria of the subgenus Symphyomyrtus, and are scattered among a number of different series. For the Boxes these are:

Oliganthae:	Steel Box ***E. rummeryi*** SUAAA
Largiflorentes:	Craven Grey Box ***E. largeana*** SUDAA (also known as Copeland Tops Box)
Moluccanae:	Grey Box ***E. moluccana*** SUL:B
Odoratae:	Coastal Grey Box ***E. bosistoana*** SUNCA
Polyanthemae:	Rudders Box ***E. rudderi*** SUT:A
Melliodorae:	Yellow Box ***E. melliodora*** SUX:A

Although unrelated (it belongs to the Symphyomyrtus section Maidenaria, with the Mountain Gums and Southern Blue Gums), Whitetopped Box (***E. guadrangulata*** SPIHA) very closely resembles the true Boxes in both appearance and timber properties. It is more typically a species of the Moist, rather than the Dry Coastal Hardwood types, but on Copeland Tops S.F. it grows with Craven Grey Box, sometimes in typical dry hardwood stands, and as a tree is extremely difficult to distinguish from the Craven Grey Box.

Apart from Red Ironbark, which belongs to the same series as Yellow Box, the Ironbarks are in two series, distinguished by anther shape and the attachment of the anthers to the filaments. Except for these floral differences, a species in one series often very closely resembles a species in the other, producing pairs that can be extremely difficult to separate in the field: ***E. paniculata/E. siderophloia, E. crebra/E. beyeri, E. fibrosa/E. tetrapleura***. The Ironbarks of the Dry Coastal Hardwood types include, by series:

Pruinosae:	Broadleaved Ironbark ***E. fibrosa ssp. fibrosa*** SUP:AA
	(Northern) Grey Ironbark ***E. siderophloia*** SUP:I
	Narrowleaved Ironbark ***E. crebra*** SUP:S
Paniculatae:	(Southern) Grey Ironbark ***E. paniculata*** SUV:D
	Beyers Ironbark ***E. beyeri*** SUV:E
	Squarefruited Ironbark ***E. tetrapleura*** SUV:H
Melliodorae:	Red Ironbark (Mugga) ***E. sideroxylon*** SUX:I

E. beyeri and ***E. tetrapleura*** are relatively restricted and uncommon species, but ***E siderophloia*** and ***E. paniculata*** are both common, with a considerable zone of overlap in their distributions. Dr. D. Boland (CSIRO Division of Forest Research) lists the main distinctions between these two important timber trees as:

1. Adult leaves of ***paniculata*** are dark, glossy green on the upper surface and paler below (i.e. discolorous), with stomates on the underside; those of siderophloia are dull-green to grey on both sides (concolorous), and have stomates on both surfaces.

2. In ***paniculata*** the filaments in the floral buds are strongly inflexed, and the outer 2-3 rows of stamens do not have anthers. (This can be easily seen with the naked eye at flowering time.) In ***siderophloia*** all stamens have anthers, and the filaments are loosely inflexed with the anthers surrounding the style. (This the main botanical distinction.)

Two subspecies of Red Ironbark occur, that on the South Coast being ***E. sideroxylon ssp. tricarpa*** SUX:IB, and that on the Central Coast (and extending inland over a wide range from Southern Queensland to Victoria) being ***ssp. sideroxylon*** SUX:IA.

Relationships between the Ironbarks have been further complicated by some nomenclatural changes introduced in 1962 (Johnson, 1962). Prior to that time the Northern Grey Ironbark was known as ***E. decepta*** and the Broadleaved Ironbark as ***E siderophloia***. Johnson showed that the earliest valid name for Broadleaved Ironbark was ***E. fibrosa***, while specimens used for the original description of ***E. siderophloia*** were in fact of Northern Grey Ironbark. In consequence, the ***E. decepta*** went out of use, the inappropriate ***E. fibrosa*** was introduced for the Broadleaved Ironbark, and ***E. siderophloia*** changed identities from the Broadleaved to the Northern Grey Ironbark - none of which helped the reputation of taxonomy in forestry circles.

2.3 Environment

As with many of the wider ranging groups of forest types, no single environmental factor appears to be of dominating significance in the distribution of the Dry Coastal Hardwood types. Rather there are a number of factors which together help to explain the distribution of theme types:

- Subtropical or warm temperate climate, with hot summers and cool to mild winters.
- Annual rainfall averaging over 700mm, with the highest falls in the summer and early autumn and the lowest during late winter and early spring.
- Soils of moderate fertility compared with many forest soils, but often shallow and usually of fairly heavy texture.
- Sites receiving relatively high levels of solar radiation, e.g. north - and west-facing slopes.

Climatic features of a number of Dry Coastal Hardwood sites are shown in Appendix 2 and illustrate the characteristics mentioned briefly above. The avoidance of severe cold in winter is probably the main climatic factor limiting the extent of the types. Girard S.F. represents sites near the altitudinal limits of the types, and Bega near the latitudinal limits: both stations are slightly away from the occurrence of Dry Coastal Hardwood types, though the types are common nearby. Related Box and Ironbark communities (some containing the same or very closely related species) occur inland, under lower and more irregular rainfall conditions, but the Dry Coastal Hardwood types normally experience annual rainfalls of over 700mm with a tendency (and in the northern stations more than a tendency) for distinct late summer wet seasons and late winter/early spring dry seasons.

Soil conditions of some Dry Coastal Hardwood types were examined by Florence (1963, 1964, 1968) in connection with studies on the ecology of Blackbutt, and he found that Blackbutt tended to be replaced by the more mixed communities where rooting depth, soil aeration and soil permeability were restricted. Both communities occurred over a range of soil fertility levels, having the appearance of dry sclerophyll forest on the less fertile sites, and changing to wet sclerophyll forest with increasing fertility. Within the Dry Coastal Hardwood types studied by Florence, Broadleaved White Mahogany occurred on the less fertile soils and Narrowleaved White Mahogany on the more fertile. The Broad leaved White Mahogany, Grey Gum-Grey Ironbark-White Mahogany and Narrowleaved White Mahogany-Red Mahogany-Grey Ironbark-Grey Gum types essentially correspond to the continuum of White Mahogany communities discussed and illustrated by Florence (1964, 1968) and attributed by him to a gradient in soil fertility. “Less fertile” is in this context a relative term only: other coastal forest communities occur on soils that are markedly more poorly supplied with nutrients (e.g. Scribble Gum types), and Blackbutt appears able to develop on poorer soils than those that can support Dry Coastal Rainforest types (e.g. some coastal sands). Soils supporting the types can be developed on a wide variety of parent materials: Florence (1964) reported White Mahogany communities occurring on soils derived from conglomerate, sandstone, trachyte, shale, schist, greywacke and dolerite, while other stands of Dry Coastal Hardwood types are known from laterised Tertiary lake deposits (Castlereagh S.F.), and on soils strongly influenced by basalt (Urbenville district).

Most of the Dry Coastal Hardwood types occur on or towards the upper topographic positions: as previously noted, in many coastal forest districts they provide the typical forest community of the ridge tops and of the xeric northern and western slopes. However there are frequent exceptions: the Narrowleaved White Mahogany-Red Mahogany-Grey Ironbark-Grey Gum type usually occurs on the lower slopes under decidedly mesic conditions, and some of the communities with Grey Box or Broadleaved Ironbark may appear on sites subject to occasional waterlogging. The Grey Gum-Grey Ironbark-White Mahogany type is often found on exposed coastal headlands along the Central and North Coasts, where the shearing effects of the offshore winds may reduce it to a scrub as little as 3m tall.

There appear to be no strong biotic influences affecting the distribution or occurrence of Dry Coastal Hardwood types. A number of wildlife studies have been carried out in areas supporting significant areas of Dry Coastal Hardwood types, though to date few of these have been published. R. Kavanagh (WT & FRD) has summarised the general conclusions from these studies in the following terms:

1. The fauna of Dry Coastal Hardwood forest is extremely diverse in comparison with many other forest types.

2. The population density of some individual species e.g. Greater Gliders, may be lower in Dry Coastal Hardwood forest compared with other forest types e.g. tablelands types, moist hardwood and Spotted Gum types, which grow on more fertile sites.

3. Dry Coastal Hardwood types, although growing on drier and sometimes less fertile sites, are generally more diverse floristically than many other forest types.

4. The result appears to be a better range and more continual supply of resources for birds and mammals that feed on nectar/pollen, sap and invertebrates.

5. Dry Coastal Hardwood forest types appear to be a stronghold for Yellow-bellied Gliders in forests of the North Coast and parts of the South Coast where Grey Gum, Forest Red Gum and Spotted Gum provide important supplies of sap and nectar for this species.

6. Forest Red Gum and Grey Gum appear to be very important for Koalas.

Working in the Upper Clarence and Richmond River Valleys, where Dry Coastal Hardwood types make up a significant proportion of the district vegetation, Calaby (1966) described the mammal fauna as *“the richest in species ever reported from any area of comparable size in Australia”:* in this area the open, grassy, hilltop and slope Dry Coastal Hardwood sites are the preferred (and common) habitat of the otherwise rather rare Prettyface, or Whiptail, Wallaby. On the North Coast, flowering of Red Bloodwood appears invariably to be associated with the feeding of flying foxes.

Fire is a frequent feature of most Dry Coastal Hardwood sites, and the types seem well adapted to survive and prosper in a fire environment, though some species (e.g. Broadleaved Ironbark) are rather surprisingly susceptible to fire damage. In some districts successes in fire control appear to have led to the expansion of creek side strips of Myrtle rainforest, which are now extending up the slopes and forming a dense understorey below some of the moister phases of Dry Coastal Hardwood types. In such cases (e.g. with Grey Myrtle on parts of the South Coast and with Neverbreak in the Wyong district) there are likely to be substantial problems in regenerating the eucalypts without massive and expensive site disturbance, and it could be justifiably claimed that in these areas the Commission's protection activities have been too successful. Unfortunately the problem, once developed, cannot readily be reversed.

3. OCCURRENCE

Dry Coastal Hardwood types have a wide distribution throughout the coastal districts of N.S.W. Their southernmost occurrence, with Woollybutt and Red Ironbark, is probably in the Eden district, though both species extend into adjacent areas of Victoria. Commercial stands of significant extent are present in Bega district (e.g. Murrah S.F.).

Over much of their distribution through N.S.W. the Dry Coastal Hardwood types form an intricate mosaic with other communities, particularly those dominated by Blackbutt or Spotted Gum, and thus they tend not to feature as distinct entities on small-scale vegetation maps. However in several districts they are themselves the major forest communities present over extensive areas - in parts of the Hunter valley; in a broad belt from near Raymond Terrace to north of Wingham; over much of the lower Macleay valley; and through the upper Clarence Valley. These are portrayed with reasonable accuracy (as "Dry Coastal Eucalypt") on the forest type map of N.S.W. (Forestry Commission of N.S.W., 1978). The types extend up into Queensland and are common coastal types at least as far north as Maryborough.

In the Hunter valley they merge more or less imperceptibly with the Western Box-Ironbark types, that cover large areas of the Western Slopes and Plains and extend north into Queensland and south into northwestern Victoria: some of the Victorian Box-Ironbark stands, with Western Grey Box and Red Ironbark, are in fact very similar in appearance and behaviour to certain Dry Coastal Hardwood types in eastern N.S.W. (Ferguson, 1957; Newman, 1961).

The types appear to have an altitude limit of about 700 m on the far North Coast (e.g. Girard S.F.), and progressively lower further south. However there is an anomalous occurrence at an altitude of about 600 m on the eastern escarpment of Wingello S.F., south of Moss Vale, well above the limit of other comparable stands on the South Coast.

The 1971-72 forest resource inventory of NSW (Hoschke, 1976) estimated the area of Dry Coastal Hardwood ("dry hardwood") types in the State at 1 200 000 ha, of which 282 000 ha were on State Forest, 540 000 ha in private ownership, over 200 000 ha leasehold, 140 000 ha vacant Crown land, and about 9 000 ha National Park. The total area would be little changed today, but much of the VCL would now have been transferred to State Forest or national park. Hoschke shows the area of the Western Box-Ironbark types (including the Yellow Box-White Box types, which he recognised separately) as over 5 million ha, with about 3.5 million ha held as either freehold or leasehold.

4. UTILISATION

Timber values of the Dry Coastal Hardwood types rest largely upon the production of heavy, durable species. This is clearly shown in the details of the properties of various major Dry Coastal Hardwood species set out in Appendix 3, and based upon information provided by Bootle (1983; 1971 in the case of Sydney Peppermint, which occurs in some of the Central Coast and nearby stands): with only a few exceptions the timbers are strong, dense and durable, often with a fine appearance but difficult to work because of their density, and they include a number of timbers that have rightly been regarded as among the State's finest hardwoods. With the development of regrowth stands, providing timber that should be generally freer from defect than that from the old growth areas, it can be expected many of these timbers will be increasingly used for decorative purposes, displaying their fine colour and figure, and some are being used for such purposes in the new Commonwealth Parliament House building in Canberra.

Excluding those species that, although listed in Appendix 3, are more usually a component of other forest types[2], the characteristic Dry Coastal Hardwood species made up about 8 per cent of the total Crown hardwood sawlog cut in the year ended May, 1985. This was a rise of about 1.5 per cent over the level of recent years, and it may reflect a genuine trend towards increased cutting for sawlogs of these generally slower growing species, following losses of forest resource and the need to allow a build up of growing stock in some of the higher yielding types. Other factors that may be leading to increased harvesting of sawlogs from the Dry Coastal Hardwood types include the results of growth response from earlier silvicultural treatment, and the general trend towards better utilisation, assisted in some areas by the introduction of pulpwood harvesting. Ironbarks made up about 3 per cent of the total cut, and White Mahogany about 2 per cent. Average log size tended to be considerably less than for State sawlog production as a whole.

The types were relatively more important as a source of sawlogs half a century and more ago, when natural durability was regarded as a more valuable attribute than is the case today. Although obviously used as sawlogs, the types are commonly preferred for other forms of wood production. Locally, individual species often have the reputation of being faulty or refractory as sawlogs - Woollybutt fairly generally, Grey Ironbark on parts of the South Coast, White Mahogany and Grey Gum in many, though not all, districts, and so on. However, as already noted, the quality of logs from regrowth stands is likely to be much better than from the remnant old stands, where faultiness is often a reflection of overmaturity and past history, and this may well result in increased use of these species for sawn timber. Existing stands frequently contain low quality logs which are sold ex-quota, often from a salvage operation, and which may be used for such products as fencing, dunnage, pallet timber and landscape sleepers. Railway sleepers may also be recovered from trees unsuitable for quota sawlogs, and still represent a significant use of Dry Coastal Hardwood timbers: in Kempsey district alone, 65 000 Ironbark sleepers, plus additional junk, were produced in 1984-85.

Durable poles, together with girders and piles, are the most valuable products from the Dry Coastal Hardwood types, and many stands have been traditionally managed primarily for pole production. Relative values in one typical area (Kiwarrak S.F., February, 1985) were:

Poles	$\$50/m^3$
Sawlogs	$\$20/m^3$
Pulpwood	$4/t

Such values provide a strong incentive to favour pole production over other products. Harvesting is increasingly carried out as an integrated operation, or alternatively there may be succession of operations over a short period: for example on Kippara S.F. there were separate but close operations on the one area to harvest, respectively, poles and girders, quota sawlogs, and finally sleepers and salvage sawlogs.

Regrowth stands are an important source of mining timber, and in several districts Dry Coastal Hardwood and Spotted Gum coppice stands are specifically managed primarily for this purpose. Red Bloodwood, which often has problems for utilisation, can be a well-regarded species for mining timber, and is favoured at Wallaroo because of its good form, satisfactory growth rate and good regeneration capacity.

[2] Statistics of annual sawlog production are maintained by species, not by forest type, and many species may occur in a number of different types. The figures in the text refer to Bloodwood, Boxes, Ironbarks, Grey Gum, Red Mahogany, White Mahogany and Woollybutt. Whilst these often also occur in other types, their yield from these external sources is estimated roughly to balance that from species such as Tallowwood, Spotted Gum and White Stringybark growing in Dry Coastal Hardwood types.

Logging residue is often used for fuel wood, and in the Nowra and Wyong areas is in part used for charcoal production.

For many years, stands north of Raymond Terrace were a major source of wood for hardboard manufacture, though most of this raw material now comes from local sawmill residues. To a very small extent on the South Coast, and to a potentially greater degree on the lower North Coast, Dry Coastal Hardwood types provide pulpwood for export as woodchips - from sawmill residues, logging residues and most recently from silvicultural residues from limited operations. Turpentine and Bloodwood are not accepted as woodchips on the North Coast, Woollybutt is not accepted on the South Coast, and a number of other common Dry Coastal Hardwood species are not particularly liked because of their high extractive content. On the other hand, hardboard manufacture usually requires some Bloodwood in its species mix, and will accept some Turpentine.

Other specialised markets for Dry Coastal Hardwood timbers exist in certain localities, e.g. Bloodwood used for furnace poles at Nowra.

Ironbarks, Boxes and Bloodwood, particularly, are well regarded for honey production, and many Dry Coastal Hardwood stands are popular with apiarists. Some bee-farming sites on Kiwarrak S.F. are permanently occupied.

Many areas are used to some extent for grazing, though the suitability of different Dry Coastal Hardwood types varies considerably, changes in burning practices appear to have reduced the suitability of some areas for stock use since World War II, largely due to the development of denser regrowth stands and understorey.

In several districts Dry Coastal Hardwood and associated types are frequently used for military exercises.

The stands play a role in catchment protection and contribute to the provision of wildlife habitat. Though not the highest ranking communities in terms of visual attraction, some of the moister stands, particularly when managed on a selection system, have considerable scenic appeal and may be popular for recreational use (e.g. Kiwarrak S.F.). On the other hand some areas (e.g. Castlereagh S.F.) appear to be more noted as the scene of various anti-social activities, such as the dumping and stripping of stolen cars.

5. HISTORY OF USE AND MANAGEMENT

The Dry Coastal Hardwood forests were almost certainly maintained as open forests, of large trees with a grassy understorey, through Aboriginal times and well into the 20th Century as a result of frequent burning - usually deliberate. These open conditions are portrayed in photographs taken by the late F.M. Bailey on Ballengarra S.F. in 1930; in pre-treatment photographs of Ourimbah and Ravensworth S.F's reproduced in a 1922 report on silvicultural work in N.S.W. (Forestry Commission of N.S.W, 1922); and in aerial photographs of parts of Kiwarrak and Yarratt S.F.'s in the late 1930's. In all cases the proverbial horseman would have had little problem in galloping through the stand. This contrasts with the conditions in most such stands today.

The timbers from these open stands appear to have been used at an early stage, and their durability was soon recognised and valued. Maiden (1917) quoted a reference to a fence built at Kincumber in 1837, with its White Mahogany posts still sound 55 years later, and he included the following eulogy to Grey Ironbark:

> *"Ironbark is the king of New South Wales hardwoods, in fact it is not excelled in any part of the continent for combined strength and durability. It is extensively used in bridge construction, for railway sleepers, for posts, for naves, spokes, shafts, and framing by the waggon and carriage builder, for large beams in building, particularly in stores for heavy goods, in a word, wherever great strength is required. For such purposes as railway sleepers it will last an indefinite period. I have seen specimens of sleepers which have*

borne the heaviest traffic of the main line, near Sydney, for twenty-five years, and which are as sound as the day they were laid.

He later goes on:

It prefers ridges, often ironstone ridges, growing on dry, poor land, of very little use for any other purpose. Just as hard struggles in his younger days bring out what is best in a man - his grit and quality - so we find, as a rule scarcely admitting of exception, that timber grown under "hard" conditions is better than timber growing more luxuriously as regards soils and moisture.

A more recent reference to the strength and durability of Ironbark is given in the 1981 and 1982 Forestry Commission Research Report, where (pp. 69-70) timber from an 80 year old railway bridge showed surface weathering, but away from the surface effects *"the strength figures were remarkably high, and there was no indication of any reduction over the years in the intrinsic strength of the wood away from the surface."*

The timbers of the Dry Coastal Hardwood types were also of value for poles, and an early report on Castlereagh S.F. (Anon., 1921) comments: *"In the past (the forest) has been largely drawn upon for ironbark pole timber*", and notes that in the previous six years it had yielded 44 000 lineal metres of poles as well as over 700 m^3 of sawlogs from a productive area of some 350 ha.

Harvesting tended to be highly selective, and the early silvicultural report (Forestry Commission of N.S.W., 1922), referring to State Forests generally, states *"…. many of them (forests) had been so irregularly exploited that today they have been deprived of the cream of value, leaving only the whey."* The report goes on to detail the treatments being undertaken to bring these forests back into a productive state - regeneration opening, ringbarking, sometimes soil disturbance and broadcast seeding, fire protection - and the cases discussed and illustrated are almost entirely of Dry Coastal Hardwood types. Many of the more accessible stands subsequently received such treatment, though it was not universal: the 1984 management plan for the Coffs Harbour M.A., referring to Dry Coastal Hardwood types, states:

"It is rare to find any area of this type which has received silvicultural treatment, and as a result a high proportion of unmerchantable veteran trees exist in these stands."

In the late 1930s the establishment of a hardboard (Masonite) plant at Raymond Terrace led to an upsurge of interest in the local Dry Coastal Hardwood stands, which for many years provided the main resource base for the plant, from both State Forest and nearby company-owned areas. Masonite timber[3] was the predominant product from the Wallaroo M.A. for some three decades, and the forests have been relatively intensely managed - in part resulting in a deficiency of large "habitat trees" over much of the Area. As part of the management a plantation programme operated for a short period and resulted in some 80 ha of eucalypt plantings, mostly of Grey Ironbark.

Slightly further north, the Commissioner at that time (E.H.F. Swain)

"…had the idea of developing Nerong, which was not a first class forest, into a highly productive forest of poles and sleeper timber, and he developed a large camp of very sound huts that were built to accommodate about 30 or 40 men. They were set out in military style in a three-sided square and a dam was built, water supply was put on and the lot - it was developed at the same time as the Wallaroo nursery which was to supply seedlings for this Nugramudgee project. It never had a soul live there apart from the one lone forester that was there and arranged the planting of 50 or 100 acres of felled forest around the camp itself, planted by local inhabitants that didn't camp in the huts. The camp was never occupied by forestry labour as it was expected to have been, and it finally was sold up. (From interview with F.M. Bailey, 1984)."

[3] *A reviewer of these Notes in draft form has commented that Masonite terminology was confusing. In most usage a billet is split; in Masonite operations billets were round. Larger trees, from which conventional billets could have been split but which were normally broken down in the plant's sawmill, were simply referred to as logs.*

Although the account may be somewhat coloured by the elapse of time, it was clearly a period of grandiose schemes!

Management in the more accessible Dry Coastal Hardwood stands mostly tended to emphasise pole production, though at the same time providing a sawlog yield. Some areas, most notably those close to the Northern Coalfields, were largely converted coppice stands for the production of mining timber. This pattern persists to the present time. Whilst the pulpwood market around Raymond Terrace contracted in the 1970s as the hardboard plant increasingly used sawmill residue as its raw material, the development of a woodchip export trade from Newcastle should have significant influence on the management of local Dry Coastal Hardwood types in the future.

6. REGENERATION REQUIREMENTS

6.1 Regeneration Establishment

There has been very little research carried out into the regeneration of the Dry Coastal Hardwood types, but field experience suggests that these types normally have few regeneration problems, with regrowth after logging coming reliably from coppice or the release of lignotubers in the advance growth pool. Direct establishment from seeding may occur, particularly in some of the more mesic stands. The pattern is thus almost identical with that of the Spotted Gum types and, where appropriate, reference should be made to the Notes on the silviculture of Spotted Gum types (No. 6 of this series).

Planting has been used in various areas to regenerate Dry Coastal Hardwood types. Only small scale planting of Dry Coastal Hardwood species has occurred, most notably the planting of Grey Ironbark and some other species (including Red Mahogany, Grey Gum and Tallowwood) at Wallaroo S.F. (see Section 5). Some areas of Dry Coastal Hardwood types have been included within local eucalypt planting projects, generally involving the planting of Blackbutt: these usually end up carrying a good stocking of Dry Coastal Hardwood regeneration amid the planted trees (e.g. Pine Creek and Cairncross S.F's). Perhaps more valid has been the inclusion in plantation projects of some of the moister Dry Coastal Hardwood types where the advance growth pool has been excessively depleted by dense undergrowth (see Section 6.4). Some of the Blueleaved Stringybark plantations in the Wyong and Cessnock districts included such sites, and the results have generally been silviculturally excellent, though the cost of site preparation has often been very great.

There has also been a limited amount of enrichment in some areas by either planting or direct seeding, using both Blackbutt and Gympie Messmate, the latter of which has shown good development on some of these sites and which is more fire resistant than Blackbutt. Enrichment is intended to introduce species of better growth or greater potential value, though the off-site use of Blackbutt needs to be approached cautiously (see Blackbutt types Notes; No. 4 of this series). For the purpose of establishing an adequate stocking of Dry Coastal Hardwood species after logging, artificial regeneration would rarely, if ever, be required.

6.2 Flowering and Seeding Habits

Details of the flowering times of Dry Coastal Hardwood species (from Blakely, 1965 and Boland et al., 1980) and of their seeding times (from Boland et al., 1980) are given in Table 1. Most of the species appear, like most eucalypts, to be somewhat irregular flowerers, with a heavy general flowering one year being followed by some years of light flowering, though individual trees may show different patterns. However the main species - Grey Ironbark, Grey Gum and White Mahogany - normally flower each year and carry some seed at virtually all times. Red Mahogany is less reliable, as was observed in an old Queensland report: *"**...** seeding has been irregular and scanty, this species in this respect having been amongst the least satisfactory of all eucalypts under observation during the last four years"* (Department of Public Lands, 1917).

Table 1
FLOWERING AND SEED COLLECTION TIMES: DRY COASTAL HARDWOODS
(from Blakely, 1965; Boland et al., 1980)

Species	Flowering	Seed Collection	Duration	No Crops
Bloodwood, Red	Jan-Apr	Jun-Mar	XX	
Box, Grey ,Coastal ,Craven Rudders Steel	Jan-Apr Nov-Feb May-Jul Feb-Mar Dec-Jan			
Gum, Grey ,Largefruited ,Smallfruited Spotted	Dec-Apr Nov-Dec Jan-Mar May-Sep (1)	Dec-Feb Dec-Feb Jan-May	XX XX XX	
Ironbark Beyers Broadleaved Grey (Northern) (Southern) Narrowleaved Red	 Aug- Oct Nov-Feb (2) Jul-Jan May-Jan (3) May-Jan May-Oct (4)	 Aug-Feb	 XX	
Mahogany, Red White (Broadleaved) (Narrowleaved)	 Oct-Feb Aug- Sep Oct-Feb	 Aug-Sep Dec-Feb	 XX XXX	 +
Tallowwood	Aug-Dec	Feb-Sep	XX	
Woollybutt	Oct-Nov			

Notes: **Seed collection**: most convenient months for collection.

Duration: indication of period in which crop is present on tree:

XXX Long duration - some seed available most months;
XX 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) For further details of Spotted Gum flowering and seeding, see Sil Notes No.6.
(2) May also have later flowering, May-June.
(3) Flowering near Sydney from May-November.
(4) South Coast form (***ssp. tricarpa)*** flowers in autumn.
(5) ***Ssp. carnea*** flowers November-January.

Features of the seed of major Dry Coastal Hardwood species are given in Table 2, again using data from Boland et al. (1980). No species are known to require or benefit from pre-treatment (e.g. stratification), and all show fairly speedy germination.

Table 2

SEED FEATURES: DRY COASTAL HARDWOODS

Species	Number Viable Seeds/kg		Germination		
	Mean	Highest	Temperature (1)	First Count (2)	Final Count (2)
Bloodwood, Red	77 000	102 000	(25)	5	14
Box, Grey	351 000	764 000	25; 30	5	21
,Coastal	491 000	665 000	25	5	14
,Craven	1 030 000	-	(25)	5	15
Rudders	326 000	-	(25)	5	14
Steel	252 000	487 000	(25)	5	10
Gum, Grey	88 000	392 000	25	5	21
,Largefruited	38 000	45 000	(25)	5	10
,Smallfruited	443 000	910 000	(25)	5	21
Spotted	109 000	252 000	25	5	14
Ironbark					
Beyers	470 000	-	(25)	3	14
Broadleaved	211 000	399 500	(25)	5	14
Grey (Southern)	419 000	1 320 000	(25)	5	21
Narrowleaved	582 000	1 176 000	30	5	14
Red **(3)**	226 000	735 000	20	5	14
Mahogany,					
Red	215 000	790 000	25	5	21
White (Broadleaved)					
(ssp *carnea*)	166 000	294 000	(25)	5	14
(ssp *umbra*)	54 500	119 000	20 (25)	7	21
(Narrowleaved)	140 000	336 000	(25)	7	21
Tallowwood	205 000	770 000	(25)	5	14
Woollybutt	132 000	161 000	(25)	7	28

Notes: **(1)** Temperatures recommended for germination tests. Where figure is bracketed,e.g. (25), this temperature is satisfactory, but others have not been tested; where two or more figures are given, e.g. 20;25, all have been found satisfactory.

(2) Count" figures relate to laboratory tests, but give a relative measure of the speed of germination (days from start of test).

(3) For the South Coast form of Red Ironbark (ssp. *tricarpa*), recommended 1st. Count is day 10 and Final Count day 15.

6.3 Seedling Establishment

The establishment of seedlings is necessary either for the direct development of regeneration or for the creation of a pool of advanced growth. The very limited studies suggest that this establishment is rather spasmodic: reviewing some Queensland studies on the effects of burning, Henry (1961) noted *"it appears that the establishment of seedlings of the major species in quantity is an exceptional event",* while Hawkins (1959), working with Narrowleaved Ironbark in more westerly Queensland forests, quoted A.R. Trist as having pointed out that the apparent combination for the successful establishment of regeneration, i.e. fair spring rains coincident with a seed crop, would not occur often: while seedlings appeared, few survived past one year. Hawkins suggested that the most important factors in Narrowleaved Ironbark seedling survival were protection from the sun up to the 6-8 leaf stage, and good follow-up rains in the immediate post-germination period, together with mild temperatures. A study reported by Henry and Florence (1966), near Maryborough, showed a variable annual germination of eucalypt seedlings over a period of 6 years, but with limited survival; those that survived formed lignotuberous plants. Henry and Florence also noted that good establishment of Dry Coastal Hardwood species occurred following burning, but that with few exceptions the seedlings that survived became part of the lignotuber pool. The exceptions they reported came from germination on ash-beds, where some Spotted Gum seedlings developed directly into saplings: this probably can also occur with other species, but it appears to be unusual.

Floyd (1960) examined regeneration development over 3 years in openings of different sizes on Kangaroo River S.F. Despite its apparent absence at the start of the study, lignotuberous advance growth proved to have been present through the area, but additional seedling regeneration only established in the larger openings (over 250 m^2), where it occurred in the shade of logs and heads and on the charcoal of burnt debris. Floyd noted that such favourable beds occurred where logging had been heaviest, and therefore the openings largest, and he attributed the seedling establishment to the seedbed conditions, rather than to opening size (i.e. light conditions) *per se*. Elsewhere he had previously observed that both Grey Ironbark and Grey Gum are reasonably tolerant of shade in the young stages (Floyd, 1956). Another proposed study on regeneration on Ingalba S.F. gave negative results when no lignotubers were located and no seedlings appeared.

In all, these studies contribute little that would not have been expected: seedling regeneration in the Dry Coastal Hardwood types is rarely prolific, but it does occur, with the surviving seedlings normally contributing to the lignotuber pool. Seedling establishment occurs when seed availability coincides with suitable weather conditions, a seedbed where germination can occur, and possibly most importantly some protection for the young seedling. Under very favourable conditions seedlings may develop through to saplings without an intermediate lignotuberous resting stage, and this may be the major regeneration mechanism in some of the more mesic sites. While adequate regeneration is usually present, problem sites may occur: on Myall River S.F. a dense undergrowth has developed and is hindering regeneration establishment, though excellent regeneration followed severe wildfires in 1980. This is one of a number of examples of fire control measures proving rather too successful. At Ourimbah S.F. regeneration is excellent on the northerly slopes, but is poorer on the moister southerly aspects where dense crops of wattle and ***Commersonia*** can develop, though eucalypt regeneration is usually present beneath the weed crop.

6.4 Advance Growth Pool

The eucalypts occurring in the Dry Coastal Hardwood types are all ones that normally produce lignotubers, and as noted above seedlings that survive typically form a lignotuber at a relatively early stage, and then enter a resting stage where they may survive for decades while maintaining the ability to make active growth if favourable circumstances occur.

Much of what is known about the development of lignotubers in eastern Australia comes from the Queensland studies of Henry and Florence (1966), working in Spotted Gum stands containing a range of typical Dry Coastal Hardwood species, and their findings would appear to have general validity for Dry Coastal Hardwood types. These findings concerning the pool of advance growth regeneration were discussed in the Notes on the Spotted Gum types (No. 6 of this series), and the summary from those Notes is repeated here:

- The number of lignotubers constituting the pool will fluctuate from year to year, though in any particular site it tends to stabilise around a fairly constant value.
- There may be substantial differences between the numbers of lignotubers in the pool in different sites.
- A well-established lignotuber up to 2.5cm in diameter can develop in a little over a year from germination.

- Additions to the pool come from seedlings that are able to survive long enough to form a robust lignotuber, most seedlings do not do this, and die within a year of germination

- It seems likely that most additions to the pool follow occasional fires, which provide suitable conditions for germination and establishment.

- Whilst a seedling can proceed actively to sapling size without an intermediate lignotuber resting stage, this seems unusual in most sites.

- The lignotubers tend to produce a few straggling branches that can be obscured in the grass or other undergrowth. Most of these stems are under 30cm high.

- The stems can be repeatedly destroyed by grazing, fire or other damage, but will be replaced from the woody base.

- Figures on the depletion rate of lignotubers (from 2 to 4 percent a year) suggest that individual lignotubers live between 20 and 50 years on average.

- Much higher depletion rates occur when the lignotubers are heavily shaded, as by dense lantana.

- Whilst repeated light fires appear to have no effect on lignotuber mortality (though they may reduce the rate of accretion of new lignotubers), heavier fires can promote the development of vigorous shoots, but then lead to accelerated mortality if the rejuvenated plants are unable to continue their development. (At the same time the heavier fire probably allows for an increased recruitment of new lignotubers.)

- Lignotubers respond rapidly with the production of actively growing shoots to removal of the canopy, but with Spotted Gum appear to require openings of at least 30m in diameter before maximum growth rates can be attained.

- Excessive grazing or browsing pressure can hold back this response to canopy opening.

In the one reported study in N.S.W., carried out on Kangaroo River S.F., Floyd (1960) concluded, *"It is evident that sufficient advanced growth is present in most openings to ensure full stocking provided they are well distributed."* The stockings of lignotuberous advance growth recorded by Floyd ranged between 200 and 2 500 per hectare in different openings. Floyd noted that when the study was established none of these stems were in evidence, having been obscured by the grassy undergrowth. He also noted that the most desirable species (Grey Ironbark and Grey Gum in this area) made up only 15 per cent of the total stocking.

Jacobs (1955, paras. 181-4) has discussed the significance of advanced growth in providing regeneration, and has pointed out the tolerance of many of the lignotuberous species: a plant of Tallowwood (admittedly one of the most shade-tolerant of all eucalypts) survived for 14 years in dense shade and root competition (light was estimated at about one fortieth full sunlight), and then responded with active growth when released (Figs. 116 and 117). Although the lignotubers can survive at low light intensities, no recruitment will occur under these conditions, leading to a gradual, or probably often not so gradual, reduction in the size of the pool, and its replacement by less desirable species. Such changes in composition are most likely to occur in the moister and more mesic sites, where fire is rare, and can result in increasing proportions of Turpentine and Brush Box in the advance growth pool. More typical, drier Dry Coastal Hardwood sites will less commonly develop very dense understoreys, though lantana will provide such conditions, and the species present in these drier sites tend to be less tolerant than Tallowwood, and therefore more prone to suffer if undergrowth does develop.

Both the limited research evidence and field experience suggest that the main threat to successful Dry Coastal Hardwood regeneration comes from this development of a dense understorey. In the more open forest stands, maintained with a grassy understorey by frequent burning, an adequate lignotuber pool can normally be expected to be present, but where a dense shrubby understorey forms, in mesic sites or through an absence of fire, the pool may become excessively depleted without new recruitment taking place.

6.5 Coppice

The Dry Coastal Hardwoods are all species that coppice well, and in forests being managed primarily for poles or other small timber production coppice tends to be the major source of regeneration, with lignotuberous advance growth serving to replace those stumps that fail to coppice. Again few studies relating specifically to Dry Coastal Hardwood coppice have been carried out, but the experience recorded for the Spotted Gum types (No. 6 of this series) would appear to apply equally here:

- Early responses of coppice tends to be much faster than that of lignotubers released in the same operation: one Newcastle study (Forestry Commission of N.S.W., 1973 and 1974a) showed a mean height of over 3m for the tallest coppice shoots 2 years after treatment, at a time when there were still on average some 4 shoots on each stump.

- Stumps should be cut low and sloped for effective drainage. As far as possible stumps should be less than 15cm high, otherwise the coppice shoots may not be windfirm.

- Coppice shoots effectively thin themselves out, and usually a single shoot assumes dominance at an early stage and forms the ultimate stem; occasionally more may survive.

- On many occasions some stumps will fail to coppice after cutting, though the number failing is usually low. Failure is possibly associated with low starch levels in the stem. Starch reserves are depleted during periods of active growth flush, and the study of Banter and Humphreys (1965) indicated that they were likely to be lowest in autumn, when the poorest coppicing response might be expected. (In the A.C.T., Jacobs (1955, para. 371) found no seasonal pattern, but noted that the highest loss of stools had occurred from a January felling during a dry spell.)

- Harvesting in the Dry Coastal Hardwood types is rarely if ever the clear cutting, to produce an even-aged crop, of the classical coppice system. Rather it involves fairly frequent selective harvesting to meet the variable demands of the local small-wood markets for mining timber and poles, and it results in decidedly irregular stands.

The development of coppice stands is considered further in Section 7.2.

6.6 Regeneration Damage

The main hazards to Dry Coastal Hardwood regeneration appear to be climatic elements during the early months after germination, especially drying conditions and insolation. These, of course, are dominant features of most Dry Coastal Hardwood sites. Once the seedling has established a lignotuber it is much more resistant to these and other damage agencies, including browsing and fire. The shoots on the lignotuber can be destroyed on frequent occasions, but the plant recovers by producing new shoots, often rather weak and straggling in the undergrowth, until conditions allow it to assume active growth or until it finally dies.

Again no studies, but ants undoubtedly remove considerable seed from the ground in Dry Coastal Hardwood stands ahead of germination, though probably not enough to have a significant effect on regeneration stocking. Other insects feed on the leaves of the shoots or produce galls on them, but the effect is not major.

Fire can destroy young seedlings, but also provides conditions favouring germination and recruitment (Henry and Florence, 1966). Lignotuberous advance growth recovers well from fire, which may prompt it into assuming active height growth. Although both larger stems and lignotubers show considerable ability to withstand fire effects, some younger Dry Coastal Hardwood stems, whether from coppice or developing lignotubers, are rather surprisingly susceptible to fire damage and will be killed back to ground level: on the frequently burnt Castlereagh S.F. relatively light fires have killed regrowth of Broadleaved Ironbark up to 3 m high back to the stump. In general it seems that efforts should be made to keep fires out of young regenerating stands for 3 or 4 years after a logging operation, and on some of the harder sites, such as Castlereagh, possibly even longer, to allow the developing regrowth to reach a size that will withstand light prescribed burning.

The Dry Coastal Hardwood types are commonly browsed both by native animals and by domestic stock, and again the lignotubers enable the advance growth pool to survive this constant loss of foliage. In the study reported by Floyd (1960) on Kangaroo River S.F., there was no significant benefit shown by excluding grazing (fenced plots) over a three years' period, and field experience indeed suggests that, when conditions are suitable for active height growth (e.g. following a harvesting operation), adequate plants can grow to sapling size despite grazing or browsing in the area.

As previously noted, the development of shady undergrowth - effectively weeds - will reduce the advance growth pool and hinder or prevent the establishment of regeneration recruits. Fire, by maintaining an open understorey, undoubtedly has a beneficial effect in this respect, and in many districts reduced burning frequencies have led to the development of quite mesic understoreys which not only affect regeneration but which make further use of fire almost impossible except under distinctly hazardous conditions: a form of vicious circle that is one of the more significant problems in the silviculture of some Dry Coastal Hardwood sites. Vines are not uncommon in many Dry Coastal Hardwood areas and can drape over saplings. In most cases the adverse effects are limited, and many of the vines make a welcome splash of brightness during the spring (e.g. Clematis, Wonga Wonga). However Devils-Twine is often locally common - generally in the rather drier and harder sites - and can at times be rather more than of just nuisance value. This is a leafless semi-parasite that, having attached itself by haustoria to the host, can survive without contact with the ground, encasing its host in a mass of fine, yellowish-green, intertwined stems. It is particularly prevalent on coppice, and can kill its host. The problem appears more significant in northern Victoria than it is in the N.S.W. Dry Coastal Hardwood forests, and a useful, review of information about this weed (under the name of "Dodder-Laurel") has been given by Pederick and Zimmer (1961), who suggested grazing as being the most effective form of control, though burning also had some positive value.

6.7 Early Development

The main features of the early development of the Dry Coastal Hardwood types have already been touched upon and are, once again, largely a reprise of the information relating to Spotted Gum (No. 6 of these Notes).

- Seedling development leads to the establishment of a lignotuber, and in this form the plant can exist for many decades in the undergrowth before it either dies or assumes active vertical growth.

- Under the most favourable conditions (e.g. planted in prepared site), seedlings will continue active growth through to sapling size and beyond without an intermediate lignotuberous resting stage. (These seedlings will usually, probably always, show the development of lignotuberous swellings, but their growth will continue without the usual lengthy check.)

- Figures are few on the early growth of Dry Coastal Hardwood species, though Floyd (1962) gives some details of their growth on Blackbutt sites on Pine Creek S.F. From seed, only Broadleaved White Mahogany showed continued active growth, which over 2 to 3 years was comparable with, or even slightly better than, that of Blackbutt: in two years some White Mahoganies were nearly 3m tall. The other Species appeared to have entered the advance growth pool, with a height of under 60cm. For responding advance growth, Floyd noted that *"Blackbutt and White Mahogany are faster than Bloodwood, Tallowwood, Blue Gum, Brush Box and Turpentine ..… Red Mahogany shows slow growth when under 60cm in height; but a sudden increase when over 2m may or may not be typical."* Apart from Blackbutt and the two Mahoganies, none of the species showed height increments exceeding a metre a year in heights of up to 4m, and this relatively slow early growth is probably typical of most Dry Coastal Hardwood species developing from the lignotuberous pool.

- By contrast, response as coppice growth can be fairly rapid, and in most cases appears to average or exceed 1m a year in height for up to 10 years. Coppice growth will be looked at more closely in Section 7.2.

- Some of the Dry Coastal Hardwood species, including Grey Ironbark, Grey Gum, Bloodwood and particularly Tallowwood, are comparatively tolerant for eucalypts, and can maintain slow, but active, vertical growth in smaller openings than can most eucalypts. (Thus, where these species grow with Blackbutt, the creation of small openings will tend to favour the lignotuberous species over the usually more desirable Blackbutt.) Turpentine is even more tolerant, and in the absence of fairly regular burning is likely ultimately to dominate many of the more mesic Dry Coastal Hardwood types where it occurs.

- Even the most tolerant species benefit from release, and this is the basis for the culling treatments that in the past have been widely applied to these types. At the same time saplings and small stems of poor form will usually coppice vigorously and produce a more acceptable stem if cut back. This combination of culling and coppicing provided the basis for much timber stand improvement (T.S.I.) carried out in the Dry Coastal Hardwood stands, and followed the earlier improvement treatments described by Swain (1911).

7. GROWTH AND YIELD

7.1 Background

Unlike its regeneration, the growth of Dry Coastal Hardwood types has been the subject of a number of studies in both N.S.W. and Queensland. The most notable are those of R.A. Curtin concerning stands managed by coppice for small-timber production (1961, 1970a) and stands managed for larger produce (l970b).

Before briefly reviewing these and other growth studies, it is reiterated that, in their natural state, the Dry Coastal Hardwood types appear to have been maintained by frequent burning as rather open stands with a clear, grassy understorey. Improved fire control and limited burning over the past four or so decades have in many areas resulted in a considerable thickening up of the stands, and this has almost certainly had an influence on growth rates.

The stands are also naturally uneven-aged and of irregular structure, conditions that lend themselves to the use of some form of selection management.

7.2 Small-timber Stands

Particularly in the Hunter Valley and Shoalhaven districts, close to the State's major coalfields, Dry Coastal Hardwood stands have been widely managed for the production of small-timber used both for mining purposes and for pulpwood. These stands are usually uneven-aged, with selective harvesting at relatively short intervals (commonly about 8 years) to supply the current, but variable, market needs. Stands may contain coppice of two or three age groups, as well as some standards, which are usually maintained for pole or small sawlog production[4]. Management appears to have developed from a more conventional even-aged coppice system under the influence of varying growth rates and markets for only a limited, but frequently changing, range of size classes.

The main information on the growth of coppice Dry Coastal Hardwood stands comes from the work of Curtin (1961, l970a), who looked at even-aged stands in the Raymond Terrace area (1961), and subsequently at a wider range of stands. Curtin's findings were reviewed in the Notes on Spotted Gum types, and are repeated here.

In his 1970 paper, Curtin summarised his earlier conclusions in the following terms:

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

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

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

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

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

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

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

8. *An examination of size class distributions suggested that reasonable merchantable yields can be obtained from stands with a mean diameter of 13 cm by logging from above. There was a complete absence of knowledge on the way such a stand might develop after logging, particularly with respect to the interaction of new coppice shoots with the older*

[4] A somewhat similar "Coppice Selection System" is briefly described by Troup (1952) and has spilt into several more recent forest terminologies. Troup noted that it "seldom has a flourishing appearance, and is not to be recommended except in the somewhat special conditions under which it is generally practised." One marked difference between this European system and the irregular N.S.W. coppice system is that, in European practice (chiefly with Beech), stools bear shoots of several different ages, with only the oldest being felled at any time. In N.S.W. there is usually only a single stem surviving on the eucalypt stools by the time felling is due, but other stools will bear younger shoots.

suppressed trees. Similarly there was no knowledge of stand reaction to thinning from below."

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

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

Curtin hypothesised some coppice stand growth relationships that are presented both as graphs and a table in his 1970 paper; he also presented some actual data from the Cessnock district on the growth of coppice of known age: his data, converted to metric, is reproduced in Table 3.

Table 3

AVERAGE SIZE OF COPPICE STEMS OF KNOWN AGE - CESSNOCK MANAGEMENT AREA
(after Curtin, 1970a)

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

Curtin posed a number of questions concerning the growth and care of these coppice forests, and unfortunately the questions are still awaiting answer: in paraphrased form they are repeated in Section 10.3.

However several points should be noted:

- The irregular coppice stands typical of most N.S.W. small-timber forests appear to be less efficient than are even-aged coppice stands, but nonetheless they have been effective wood producers for a long period.
- Because of the limited range of sizes usually sought at any time for mining timber, and because of the economic facts of harvesting, stems can escape harvesting when of commercial size and grow into larger sizes for which no markets are

available until, and if, they become poles or small logs. In addition stems of little or no merchantable capacity also tend to build up in the stand. If these stands are to continue to be managed for small-timber production, a periodic clear felling (with desirable standards retained) is probably necessary to remove the useless components and to rejuvenate the coppice stand.

- At least one highly respected silviculture text (Daniel, Helms and Baker, 1979) states that one of the requirements for successful coppice management is that *"the site must be very fertile and have a high moisture supply so frequent cuts do not cause site deterioration."* This is very much the reverse of the conditions under which most Australian coppice systems are applied, and there does seem to be a need for monitoring the continued nutrient availability under local coppice systems on what are frequently among the least fertile of the Dry Coastal Hardwood soils.

- Efforts should always be maintained to keep stump height low (under 15cm) when harvesting in stands were coppice is sought. In the past, silvicultural funds have been spent in a number of forests in reducing stump heights when harvesting operations have left them too high.

7.3 Large-timber Stands

Whilst small-timber production is important in a number of Dry Coastal Hardwood stands, in most such forests the aim of management is to produce large - or at least larger - stems for use as poles, girders, piles, sawlogs and so on. These stems may frequently originate from coppice, but the stands are not managed under a coppice system; rather they are usually managed as selection or group selection stands. On Kiwarrak S.F., which is probably typical of many Dry Coastal Hardwood forests, there is a cutting cycle of about 20 years for sawlogs, with more frequent operations for poles, while Curtin (1970b) records a 25 years cutting cycle for logs on Yarratt S.F., again with pole operations on a shorter cycle.

The most thorough review of growth in such stands was made by Curtin (l970b), analysing the results of remeasurement, after an interval of 6 years, of a series of continuous forest inventory plots on Yarratt S.F., almost the archetypal Dry Coastal Hardwood forest. The results of this study can be summarised as follows:

- The results were analysed to give growth data on species associations containing Bloodwood, White Mahogany, Grey Gum, Ironbark and other hardwoods. Useful growing stock increased from 39.2 m^3/ha in 1960 to 41.6 m^3 in 1966. An average of 1.4 was removed from the forest each year and of this 0.3 m^3 was sold and 0.4 m^3 was rejected or felled in timber stand improvement (T.S.I.) operations. Other mortality, mostly from fire, accounted for the remaining 0.7 m^3/ha.

- Average annual recruitment into the 10 to 20cm size class was 12.9 trees per hectare.

- Survivor growth of useful trees was 1.0 m^3/ha per annum. The average annual diameter increment of useful trees was 0.33 cm, and remained stable over the size classes.

- The apparent effect of wildfire was to reduce the increment by more than 50 per cent. T.S.I. was found to have a strong positive effect on growth.

The forest contains a number of types, but the Dry Coastal Hardwood stands make up some 70 per cent of the total area, and have been divided into three groups: low SQ poles, high SQ poles, and semi-moist hardwood. These form the common spectrum of Dry Coastal Hardwood types on the North Coast (see Section 2.1, types 60 and 62), and the gradient from low to high SQ was reflected in the total volume increments of these groups (useful and useless stems):

Low SQ poles	1.15 m^3/ha/an
High SQ poles	1.33
Semi-moist hardwood	1.47

Table 4

DIAMETER GROWTH OF DRY COASTAL HARDWOOD SPECIES (CM/AN)

State Forest	**Yarratt**	**Pine Creek**				**Wyong**				
Source	Curtin (1970b)	Vanclay (1977)				Curtin (l970a)				
Categories	**Useful**	**Dom**	**Co-dom**	**Sub-dom**	**Suppressed**	**1917-23**	**' 23-27**	**' 27-32**	**'32-62**	**'17-62**
Species										
Ironbark	0.38	0.88	0.46	0.43	0.34	0.71	0.51	.69	.20	.36
White Mahogany	.33	59	.64	.44	.28	.89	.64	.25	.15	.30
Red Mahogany	.25	–	.46	.17	.05	.64	.46	.25	.08	.20
Grey Gum	.38	–	.40	.39	-0.10	.79	.58	.41	.28	.38
Turpentine	.25	.26	.27	.18	.19	.58	.38	.28	.15	.23
Blackbutt	.43	.89	.88	.54	.45	1.09	.94	.51	.38	.53
Brush Box	.28	–	.42	.16	.09	-	-	-	-	-
Bloodwood	.18	.59	.39	.19	.08	-	-	-	-	-
Spotted Gum	.30	-	-	-	-	.79	.51	.51	.20	.33
Tallowwood	.45	65	.56	.40	.09	-	-	-	-	-
Smoothbarked Apple	.15	-	-	-	-	-	-	-	-	-
White Stringybark	.38	-	-	-	-	-	-	-	-	-

Five merchantability classes were used in the Yarratt CFI plots - sawlog, pole and sleeper trees, salvage trees and useless. Curtin, for simplicity, combined the first 3 into his "useful" class and the last two into "useless". The yield of products from the useless class (e.g. see Table 8) was almost entirely of low value salvage logs, and Curtin notes that in general the deliberate removals compare with the original estimate of merchantability.

The diameter increments shown by useful stems, by species, are included in Table 4: the direct comparison between species is not necessarily valid, as the average increments shown will vary with differences in size class distribution, dominance class and so on, but nonetheless the relative rankings appear fairly comparable with those from other sites included in Table 4. Curtin in fact found little evidence to suggest that useful diameter increment decreased with increasing size class over the range of 10cm to 70cm, as had earlier been surmised: the recorded increments averaged 0.33 cm/an and varied little from that over the range of sizes to 70cm, but dropped in the 70cm + class. Diameter increment, averaged over all species and size classes, showed a predictable relationship with dominance class:

Dominants	0.41 cm/an
Co-dominants	0.36
Subdominant.	0.28
Suppressed	0.20

Stems classed as useless showed reduced diameter increments in all size and dominance classes.

Based on the diameter increments, Curtin calculated that it would take, on average, 157 years for a useful stem to grow from 10 to 60cm Dry Coastal Hardwood, and he suggested that something *"considerably less than 29 years"* is required for a stem to reach 10cm. (The 29 years was based on diameter growth in the 10-20cm class.)

Curtin showed that stand volume increment increased with increasing stand BA, and decreased with increasing mean DBH. Timber stand improvement treatment had a definite effect on total growth rate, including a bonus of 0.45 m^3/ha/an: Curtin attributes this partly to the faster growth of useful stems, compared with useless stems which are largely eliminated by T.S.I. operations.

Two out of the six years covered by Curtin's study experienced unusually severe drought conditions, and based on subsequent measurement of a limited number of plots for a further 3 years, Curtin showed that diameter growth had indeed been depressed by the drought, and that the average useful increment should be increased by about 0.03cm, bringing it to 0.36cm, to reflect more accurately normal conditions: this would reduce the period for a stem to grow from 10 to 60cm Dry Coastal Hardwood to about 140 years.

A feature of Curtin's review of the Yarratt CFI plots was his examination of different concepts of forest growth - concepts, of course, that have general application. He describes these different measures as follows:

In the calculation of merchantability class growth, it is necessary to recognize the effect of reclassification in that certain trees from the initial inventory have entered a new class (E) and have left the original class (L) at the time of the second inventory. The 1960 volume or basal area of these trees can be treated in the same way as trees sold (C) or mortality (M) by a suitable adjustment to the initial growing stock (GS_{60}). Similarly the ingrowth (I) can be used to adjust the final growing stock (GS_{66}). Since a 6-year period is involved between the determination of GS_{60} and GS_{66}, all other parameters must be the volume or basal area per acre entering, leaving, dying or sold over the whole period. The growth thus calculated is divided by 6 to give a final estimate of growth per acre per annum. The following estimates of growth have been made:

(1) Gross growth (including ingrowth): GGii

$$GGii = GS_{66} - (GS_{60} - M - C - L + E)$$

(2) Gross growth (initial volume): GG

$$GG = GS_{66} - I - (GS_{60} - M - C - L + E)$$

(3) Net growth (including ingrowth): NGii

$$NGii = GS_{66} - (GS_{60} - C)$$

(4) Net growth (initial volume): NG

$$NG = GS_{66} - I - (GS_{60} - C)$$

(5) Net increase: NI

$$NI = GS_{66} - GS_{60}$$

These different growth rates are given in Table 5.

The gross growth including ingrowth (GGii) is a measure of performance of the complete management system, and the useful growth is 1.11 m^3/ha per annum. Gross growth of initial volume (GG, which excludes ingrowth) is synonymous with survivor growth and is the best measure of the growth performance of the original stand in 1960, with a growth of 0.96 m^3. Net growth (NGii) adjusts the calculation for trees actually sold, but regards all other mortality, including rejects and fire-killed trees amongst others, as a growth loss. The useful net growth of 0.54 m^3 is therefore considerably lower and can be compared with the allowable cut (sawlogs and poles) for the forest of 0.43 m^3.

While the gross growth of the useless volume is a considerable 0.31 m^3/ha per annum, the various cultural operations and other causes of mortality have been successful in achieving a net decrease in the useless volume of 0.33 m^3 per annum.

While all of these growth calculations are valid it is stressed that gross growth of initial volume (or survivor growth) is the real increment of the surviving trees.

Vanclay (1977) carried out a similar growth analysis to that of Curtin, using the results of a series of CFI plots established on Pine Creek S.F. by the Australian National University. These plots identified four types on the forest - two of Blackbutt, Flooded Gum, and Mixed Hardwoods. The last of these was essentially Dry Coastal Hardwood in its more mesic phase.

Diameter increments for the species occurring in the Mixed Hardwoods type are given in Table 4: these relate to these species over the forest as a whole, not just in the Mixed Hardwoods type, though the three characteristic Dry Coastal Hardwood species occur chiefly in this type. All species tend to show better growth at Pine Creek than they do at Yarratt, and this reflects the better growing conditions at Pine Creek that would include some of the State's best Dry Coastal Hardwood stands.

Table 5

FOREST GROWTH - DRY COASTAL HARDWOOD STANDS (m^3/ha)

(see text for explanation)

State Forest	Yarrat			Pine Creek
Source	Curtin, 1970b			Vanclay
Category	**Useful**	**Useless**	**Total**	**Mixed Hardwoods (Total)**
GS1	39.2	32.1	71.1	87.0
GS2	41.6	30.1	71.7	98.5
Net increase	2.4	-2.0	0.4	11.5
Period of measure	6 yrs	6	6	10
Annual increase	0.40	-0.33	0.07	1.15
Cut/annum	0.15	0.12	0.27	0.7
Mortality, other removals	0.06	1.05	1.11	0.8
Total Drain	0.21	1.17	1.38	1.5
Ingrowth	0.16	0.04	0.19	0.9
Net increase: NI	0.19	-0.34	0.05	1.15
Net Growth (init. vol.): NG	0.39	-0.29	0.13	0.95
Net Growth (incl. ingrowth): Ngii	0.54	-0.21	0.33	1.85
Gross Growth (init. vol.): GG	0.36	0.27	1.24	1.76
Gross Growth (incl. ingrowth) : Ggii	1.11	0.31	1.43	2.66

Volume growth, calculated in the same ways as by Curtin, is included in Table 5 for the Pine Creek Mixed Hardwoods type: the figures are comparable with Curtin's 'Total" column. Again the improved growing conditions of Pine Creek are clearly shown, even though Vanclay comments that *"production of Mixed Hardwoods is appallingly low":* by comparison, Vanclay calculated the GGii of the Flooded Gum type to be 4.1 m^3/ha/an, and of the Blackbutt types about 3.7 m^3.

Curtin (1970a) has also given details of diameter growth in a plot on Wyong S.F., measured over a period of 45 years (1917 to 1962): the plot would primarily be classed as Dry Coastal Hardwood type. When established the plot carried a mixed regrowth stand with an average DBH of about 20cm. Average species growth is shown in Table 4, split between different measurement periods. Growth rates over the whole 45 years are very similar to those for Yarratt.

Studies on growth in somewhat similar stands have been conducted in Queensland (Grimes, 1978; Fisher, 1978; Grimes and Pegg, 1979). Features from these studies include:

- Diameter growth rates comparable with those found for Yarratt S.F.

- In general, little variation in diameter growth over the range 10 to 50cm DBH, but with a tendency to decrease with increasing size. However Fisher's results showed a reverse trend of increasing increment with size.

- Undergrowth removal in (Queensland) Grey Ironbark stands on Benarkin S.F. led to improved growth in the overstorey, apparently reflecting the inhibitory effects of the dense understorey that has developed with improved fire control.

- Volume increments of 0.76 to 1.15 m^3/ha/an recorded in the Maryborough Spotted Gum-Ironbark stands, and about double these values at Benarkin S.F.

For the Victorian Box-Ironbark stands, Newman (1961) has reported average diameter increments of about 0.6 cm a year on even-aged stands up to 60 years, the rate exceeding 1cm a year in the younger stages but dropping to about 0.25 cm a year at age 60. Volume production averaged about 1.6 m^3/ha/an for stands of Western Grey Box or Yellow Gum, and about 1.2 m^3/ha for the thicker barked and less tall Red Ironbark.

Some studies have also been carried out on even-aged stands of Dry Coastal Hardwood species in N.S.W. - mostly from planting, and in one study in regrowth following a severe fire. Details from selected plots are summarised in Table 6. As expected, growth rates tend to be better than those in the irregular stands, but apart from Gympie Messmate, which has shown excellent growth on some (though not all) Dry Coastal Hardwood types, the results do not suggest that planting has much future on these sites. However there would seem to be scope for enrichment with Gympie Messmate in some circumstances.

Table 6
GROWTH OF EVEN-AGED DRY COASTAL HARDWOOD STANDS

Location	Age (yrs)	Stems/ ha	BA m^2/ha	Mean DBH (cm)	Mean Dom Ht.	Vol m^3/ha	MAI	Notes
Grey Gum								
Girard S.F.	27	964	25.8	17.8	21	93	3.4	(1)
Grey Ironbark								
Tamban S.F.	26	1264	23.7	14.6	18	55	2.1	(2)
Tamban S.F.	26	714	19.2	17.8	19	55	2.1	(3)
Wallaroo S.F.	37	977	29.0	18.3	27	145	3.9	(4)
Red Mahogany								
Tamban S.F.	26	1184	25.5	15.5	23	94	3.6	(5)
Tamban S.F.	26	632	26.8	23.0	25	167	6.4	(6)
Kiwarrak S.F.	37	1372	33.5	16.2	25	130	3.5	(7)
Kiwarrak S.F.	37	1112	37.1	19.7	24	166	4.5	(8)
Gympie Messmate								
Maria River S.F.	28	417	41.3	32.6	27	-	-	(9)
Doubleduke S.F.	25	823	49.3	26.7	29	-	-	(10)
Doubleduke S.F.	25	494	9.8	14.9	11	-	-	(11)

Notes:
(1) Natural regrowth of Grey Gum and New England Blackbutt following a fire in 1946. Mean DBH of Grey Gum at age 27 was 16.4cm, and New England Blackbutt, 19.5cm. Largest 100 stems/ha had mean DBH of 25.2cm.
(2) Planted 1947, unthinned.
(3) Planted 1947, thinned before age 15.
(4) Planted 1940 on abandoned farmland; seed from Mt. Lindsay S.F. Mean DBH of largest 100 stems/ha = 28.7cm.
(5) Planted 1947, unthinned. Mean DBH of largest 100/ha = 24.5cm.
(6) Planted 1947, thinned before age 15. Mean DBH of largest 100/ha = 26.3cm.
(7) Planted 1940, unthinned. Mean DBH of largest 100/ha = 30.5 cm.
(8) Planted 1940, lightly thinned before age 10. Mean DBH of largest 100/ha = 30.8cm.
(9) Planted stands; seed probably originally from near Gympie.
(10) Good site.
(11) Poor site.

7.4 Size and Longevity

Trees of the Dry Coastal Hardwood types are not normally of very large stature, but nonetheless some of the species typical of these types can reach considerable size on favourable sites. Some of the more outstanding specimens recorded from State Forests are listed in Table 7.

As indicated from Curtin's Yarratt study in the previous Section, a period in the order of 150-200 years is likely to be needed to grow stems of 60cm DBH on typical Dry Coastal Hardwood sites. On more favourable sites, this period could be reduced to 100-150 years. On the basis of such growth rates, some of the larger stems in Table 7 could be between 500 and 1 000 years old. Radio-carbon dating of the heartwood of some of the larger specimens would be instructive.

Table 7
OUTSTANDING SPECIMENS IN DRY COASTAL HARDWOOD STANDS

Location	Height (m)	DBH (m)	Notes
Apple, Smoothbarked			
Nerong S.F.	37	3.14	
Dampier S.F.	37	0.86	Vol 7.9 m³
Bloodwood , Red			
Burrawan S.F.	60	4.75	(1)
Box, Coastal Grey			
Bodalla S.F.	56	1.46	Vol 28.1 m³
Box, Rudders			
Kiwarrak S.F.	49	1.47	
Gum, Northern Grey			
Tooloom Scrub F.R.	37	1.62	
Gum, Smallfruited Grey			
Burrawan S.F.	40	0.93	Very good form
Ironbark, Northern Grey			(3)
Mebbin S.F.	56	1.72	(2) Vol 42 m³
Beaury S.F.	48	1.69	
Wild Cattle Creek S.F.	51	1.94	Vol m³
Ironbark. Southern Grey			
Mistake S.F.	48	1.68	
Ingalba S.F.	50	1.60	(4)
Mahogany, Narrowleaved White			
Ingalba S.F.	61	1.45	
Strinqybark, White			
Queens Lake S.F	43	0.99	
Woollybutt			
Bega District	55		(5)

Notes: (1) "Old Bottlebutt." This tree has a curiously swollen base; the diameter at a height of 3m is reduced to 2.86m.

(2) "Tom Caddells Tree". Tom Caddell was forester at Murwillumbah from 1940 to 1961. After his death in 1961 his ashes were scattered round the base of this tree, of which he had been extremely proud.

(3) These specimens are believed to be *E. paniculata*, but botanical identification needs checking.

(4) Near the base of this tree is the stumphole of a much larger Ironbark, probably 3-4.5m DBH.

(5) Tree referred to by Maiden (1917), who also mentions accounts of trees 2.5 to 3m in diameter at Wyong, and up to 45m tall and 1.5m DBH at Moruya.

8. DAMAGE TO OLDER STANDS

Curtin (1970b) has provided a breakdown of the loss of trees from various causes in the CFI plots on Yarratt S.F. Details are summarised in Table 8.

Table 8

LOSS OF STEMS - YARRATT S.F.
(from Curtin, 1970b; loss expressed as volume in m^3/ha/an)

	Merchantability Class		
Cause of Loss	**Useful**	**Useless**	**Both Classes**
Products sold	0.14	0.12	0.27
Other deliberate removal (TSI, reject trees)	0.02	0.35	0.37
Mortality from logging, TSI	0.01	0.00	0.01
Fire	0.03	0.50	0.53
Wind	0.00	0.05	0.05
Other	0.00	0.14	0.15

Mortality incidental to forest operations was insignificant at 0.01 m^3/ha, but Curtin observes that the fire mortality of 0.53 m^3/ha/an seems high for what are usually considered fire-resistant species: fortunately it was concentrated among the stems that had been classed as useless. During the 6 years of the Study, about a quarter of the forest area had been burnt by wildfire, Wind throw was also confined to the useless component, while “other” mortality resulted from a relatively few, but large, stems over 70cm DBH, again essentially all classed as useless.

As indicated above, and as with most eucalypt forests, fire tends to be the major damage agency in the Dry Coastal Hardwood forests, though its role and effects are somewhat equivocal.

On the one hand there seems little doubt that improved protection from wildfire has resulted in some areas in a spread of mesic lower value species or weeds (Never-break, Grey Myrtle, Brush Box, lantana, etc), leading to an absence of regeneration, and elsewhere to a marked thickening up of the stands, with some evidence that growth rates have been reduced in the overstorey stems (Fisher, 1978; Henry, 1961). Prescribed burning in some Queensland studies has resulted in at least a temporary increase in diameter growth, though where the mesic understorey has developed it may not be possible to burn except under extreme conditions: on such sites we may well be facing a permanent loss of Dry Coastal Hardwood area, unless very heavy treatment expenses are incurred or a severe wildfire intervenes.

Whilst Dry Coastal Hardwood species generally show considerable ability to withstand fire, fire can nonetheless damage these stems, though the effects are usually most marked in the regenerating stems (see Section 6.6). In the severe 1979 fire on Uffington S.F., defoliation occurred on trees to a height of 12m, some large trees died, and many developed dead tops and stem epicormics. Gum veins and other defects are other results of fire damage. On Yarratt S.F. Curtin was able to examine the effects of both prescribed burning and wildfire of differing intensities, occurring during the 6 year period between measurements, on diameter growth: see Table 9.

The apparent growth of trees burnt by wildfire was only about half that of unburnt stems, but Curtin notes that the fires occurred towards the end of the measurement period, so that bark loss would not have been made up: in the longer term the effects would almost certainly have been less.

In a report on the effects of light prescribed burning on the South Coast, Hoare (1982?) notes that, with scorch heights confined to 5m, stems less than 2.5cm DBH were defoliated and killed, but regenerated from coppice shoots or epicormics; stems between 2.5 and 7.5cm DBH showed minor fire scarring which was occluding; and larger stems showed no signs of fire damage except for minor surface cracking in the bark of Spotted Gum.

Table 9

EFFECTS OF FIRE ON DIAMETER GROWTH - YARRATT S.F. (PAI in cm)
(from Curtin, 1970b)

Fire Intensity	Dominant Stems	Suppressed Stems	Total
Unburnt	0.38	0.28	0.33
Prescribed Burning	0.30	0.23	0.28
Wildfire - Light	0.33	0.25	0.28
Moderate	0.25	0.15	0.20
Severe	0.13	- 0.02	0.05
All Wildfire	0.20	0.10	0.15

A study on a typical Grey Gum-Ironbark type on Ballengarra S.F. showed initial (equilibrium?) fuel weights of about 12.6t/ha. Reduced to about 3t/ha by prescribed burning, the fuel weights rose to about 8t/ha in two years (Forestry Commission of N.S.W, 1971 and '72; 1973 and '74b). Similar studies on a Spotted Gum-Ironbark type at Yarratt S.F. showed an initial weight of 9.5 t/ha, reduced to about 4.5t/ha and recovering close to the initial level within 3 years of the prescribed burn.

As a general rule, prescribed burning on a fairly regular basis appears to be a desirable measure in Dry Coastal Hardwood types, both to minimise wildfire damage and to maintain the productivity of the eucalypt component. Where coppice regeneration is relied upon, burning should be delayed for 3 or 4 years after harvesting to allow the coppice to reach a size where it can withstand fire. (However in some localities, e.g.near Cessnock, such a fire-free period may be more than is normally granted.)

Climatic influences can damage Dry Coastal Hardwood stems. Curtin showed a small mortality due to wind damage at Yarratt S.F. (Table 8), and in addition recorded 0.2 per cent of useful stems and 1.5 per cent of useless stems showing signs of wind damage. Drought is probably a more significant cause of damage, increasing the severity of wildfires, reducing growth (see Section 7.3, concerning effects on the Yarratt plots), and sometimes leading to the death or dieback of trees growing in sites most affected by the dry conditions. In studies on the effects of drought in dry tableland forests it has been shown that, although most stems survived, trees visibly affected by severe dry conditions suffered considerable degrade and were particularly prone to subsequent attack by longicorn beetles (Cremer, 1966; Pook and Forrester, 1984). Similar effects appear to apply to Dry Coastal Hardwood.

The types can also suffer from insect attack. Psyllids can infest a wide range of Dry Coastal Hardwood eucalypts, causing debilitation where the attack continues. Infestations of psyllids on Grey Ironbark on Ourimbah S.F. are nearly always associated with Bellbird colonies, which appear to help maintain the attack (e.g. Loyn et al., 1983), and are often also associated with dense Neverbreak understorey, which probably reduces the vigour of the eucalypts. Local areas may sometimes be defoliated (e.g. caterpillar attack on Kiwarrak S.F. during drought), but this is unusual.

Termite damage to trees is not uncommon, though the incidence is variable. Greaves (1959, 1962) records Grey Gum as not being attacked by *Coptotermes acinaciformis* when growing amid a number of infested trees on Pine Creek S.F., but as being attacked in a similar situation on Tabbimoble S.F., where other infested trees included Broadleaved Ironbark, Red Mahogany, Spotted Gum and White Mahogany. On Wollomba S.F. Grey Box is very prone to termite damage, to the extent that it can rarely be used for sawlogs or poles, while in the Coffs Harbour Management Area fungal attack is a more significant cause of stem defect in Grey Gum than is termite attack. Failures of durable Dry Coastal Hardwood poles in the Sydney district have been attributed to *Glyptotermes brevicornis* (and occasionally *G. tuberculatus*) infestations, in association with the fungal degrade which is always present with this termite. The termite has been found to occur in living trees of Tallowwood, White Mahogany and occasionally Grey Gum, and the infestations are usually close to the butt or less commonly near branch stubs. In many cases infestation appears to be directly related to butt wounds incurred during previous harvesting operations (Forestry Commission of N.S.W., 1979 and 1980).

Stem borers are also not uncommon as a cause of defect in logs.

As discussed above, the development of a dense understorey can act as weeds, adversely affecting tree growth. Native Cherry is common in many Dry Coastal Hardwood stands, and as a root parasite presumably has some retarding effect on the growth of its hosts. Mistletoes are often present, but seldom appear to be of major significance.

9. PRESERVATION

The Dry Coastal Hardwood types are widely distributed through the coastal and escarpment forest districts of N.S.W, and examples of them are to be found in many of the national parks located in these districts.

They are also represented in a large number of areas specifically preserved by the Forestry Commission, and the more significant of these sites, covering 22 Flora Reserves (total area 5 800 ha) and 9 Forest Preserves (area 4 100 ha), are listed and briefly described in Appendix 4.

The trees listed in Table 7, and occurring on State Forest, have also been preserved for their lifetime.

10. MANAGEMENT ASPECTS

10.1 Objectives

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

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

Most of the Dry Coastal Hardwood stands of commercial significance tend to be among "the accessible forests of the coastal plain", and the policy requirements in general meet the silvicultural needs of these stands, although in most cases the emphasis in management is less towards sawlog production than towards the supply of other products.

10.2 Management Practices and Problems

The Dry Coastal Hardwood types are among the less productive of the main commercial forest types of the coastal and tableland districts, although some of the more mesic forms probably have a moderately high productive capacity. The low production is balanced by their occurrence over extensive areas throughout most coastal and escarpment forest districts, and many of their timbers have been well regarded as durable hardwoods throughout much of the period of European settlement, and have considerable potential for decorative purposes.

The stands are usually managed on an extensive selection system, which appears adequately to suit their needs, with some areas managed for small-wood production under a form of coppice selection. Whilst suitable markets can absorb most product, occasional culling is likely to be required under either system in order to reduce the inevitable build up of unsaleable trees, while retaining those needed for habitat or other environmental purposes. (In some areas large Bloodwood trees are specifically retained as providing both a valuable honey source and numerous nesting or den hollows.) Periodic prescribed burning seems desirable not only as a protection measure, but to avoid the development of excessively dense stands and in some cases the invasion of a mesic understorey, either of which appears to reduce overstorey growth and vigour, and the latter of which can prevent regeneration establishment - a condition that on present knowledge can be rectified in a controlled manner only at great expense. Usually, however, regeneration is readily obtained either from release of an existing lignotuber pool or from coppice. Some of the more common species are comparatively tolerant in their younger stages, and can assume active growth in smaller openings than are needed by most eucalypts.

Blueleaved Stringybark and, to a lesser extent, some other species have been successfully planted into some mesic Dry Coastal Hardwood sites. Otherwise there seems little scope for the artificial regeneration of Dry Coastal Hardwood species, nor for the artificial regeneration by other species of Dry Coastal Hardwood sites, except possibly for some enrichment with Gympie Messmate, which seems well suited to many Dry Coastal Hardwood sites in N.S.W. and which would be a valuable added component to these stands.

While there is a continued yield of sawlogs from most Dry Coastal Hardwood stands, management usually concentrates on other products benefiting from the durability of the timbers and harvested at smaller sizes than most sawlogs.

10.3 Further Research

To a greater extent than any of the other major forest types in N.S.W., research into the silviculture of the Dry Coastal Hardwood types remains very much an open book. Except in the field of growth and stand dynamics (Section 7), little organised research has been conducted into these types. Aspects where studies seem particularly desirable include:

- Factors determining the occurrence of Dry Coastal Hardwood types, and particularly separating them from Spotted Gum types.
- The extent, recruitment and behaviour of the lignotuber pool in Dry Coastal Hardwood stands.
- The control of dense undergrowth in some stands, apparently as a result of changed burning patterns.
- Following the 1970 suggestions of R.A. Curtin, various aspects of the local coppice selection system, including growth and efficiency compared with traditional even-aged coppice; desirable treatment of the coppice stands with respect to stocking, release and the effects of coppice on crop stems and vice versa; and the relationship between previous tree quality and coppice quality from the same stump.

- Long-term nutrient availability for coppice stands on low quality sites.

The list could be easily extended, but these are items that should receive some priority.

11. ACKNOWLEDGEMENTS

These Notes are largely based on the experience of many foresters working with Dry Coastal Hardwood types in virtually all the coastal districts of N.S.W., and the compilers of these Notes gratefully acknowledge their debt to all who so freely have made available their accumulated knowledge and experience. There is less published information than has been available for previous Notes, but mention must be made of the outstanding work carried out and recorded by Dr. R.A. Curtin on the growth of these types and, once more, on the reports prepared by various officers of the Queensland Department of Forestry. Finally, special thanks are due to those who read and so constructively commented on an earlier draft of these Notes. They include:

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Appendix 1

PLANT SPECIES MENTIONED IN TEXT

Common Name	Botanical Name
Apple, Broadleaved	Angophora subvelutina AAABA
Roughbarked	A. floribunda AAABB
Smoothbarked	A. costata AAADA
Ash, Silvertop	Eucalyptus sieberi NAKED
Bangalay	E. botryoides SECD
Beech	Fagus sylvatica
Blackbutt	Eucalyptus pilularis MAIAAA
, New England	E. andrewsii ssp. campanulata MATHDB
Bloodwood ,Pink	E. intermedia CAFID
Red	E. gummifera CAPUF
Box, Brush	Lophostemon confertus
Coastal Grey	Eucalyptus bosistoana SUNCA
Craven Grey	E. largeana SUDAA
Grey	E. moluccana SUL:B
Rudders	E. rudderi SUT:A
Steel	E. rummeryi SUAAA
Western Grey	E. woollsiana ssp. microcarpa SUL:DB
White	E. albens SUL:G
Whitetopped	E. quadrangulata SPIHA
Yellow	E. melliodora SUX:A
Cherry,Native	Exocarpos cupressiformis
Clematis	Clematis sp
Devil's Twine	Cassytha sp.
Gum, Forest Red	Eucalyptus tereticornis SNEEB
Grey	E. punctata, also general name for related species
Largefruited Grey	E. punctata ssp. canaliculata SECEDC
Mountain	E. dalrympleana SPINC; also general name for certain tableland species.
Northern Grey	E. punctata ssp. didyma SECEDD
Scribbly	E. haemastoma MATKA and related species
Slaty Red	E. glaucina SNEEC
Smallfruited Grey	E. propinqua SECEA
Southern Blue	E. globulus SPIFL and related species
Spotted	E. maculata CCC:B
Sydney Blue	E. saligna SECAC
Yellow	E. leucoxylon SUX:C
Ironbark, Beyers	E. beyeri SUV:E
Broadleaved	E. fibrosa asp. fibrosa SUP:AA
Grey (Northern)	E. siderophloia SUP:I
(Queensland)	E. drepanophylla SUP:E
(Southern)	E. paniculata SUV:D
Narrowleaved	E. crebra SUP:S
Red	E. sideroxylon SUX:I
Squarefruited	E. tetrapleura SUV:H
Lantana	Lantana camera
Mahogany, Broadleaved White	Eucalyptus umbra MAG:A
Narrowleaved White	E. acmenioides MAG:C
Red	E. resinifera SECCC or E.pellita SECCA
White	E. acmenioides MAG:C and related species
Mallee, Pokolbin	E. pumila SNACH
Messmate, Gympie	E. cloeziana IAA:A
Mistletoe	Amyema & related app.

Myrtle	General name for species of family Myrtaceae
, Grey	Backhousia myrtifolia
Neverbreak	Choricarpia leptopetala
Oak, Forest	Allocasuarina torulosa
Paperbark	Melaleuca sp.
Peppermint, Sydney	Eucalyptus piperita MATHA
Pine, Hoop	Araucaría cunninghamii
Scalybark	Eucalyptus squamosa SIQ:A
She-oak, Black	Allocasuarina littoralis
Stringybark, Blue leaved	Eucalyptus agglomerata MAHCG
Diehard	E. cameronii MAHEH
Thinleaved	E. eugenioides MAHEA
White	E. globoidea MAREF
Tallowwood	E. microcorys SWA:A
Turpentine	Syncarpia glomulifera
Wattle, Bodalla	Acacia silvestris
Wonga Wonga (Vine)	Pandorea pandorana
Woollybutt	Eucalyptus longifolia SECGA

Appendix 2

CLIMATIC DETAILS - DRY COASTAL HARDWOOD SITES
(Adapted from Hall. 1972)

Note: Hottest month is January unless otherwise stated; coldest month is July.

URBENVILLE: **Lat** 28.5°S **Long** 152.5°E **Altitude** 370m

Rainfall (mm)

Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Total
152	**158**	**157**	**67**	**57**	**85**	**57**	**40**	**40**	**74**	**75**	**120**	**1082**

Lowest Annual: 635 mm   Highest Annual: 1649 mm

Temperature

Hottest Month: Mean Min : 16.5° (Feb)   Mean Max: 29.0° (Dec)
Coldest Month: Mean Min: 2.6°   Mean Max: 17.0°
Highest recorded: 42.8°   Lowest recorded: -8.0°
No. over 32°C: 23 days   Over 38°C: 1 day
Av. No. Frosts/ year: 26   Ave frost free period: 239 days

GIRARD S.F.: **Lat** 28.9°S **Long** 152.3°E **Altitude** 760m

Rainfall (mm)

Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Total
195	208	200	90	73	81	85	51	53	88	99	164	1387

Lowest Annual: 639 mm   Highest Annual: 2424 mm

Temperature

Hottest Month: Mean Min : 14.8° (Feb)   Mean Max: 26.2° (Feb)
Coldest Month: Mean Min: 2.0°   Mean Max: 15 °

COFFS HARBOUR: **Lat** 30.3°S **Long** 153.1°E **Altitude** 21m

Rainfall (mm)

Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Total
164	211	242	191	144	124	96	77	70	95	104	140	1658

Lowest Annual: 685 mm   Highest Annual: 3376 mm

Temperature

Hottest Month: Mean Min : 18.8° (Feb)   Mean Max: 26.7° (Feb)
Coldest Month: Mean Min: 6.5°   Mean Max: 18.5°
Highest recorded: 43.3°   Lowest recorded: -3.5°
No. over 32°C: 14 days   Over 38°C: less than 1 day

KEMPSEY: **Lat** 31.1°S **Long** 152.8°E **Altitude** 9m

Rainfall (mm)

Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Total
126	144	144	118	88	95	79	71	61	72	86	104	1190

Lowest Annual: 497 mm   Highest Annual: 2357 mm

Temperature

Hottest Month: Mean Min : 17.4° (Feb)   Mean Max: 29.2°
Coldest Month: Mean Min: 0.5°   Mean Max: ? °
Highest recorded: 46.5°   Lowest recorded: -7.5°
No. over 32°C: 19 days   Over 38°C: 2 days
Av. No. Frosts/ year: 4   Ave frost free period: 193 days

CESSNOCK: **Lat** 32.8°S **Long** 151.3°E **Altitude** 12m

Rainfall (mm)

Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Total
72	81	73	69	59	63	52	42	44	53	57	78	742

Lowest Annual: 353 mm   Highest Annual: 1390 mm

Temperature

Hottest Month: Mean Min : 17.0° (Feb)   Mean Max: 30°
Coldest Month: Mean Min: 4 °   Mean Max: 17.3°
Highest recorded: 46°   Lowest recorded: -6°
No. over 32°C: 41 days   Over 38°C: 7 days
Av. No. Frosts/ year: 14   Ave frost free period: 248 days

MORUYA HEADS: **Lat** 35.9°S **Long** 150.1°E **Altitude** 17m

Rainfall (mm)

Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Total
99	88	106	85	88	86	61	54	62	72	68	75	943

Lowest Annual: 500 mm   Highest Annual: 1823 mm

Temperature

Hottest Month: Mean Min : 16 ° (Feb)   Mean Max: 24° (Feb)
Coldest Month: Mean Min: 5.8°   Mean Max: 15°
Highest recorded: 44°   Lowest recorded: 0°
No. over 32°C: 4 days   Over 38°C: 1 day
Ave frost free period: 258 days

BEGA: **Lat** 36.7°S **Long** 149.8°E **Altitude** 15m

Rainfall (mm)

Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Total
86	89	92	68	78	90	59	54	53	66	59	81	876

Lowest Annual: 401 mm   Highest Annual: 1834 mm

Temperature

Hottest Month: Mean Min : 14° (Feb)   Mean Max: 27 °
Coldest Month: Mean Min: 1.2°   Mean Max: 16.8°
Highest recorded: 47°   Lowest recorded: -7°
No. over 32°C: 14 days   Over 38°C: 2 days
Av. No. Frosts/ year: 31   Ave frost free period: 206 days

Appendix 3

PROPERTIES OF MAJOR TIMBER SPECIES: DRY COASTAL HARDWOOD TYPE
(Derived from K. R. Bootle: 'Wood in Australia')

Abbreviations: L-S, Lyctid susceptible; G, green; ADD, air-dried (re density)

Common Name	Blackbutt New England	Bloodwood, Red	Box, Grey	Box, Coastal Grey
Botanical Name	Eucalyptus andrewsii ssp. campanulata	Eucalyptus gummifera	Eucalyptus moluccana	Eucalyptus bosistoana
General Properties	Pale brown; paler sapwood. Medium even texture. Straight grain.	Dark pink to red. Coarse texture. Grain often interlocked. Usually concentric gum veins	Pale yellowish-brown. Fine, even texture. Interlocked grain. Seldom with gum veins.	Pale brown. Occasional pink tinge. Fine, even texture. Interlocked grain. Very similar to Grey Box.
Density kg/m³	GD:1150 ADD:930	GD:1140 ADD:900	GD:1170 ADD:1120	GD:1180 ADD:1100
Durability	2 - 3 L - S	1 L- S	1 Rare lyctid attack	1 L – S
Strength	S3	S3	S2	S1
Sawlog Group	B	D	A	A
Uses	General construction	Because of gum veins usually only used in round-poles, piles, and posts. Suitable for decorative panelling. Not accepted for woodchips on North Coast.	Heavy engineering construction. Poles piles sleepers.	Heavy engineering construction. Poles, piles sleepers.
Other Notes	Slight collapse in drying.	Little movement in drying; but gum veins may open.	Slow in drying, but not subject to surface checking. Difficult to work because of density.	Slow in drying. Satisfactory for steam bending.

PROPERTIES OF MAJOR TIMBER SPECIES: DRY COASTAL HARDWOOD TYPE
(Derived from K. R. Bootle: 'Wood in Australia')

Abbreviations: L-S, Lyctid susceptible; G, green; ADD, air-dried (re density)

Common Name	Box, Steel	Gum, Grey	Gum, Spotted	Ironbark, Broadleaved
Botanical Name	Eucalyptus rummeryi	Eucalyptus propinqua, punctata	Eucalyptus maculata	Eucalyptus fibrosa ssp. fibrosa
General Properties	Pale brown. - very similar to Grey Ironbark. And with similar properties.	Red, coarse, even texture. Interlocked grain. Similar to Ironbarks, but often with grub holes.	Pale to dark brown wide sapwood. Moderately coarse texture. Grain variable, sometimes fiddleback. Slightly greasy. Gum veins common.	Dark red, texture coarse and even. Grain often interlocked.
Density kg/m³	GD:1300 ADD:1130	GD:1170 ADD:1080	GD:1150 ADD:950	GD:1210 ADD:1140
Durability	Sapwood not S2. lyctid susceptible	1 Resistant to lyctid attack	2 - 3 L- S	1 usually Resistant to lyctid attack
Strength	S2	S1	S2	S1
Sawlog Group	A	C	B	A
Uses	Girders, poles.	Heavy engineering construction. Poles, sleepers.	Heavy engineering construction. Piles, poles, shipbuilding, flooring, plywood. Main Aust. sp. For handles subject to impact forces.	Heavy engineering construction. Poles, sleepers, flooring, bridge construction.
Other Notes		Slow drying. Difficult to work when dry.	Care in drying to avoid some checking. Not hard to work. Suitable for steam bending if straight grained.	Slow drying; care needed to avoid checking. Hard to work but attractive appearance.

PROPERTIES OF MAJOR TIMBER SPECIES: DRY COASTAL HARDWOOD TYPE
(Derived from K. R. Bootle: 'Wood in Australia')

Abbreviations: L-S, Lyctid susceptible; G, green; ADD, air-dried (re density)

Common Name	Ironbark, Grey	Ironbark, Narrowleaved	Ironbark, Red	Mahogany, Red
Botanical Name	Eucalyptus paniculata, siderophloia	Eucalyptus crebra	Eucalyptus siderophloia	Eucalyptus resinifera, pellita
General Properties	Variable heartwood colour - pale brown, dark chocolate, dark red. Texture coarse and even. Grain usually interlocked. Fine appearance, but too difficult to work for some species.	Dark red, texture medium, even. Grain interlocked.	Dark red, texture medium, even. Grain interlocked.	Dark red, texture medium, even. Grain slightly interlocked. Often shown pin-holes (Ambrosia)
Density kg/m³	GD:1210 ADD:1120	GD:1160 ADD:1090	GD:1220 ADD:1130	GD:1150 ADD:950
Durability	1 usually Resistant to lyctid attack	1 usually Resistant to lyctid attack	1 Rarely attacked by lyctids	2 L- S
Strength	S1	S1	S1	S2
Sawlog Group	A	A	A	B
Uses	Heavy engineering construction. Poles, sleepers, flooring, decking, ship building.	Heavy engineering construction. Poles, sleepers, wharfage.	Heavy engineering construction. Poles sleepers, etc.	Flooring, cladding, panelling, general construction, sleepers, poles.
Other Notes	Slow drying; care needed to avoid checking. Hard to work because of density.	Slow to dry. Hard to work.	Slow to dry. Care needed to avoid checking. Hard to work.	Dries with little degrade if carefully stacked. Relatively easy to work. Takes paint well.

PROPERTIES OF MAJOR TIMBER SPECIES: DRY COASTAL HARDWOOD TYPE
(Derived from K. R. Bootle: 'Wood in Australia')

Abbreviations: L-S, Lyctid susceptible; G, green; ADD, air-dried (re density)

Common Name	Mahogany, White	Messmate, Gympie	Peppermint, Sydney	Stringybark, White
Botanical Name	Eucalyptus acmenioides	Eucalyptus cloeziana	Eucalyptus piperita	Eucalyptus globoidea
General Properties	Yellow- brown. Texture medium, even. Grain usually interlocked. Sometimes has wood-moth holes or water rings, but gum veins not common.	Yellow- brown. Texture medium, even. Grain may be slightly interlocked.	Light brown. Moderately coarse texture. Straight grained.	Pale brown, pinkish tint. Texture medium. Grain often interlocked.
Density kg/m³	GD:1200 ADD:1000	ADD:1000	GD:1050 ADD:770	GD:1100 ADD:820-900
Durability	1 Resistant to lyctid attack	Durable. Resistant to lyctid attack	3 L- S	Moderately durable. Resistant to lyctid attack
Strength	S2	S2	S3	S3
Sawlog Group	C	-	D	B
Uses	Heavy engineering construction. Poles, sleepers, shipbuilding. Not a good fuel.	General construction. Poles, sleepers, bridges etc.	General construction where shrinkage can be tolerated. Well regarded for mining timber.	Building framework, preservative treated poles and posts.
Other Notes	Slow to dry.	Easy to dry. A Qld species sometimes planted in DCH types.	Liable to distortion and collapse in seasoning.	Needs careful drying with some collapse.

PROPERTIES OF MAJOR TIMBER SPECIES: DRY COASTAL HARDWOOD TYPE
(Derived from K. R. Bootle: 'Wood in Australia')

Abbreviations: L-S, Lyctid susceptible; G, green; ADD, air-dried (re density)

Common Name	**Tallowwood**	**Turpentine**	**Woollybutt**
Botanical Name	Eucalyptus microcorys	Syncarpia glomulifera	Eucalyptus longifolia
General Properties	Yellowish brown with tinge of olive green. Grain often interlocked. Greasy feel. Complete absence of gum veins. May have water rings, pin-holes marks.	Reddish-brown. Texture fine, even. Grain interlocked. No gum veins	Red, texture medium, even. Grain usually interlocked. Dressed surface often with waxy sheen.
Density kg/m³	GD:1230 ADD:990	GD:1110 ADD:930	GD:1120 ADD:930
Durability	Very durable L- S	Very durable. Not lyctid susceptible Very resistant to marine borers	Durable L- S
Strength	S2	S3	S3
Sawlog Group	A	D	C
Uses	Heavy engineering structures, sleepers, bridges, wharfage, flooring, cladding, sills, crossarms, poles, piles, cooling towers.	Marine piling (usually with bark on), poles, sleepers, shipbuilding, wharf and bridge decking, bearings, flooring, panelling, building framework. Not accepted for woodchips on North Coast.	Building framework, sleepers, poles, and posts.
Other Notes	Slow in drying Fairly easy to work. Problem gluing. Moderately suitable for stress bending.	Slow in drying and some collapse. High silica content blunts tools. Suitable for steam bending. Hard to glue. Not suitable for charcoal.	Slight collapse in drying.

Appendix 4

FORESTRY COMMISSION PRESERVED AREAS CARRYING DRY COASTAL HARDWOOD TYPES

Tooloom Scrub Flora Reserve No. 62253. Beaury S.F. 1 420 ha (including proposed Rockhill Creek extension, currently Forest Preserve No. 210). Contains good examples of a number of DCH types, including Grey Gum-Ironbark- White Mahogany, Forest Red Gum-Grey Gum-Grey Ironbark-Roughbarked Apple, Grey Box, Grey Box-Northern Grey Gum and Grey Box-Forest Red Gum types, together with moist eucalypt and rainforest types.

Bruxner Park P.R. No. 73036. Orara East S.F. 407 ha. Typical ridge - top examples of Grey Gum-Grey Ironbark type.

Sugar Creek P.R. No. 79958. Wallingat S.F. 85 ha. Includes White Mahogany-Red Mahogany-Grey Ironbark-Grey Gum type.

O'Sullivans Gap P.R. No. 79966. Bulahdelah and Wang Wauk S.F. 320 ha. Good ridge-top stands of White Mahogany-Grey Gum-Grey Ironbark type are present.

Glenugie Peak P.R. No. 79972. Glenugie S.F. 105 ha. Areas of Broadleaved Ironbark on the broad flats and of Narrowleaved Ironbark, with unusually eastern occurrence of Yellow Box, on the slopes of the Peak. Also contains an occurrence of the rare Squarefruited Ironbark E. tetrapleura).

Edwards Plain P.R. No. 79976. Wild Cattle Creek S.F. 35 ha. Same Grey Ironbark stands present.

Tulipwood P.R. No. 79988. Kangaroo River S.F. 60 ha. Dry rainforest communities with DCH types, including Steel Box and Grey Box-Grey Ironbark types.

Brysons P.R. No. 79992. Myall River S.F. 18 ha. Mostly Broadleaved White Mahogany type on steep slope.

Diggers Hill P.R. No. 80000. Queens Lake S.F. 40 ha. Grey Gum-Stringybark type giving way to Paperbark flats.

Madmans Creek P.R. No. 80001. Conglomerate S.F. 92 ha. Very mixed composition, including Steel Box type.

Wallaroo P.R. No. 80008. Wallaroo 8.7. 28 ha. Grey Ironbark type, associated with Spotted Gum and Paperbark communities.

Cambridge Plateau P.R. No. 80009. Richmond Range S.F. 870 ha. Includes Forest Red Gum-Grey Gum-Roughbarked Apple type on slopes of basalt plateau.

Mallanganee P.R. No. 80013. Cherry Tree North S.F. 222 ha. Ridge-top areas of Narrowleaved Ironbark included in this primarily dry rainforest Reserve.

Rudders Box P.R. No. 80014. Kiwarrak S.F. 31 ha. Typical spectrum of Grey Gum-Grey Ironbark-White Mahogany types, with populations of the localised Rudders Box (E. rudderi).

Tirrill Creek P.R. No. 80016. Bulga S.F. 187 ha. Takes in small area of White Mahogany-Grey Gum and New England Blackbutt types in moist phases.

Pokolbin P.R. No. 80019. Pokolbin S.F. 90 ha. Area of very mixed Dry Coastal Hardwoods, with some western species present and including the rare Scalybark *(E. squamosa)* and Pokolbin Mallee *(E. pumila).*

Banda Banda P.R. No. 80020. Mt. Boss and Yessabah S.Fs. 1 400 ha. Includes significant area of Broadleaved White Mahogany type.

Steel Box P.R. No. 80022. Mt. Pikapene S.F. 20 ha. Fine stand of Steel Box type, with associated dry rainforest.

Black Creek P.R. No. 80023. Lame S.F. 73 ha. Reserve containing a range of local forest types, including White Mahogany-Grey Gum-Grey Ironbark type.

Richters Caves P.R. No 80026. Ourimbah S.F. 22 ha. Sandstone area carrying Grey Gum-Greylronbark-White Mahogany type on upper slopes.

Selection Flat P.R. No. 97529. Myrtle S.F. 140 ha. Includes areas of Grey Box-Ironbark and Forest Red Gum-Grey Gum-Roughbarked Apple types, and contain the restricted Slaty Red Gum *(E. glaucina)*

Bago Bluff P.R. No. 97531. 132 ha. Stands of Grey Gum-Grey Ironbark type are included.

38. Forty Spur F.P. Mebbin S.F. 8 ha. Association of Grey Ironbark and Hoop Pine over dry rainforest, with White Mahogany and Pink Bloodwood present: typical of much of Mebbin S.F.

39. Acacia Plateau F.P. Koreelah S.F. 618 ha. Mostly rainforest, but includes areas of Forest Red Gum-Grey Gum/Grey Ironbark-Roughbarked Apple type.

67. Silvestris F.P. Bodalla S.F. 21 ha. Open stand of Coastal Grey Box-Woollybutt type with thickets of Bodalla Wattle.

69. Tinpot F.P. Bodalla S.F. 47 ha. Contains Coastal Grey Box stands with Forest Red Gum.

174. Twelve Sixty F.P. Bagawa S.F. 305 ha. An area of very mixed composition, including Grey Gum-Grey Ironbark-White Mahogany and Steel Box types.

195. The Castles F.P. Carrai S.F. 2 420 ha. Extensive preserved area containing limestone outcrops, and including significant area of Grey Gum-Grey Ironbark-White Mahogany type.

202. Yessabah F.P. Yessabah S.F. 24 ha. Contains Dry Coastal Hardwood types with most significant occurrence of Craven Grey Box *(E. largeana)* in Macleay valley.

205. Copeland Tops F.P. Copeland Tops S.F. 264 ha. Includes Grey Gum-White Mahogany type and fine occurrence of Craven Grey Box, together with the very similar looking Whitetopped Box.

208. Captains Creek F.P. Beaury S.F. 369 ha. Stands of Grey Gum, Grey Ironbark and Grey Box adjoin areas of dry rainforest.