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

3. DRY SCLEROPHYLL ASH TYPES

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3. DRY SCLEROPHYLL ASH TYPES

1. INTRODUCTION

The Ashes are a group of fairly closely related eucalypts belonging, to the informal series Obliquae (MAK), which includes plants ranging from the world's tallest hardwood tree, Mountain Ash[1], to some of the smallest mallees e.g. Blue Mountains Mallee, Cliff Mallee Ash (Pryor and Johnson, 1971). The trees possess generally similar timbers: pale coloured, straight-grained, relatively light weight, and fissile - features which are the cause of the common name of the group, from their resemblance to those of the wood of the Northern Hemisphere *Fraxinus* spp. For Australia as a whole they are by far the major timber-producing group of eucalypts, contributing probably about 40 per cent of the volume of industrial hardwood harvested each year.

The most important species as timber producers - Mountain Ash, Alpine Ash, Brown Barrel and Messmate - are typically trees of the wet sclerophyll forests. However there are several species, including one of considerable significance in three States, more usually found ocurring in lower quality dry sclerophyll forest stands. It is these, and in particular Silvertop Ash (also known as Coast Ash, Black Ash or, in Victoria and often at Eden, Silvertop), that, with their associates, are the subject of these notes. Besides Silvertop Ash these Dry Sclerophyll Ash types include stands dominated by Blue Mountains Ash, White Ash and Yertchuk.

The types have a long history of generally low intensity use for timber, but by the late 1940's Victorian stands were being used on a substantial scale for integrated sawlog and pulpwood production (Mann, 1958). In N.S.W. interest in the Silvertop Ash types increased greatly in the late 1960's, with the establishment at Twofold Bay of a woodchip export project designed to operate largely on raw material coming from these stands; a similar development occurred in northeastern Tasmania at about the same time. The developments on the South Coast coincided with the appointment to Eden of R. G. Bridges as research forester investigating the silvicultural requirements of these and associated types, and the information in these notes in chiefly based on the results of work subsequently carried out by him.

The other dry sclerophyll Ashes are much more restricted in occurrence than Silvertop Ash, and little information relating to their silviculture appears to be available, at least in published form. However a recent thesis has thrown much light on aspects of the life cycle of Blue Mountains Ash, and in the process has demonstrated that even in the 1980's significant advances in knowledge can still be made by someone prepared to use his or her powers of observation (Glasby, 1981).

2. FOREST ECOLOGY

2.1 The Types

The main communities covered by these Notes are those clearly dominated by Silvertop Ash in the Scribbly Gum - Stringybark - Silvertop Ash League of Forestry Commission Research Note No. 17, "Forest Types in N.S.W." (Forestry Commission of N.S.W. , 1965). These types are commonly intimately associated with stands dominated by Stringybarks, so that these Stringybark types are also, to some degree, dealt with here. In addition the stands dominated by the other dry sclerophyll Ashes are also included. Consequently, the types covered by these Notes are:

112. Silvertop Ash. Silvertop Ash forms over 50 per cent of the stand, and may make up 100 per cent. A wide range of associates may be present. Stands are normally under 30m in height, but on favourable sites may exceed 40m. Widespread through Southern and Central Tablelands and Coasts districts, and particularly common on far South Coast. Often occurs along ridgetops.

[1] For botanical names, see Appendix 1.

113. Silvertop Ash - Peppermint. Narrowleaved, Broadleaved or Sydney Peppermints occur with the Ash, usually together with other associates. Similar occurrence to type 112, but rarely as well developed and usually less than 30m in height.

114. Silvertop Ash - Stringybark. Another widespread type of the South and Central Coasts and Tablelands, with the Silvertop Ash codominant with one or more species of Stringybark, including Yellow, White, Brown and Blueleaved. Height may exceed 40m, though more usually under 30m.

118. Scribbly Gum - Silvertop Ash. A minor type from the Central Coast and Tablelands. Height normally under 20m.

121. Blueleaved Stringybark. Distinctive looking stands up to 30m in height, occupying ridge sites. Common on South Coast and extending to Central Tablelands.

123. Southern Stringybarks. Types dominated by one or more different stringybarks, but particularly White Stringybark. Common on parts of South Coast, but extending to Tablelands and to Central districts. Rarely exceeds 30m.

101. Blue Mountains Ash. Common in the more sheltered sites on sandstone in the upper Blue Mountains, with heights up to 35 - 40m. Associates may include Silvertop Ash, Sydney Peppermint and Stringybarks. In older stands the Blue Mountains Ash trees tend to stand above their associates, rendering them rather prone to windblow (Glasby, 1981). Occurs also in a few upland sites on the North Coast (e.g. Mt. Boss S.F., Mt. Warning N.P.), but usually as trees of much smaller stature. Stands often possess a fairly dense understorey.

102. Yertchuk. Found on dry, shallow soils of generally low fertility on the South Coast and parts of the Central Tablelands. Height usually under 20m. Various associates may be present.

162. White Ash. Though included in the Messmate - Brown Barrel League, and considered, among others, in the Notes on the Moist Tableland Hardwood types, this type most usually occurs as a dry sclerophyll forest on exposed ridges and peaks, frequently with the White Ash occurring in pure stands though other associates, including Silvertop Ash, may be present. Found through the escarpment zone of the South Coast, and in places further back on the Tablelands (e.g. Tallaganda S.F.), and extending north to the Illawarra escarpment.

Two other related Ashes also belong in this group of types, but have such limited occurrences that interest in them is botanical rather than silvicultural, and they are not recognised as constituting distinct types in Research Note No. 17. These species are Budawang Ash, which occurs in scattered small stands around the rocky edges of scarps from near Fitzroy Falls south to Budawang National Park, and Jilliga Ash which occupies a number of ridgetop sites in Dampier S.F. and adjacent areas west of Narooma: the invariable lean on the latter tree gives its stands a most characteristic and unusual appearance.

Stands included in these Dry Sclerophyll Ash types have been the subject of vegetation studies by a number of ecologists who appear to have encountered almost uniform difficulty in deciding how to cope with them. Workers who have faced this problem include Davis (1936, 1941); Pidgeon (1937, 1941, 1942); Costin (1954); Story (1969); Hayden (1971), whose classification was largely used by Specht et al. (1974) for their coverage of N.S.W.; Austin (1978); Turner et al. (1978); and Recher et al. (1980). Some notes on these varied approaches appear in Appendix 2. There seems little consistency between these, particularly in relation to Silvertop Ash, and the main message appears to be that this species can occur with a large number of associates or alone, usually as dry sclerophyll forest though sometimes verging towards wet sclerophyll forest.

From the interstate occurrences, Felton and Cunningham (1971) have briefly discussed the stands in eastern and northeastern Tasmania. Main species present are Silvertop Ash, Messmate, Black Peppermint and Manna Gum. Messmate and Manna Gum occupy the more fertile sites and Silvertop Ash the drier sites, with the Peppermint replacing Messmate as fertility decreases. Specht et al. (1974) recognise this as a Silvertop Ash - Black Peppermint - Manna Gum Alliance. In Victoria, Ferguson (1957) recognises a widespread Sclerophyllous Stringybark - Peppermint - Gum type which, in parts of Gippsland, carries stands where Silvertop Ash and White Stringybark predominate. Specht and his colleagues term this the Silvertop Ash - White Stringybark Alliance, and it is clearly part of the same forest pattern as occurs across the border on the South Coast of N.S.W. Further details of the composition of some of these Victorian stands have been provided by Loyn et al. (1980) for Boola Boola S.F.

2.2 Fauna

Concern over the possible effects of large scale logging operations in the Silvertop Ash and related types has resulted, inter alia, in several fairly intensive studies into the fauna of these types and the effects of timber harvesting and other operations on the fauna. These studies have been reported by Recher et al. (1980) for the Eden area in N.S.W. and by Loyn et al. (1980) for Boola Boola S.F. in eastern Victoria. In both areas the studies covered a range of local forest communities, and of these, as Loyn and his colleagues state: *"... stands with a particularly high proportion of silvertop appear to be among the habitats least attractive to many species of birds and arboreal mammals."* By contrast, Yertchuk stands supported a very diverse wildlife population. Tall gully stands with Mountain Grey Gum usually provided the most valuable habitat in the areas studied.

Nonetheless the drier Silvertop Ash stands did support wildlife, including some species that were uncommon in adjacent types. Thus of 105 species of birds surveyed by Loyn and his colleagues, 20 species were found mainly on the ridges (i.e. Ash stands), though as the authors note, in comparison with the species found mainly in the moist gullies these ridge species *"tend to be more widespread in Victoria, extending into drier types of forest."* The value of the Silvertop Ash types as wildlife habitat appears to lie in their association with other, more favoured types of habitat, rather than in any special features of the Ash types themselves.

2.3 Ecological Relationships

As understood in these Notes, the Dry Sclerophyll Ash types form a fairly coherent group of types. They are typified by several closely related species of Ash eucalypts, with Silvertop Ash commonly occurring as an associate of all the other Ash species. Certain Stringybarks are also frequently associated with the Ashes. They occur usually as dry-sclerophyll forest, though occasionally taking on a moister sites, often occupying ridgetops or upper slopes on soils of relatively low fertility. Perhaps most significantly, their regeneration establishment and subsequent growth is very strongly related to the occurrence of fire.

Ecologically they appear closely related to the wider grouping of dry sclerophyll communities that carry species such as Scribbly Gums, Peppermints and Stringybarks, and that are widespread on the lower fertility soils of eastern N.S.W.

They also occur with other types. Thus Silvertop Ash and White Ash communities are frequently associated with the Moist Tableland Hardwood types, occupying the higher topographic sites, while elsewhere on the South Coast Silvertop Ash types may occur with Spotted Gum or Blackbutt types under the influence of soil and topography.

2.4 Environment

Climatic averages for eight stations are summarised in Appendix 3. Each station is for a site close to where Silvertop Ash occurs, with Olney near its northernmost occurrrence. Newnes is a site within the major occurrence of Blue Mountains Ash; Nerriga and Bondi are in localities where White Ash occurs; and Narooma and Merimbula represent sites where Yertchuk is found. Features of the climates shown by these stations are:

- Rainfall in excess of 700mm a year.
- Fairly uniform distribution of rainfall throughout the year, but with a tendency towards wet summers and dry winter-spring seasons. (Note, however, that Merimbula shows a fairly marked seasonality of rainfall, with nearly half the annual total falling in the three summer months, while Bondi is fractionally wetter in May-July than in any other three-monthly period.)

- Typically low reliability of rainfall, so that extended dry periods may quite commonly occur.

- Warm summers, with surprisingly little difference between the mean maximum temperatures of the hottest months, and cool to cold winters, with frosts a feature of most sites.

The Dry Sclerophyll Ash types occur on a variety of **soils**, though usually ones of relatively poor nutritional status. In the Central Coast and Tablelands, the types are located on the Triassic Hawkesbury, and at higher elevations, Narrabeen, sandstone deposits; Blue Mountain Ash in its more northerly occurrences usually appears on acid igneous rocks; while on the South Coast the various types occur on a number of different sediments and igneous rocks.

Some of these rocks, particularly the coarser ones, are prone to erosion when bared or disturbed.

Kelly and Turner (1978) and Turner et al. (1978) have examined vegetation-soil relationships in the Eden area. Stands containing Silvertop Ash and/or Yertchuk occurred on all six of the soil parent materials present in the area, but usually in sites with the lower total soil phosphorus and exchangeable cation levels.

Topography appears important in the occurrence of at least some of these types. White Ash is almost invariably found on exposed ridges and knolls, while Silvertop Ash is most commonly a species of the upper slopes and ridges, though not unknown in lower topographic situations. Turner et al. note that stands carrying Blueleaved Stringybark usually occur on the higher slopes and ridges, whereas those with White Stringybark were more usually on the lower slopes. On the Blue Mountains, Glasby (1981) has observed that Blue Mountains Ash is rare on exposed ridges, but rather generally occurs on steep, sheltered slopes, around the heads of valleys or around cliffs: the common factor in each situation is shelter from most fires, and the species is best developed on sheltered easterly or southeasterly slopes. Austin (1978) brings out the role of topography, through high radiation indices, in the occurrence of Silvertop Ash and Yertchuk.

As already mentioned, **fire** appears a major factor in the behaviour of the Dry Sclerophyll Ash types. The nature of the forest stands, usually with a somewhat variable, low, xeromorphic understorey; the hot summers; and the not infrequent summer droughts combine to produce an environment that is notoriously fire-prone. Evidence of past fires, of varying severity, can be found in any stand, and the trees and other species present have evolved various adaptations to assist in their survival - as species, if not as individuals - in the face of repeated fire. Glasby has commented in relation to Blue Mountains Ash: *"Each E.oreades stand has a history which is closely related to fire. The age structure is due to a past fire history, with each fire resulting in both new recruits ... and the attrition of standing trees."* The role of fire, particularly in the regeneration of Silvertop Ash stands, has been the subject of some recent debate in Tasmania (Mount, 1979, 1981; Bowman and Jackson, 1981; Jackson and Bowman 1982; Felton, 1982), though it appears that at least some of the disagreement is between the need for fire following logging on the one hand, and under natural conditions on the other. Fire appears as the normal process for regeneration establishment in natural Dry Sclerophyll Ash stands, and whilst there are almost certainly occasions when regeneration will establish in the absence of fire in Nature, the apparent inevitability of fire in these stands means that essentially all regeneration of any age can be dated from some previous fire.

The presence of appropriate **flora and fauna** is obviously necessary for any plant community to develop. In the case of the Dry Sclerophyll Ash types, this development requires in particular the presence of one or more of the appropriate species of Ash eucalypts. Such species are absent in northern N.S.W. except for several rather unthrifty, relic occurrences of Blue Mountains Ash. In southern N.S.W., and southwards to Tasmania, the suitable species are present.

As already noted, these species have developed strategies (or perhaps better, mechanisms -"strategy" has too deliberative a ring to it) to cope with the fire environments in which they grow. Based on the work of Glasby for Blue Mountain Ash and Bridges for Silvertop Ash, Appendix 4 outlines some of the major features of the natural life-cycles of these species and indicates the way in which the two species have differently responded to the prevalence of fire. Of the two, the mechanisms evolved by Silvertop Ash appear the more effective, and this is undoubtedly reflected in the much wider and more aggressive distribution of this species. Unfortunately, information is not available to provide a similar summary for the other commercially significant species, White Ash, though several years' observation and occasional measurement by a local forester should do much to fill this blank. However, it is probably more similar in its behaviour to Blue Mountains Ash than to Silvertop Ash.

3. OCCURRENCE

Apart from several small, relic occurrences of Blue Mountains Ash on the North Coast (Big Nellie Mtn. on Landsdowne S.F.; Doyles River S.F.; Mt. Boss S.F.; McPherson Range; Mt. Warning), the Dry Sclerophyll Ash types have their northernmost occurrence on the sandstone plateaux near Wyong and in the northern Blue Mountains. From here they extend southward in a discontinuous manner along the South Coast and adjacent tablelands into Victoria and thence to northeastern Tasmania.

Silvertop Ash types are by far the most widespread of these types and, apart from the anomalous northern locations of Blue Mountains Ash, the distribution of Silvertop Ash virtually brackets that of all the other Dry Sclerophyll Ash types. They extend west as far as Newnes S.F., Mt. Werong S.F., the Moss Vale area, Tallaganda S.F., Glenbog S.F. and Bondi S.F., often interspersed with Moist Tableland Hardwood stands on the more favoured sites. They reach their best development in the Eden area, where they cover an extensive area.

Within this zone, Blue Mountain Ash occurs on sandstone soils in the northern part of the area, usually at elevations exceeding 600m; Yertchuk has a very similar range to Silvertop Ash, usually on rather poorer sites and generally more common at the lower elevations; and White Ash has a scattered occurrence south from the Illawarra, again generally at altitudes above 600m.

Silvertop Ash types represent the major resource of the Eden Native Forest Management Area, and are a significant segment of other management areas along the South Coast and in the adjacent tablelands. With Blue Mountains Ash, they provide the main hardwood resource on the Newnes S.F. section of the Bathurst M.A.: Newnes carries about 5 000 ha of "mining timber types," including some 3 700 ha containing Blue Mountains Ash (Forestry Commission of N.S.W. 1982a and b).

The 1971 forest resource inventory of N.S.W. (Hoschke, 1976) separated out the Silvertop Ash types (in practice these probably also included most Blue Mountains Ash and much of the White Ash types). Stringybark types were recorded separately, and the areas reported were:

Type	State Forest	National Park	VCL[1]	Total
Silvertop Ash	92 000 ha	28 000	250 000	434 000
Stringybark	161 000	83 000	363 000	1 442 000

[1] Vacant Crown Land

Much of the Stringybark types lay north and west of the Dry Sclerophyll Ash types, but an uncertain proportion was intimately mixed with them on the South Coast and hinterland. Since the time of the inventory major land use determinations have eliminated most of the vacant Crown land on the South Coast, so that the VCL area of Silvertop Ash types and some of the VCL area of Stringybark types have been largely divided between State Forest and National Park. The area of Silvertop Ash types now present on State Forests is probably in excess of 250 000 ha.

The Silvertop Ash and Stringybark types are not distinguished on the forest type map of N.S.W. (Forestry Commission of N.S.W., 1978), but much of the mixed type shown south of latitude 33º 30' and east of the Goulbourn - Queanbeyan - Bombala line would be Dry Sclerophyll Ash types.

4. UTILISATION

Properties of the main commercial timber species present in the Dry Sclerophyll Ash types are summarised in Appendix 5, based on information from Bootle (1971).

Whilst the types have been far from the most favoured timber-producing stands in N.S.W., they have for a long time supported low intensity sawmilling industries and, in the Eden area at least, periodic bursts of sleeper-cutting activity. Trees of all species are very prone to high levels of stem defect, largely as a result of repeated fire damage, and this has greatly reduced the availability of sawlogs. All species listed in Appendix 5 are suitable for paper pulp, and the development of the woodchip industry on the far South Coast has led to a great expansion in the use of these types, has revolutionised management of the stands, and has increased the availability of sawlogs. Nonetheless the sawlog production from these types remains low, with the two main species, Silvertop (Coast) Ash and White Stringybark, together making up less than 4 per cent of the total Crown hardwood cut in N.S.W. (Forestry Commission of N.S.W. 1981). However the types currently provide the bulk of the hardwood pulpwood produced in N.S.W., with production from the types probably at a level between 5 and 10 times as great as their sawlog production. This reflects the present low quality and damaged condition of much of these types.

Regrowth stands of essentially all species, but locally particularly Blue Mountains Ash, are highly regarded for the production of mining timber; and larger regrowth stems of White and Silvertop Ash are commonly used for competitive axemanship events.

The types receive some use for honey, and to a limited extent for grazing. They are not rich wildlife habitat (see 2.2), and, for the Silvertop Ash and Yertchuk types at any rate, have usually limited appeal for recreational use: major recreational use of the types at Eden appears to be a direct result of the woodchip industry.

5. HISTORY OF USE AND MANAGEMENT

As previously noted, the types have supported low intensity sawmilling for many years, together with some production of hewn and other products (Main, 1920) and more recently, of mining timber.

In the Eden area stands were viewed as a possible pulpwood resource in the 1930's, but were passed over in favour of Gippsland. Interest, this time as a basis for a woodchip export industry, was renewed in the late 1960s, and culminated in the commissioning of a woodchip plant beside Twofold Bay in 1969. The developments following this have been outlined by the Forestry Commission of N.S.W. (1979, 1982b), and have been parallelled by considerable research into the silviculture and management of the Silvertop Ash types and by a regular strengthening of measures aimed at minimising soil loss and retaining wildlife populations. Whilst conditions and requirements have changed on a number of occasions since 1969, logging in the Eden area has been essentially at all times a combined operation for sawlogs and pulwpood. This has produced a virtual clearfelling with usually only scattered trees remaining standing within the actual logged coupes. These remaining stems include trees unsuitable, by species, form or damage, for use either as sawlog or pulpwood; individual small stems or clumps of regeneration (sometimes following thinning within the clumps); trees deliberately retained to grow to larger, sawlog size; some stems kept as wildlife habitat; and, since the 1980 fires, some additional stems as a seed reserve. Creekside strips are retained along watercourses once the catchment area exceeds 30 to 50 ha. Coupe size has varied from about 800 ha at the start of the project to a more recent average of about 15 ha, based on the area served by a single log dump, with alternate coupes being retained unlogged for a further cutting cycle (about 20 years). Following the 1980 fires there has been an increase in coupe size, in the interests of improved fire protection. Coupes are expected to average about 50-60 ha, with a maximum size of about 100 ha. Fire has not normally been used to reduce slash or to promote regeneration establishment after logging, though this is under review.

Whilst such operations are best developed in the Eden region, similar treatments are applied in many stands where a market for pulpwood exists. Where no such market is present, logging in the Dry Sclerophyll Ash types often results in the retention of a large number of unmerchantable stems.

The types generally regenerate most readily, particularly following the frequent fires, and it seems likely that any deliberate silvicultural treatment applied to these stands prior to the start of the woodchip industry was very limited, and confined to occasional culling.

6. REGENERATION REQUIREMENTS

6.1 Seeding Habits

Information on the flowering times and seed ripening of various species from the Dry Sclerophyll Ash types is given in Table 1, from data summarised by Boland et al. (1980).

Table 1
FLOWERING AND SEED COLLECTION TIMES: DRY SCLEROPHYLL ASH TYPES

Species	Flowering	Seed Collection(1)	Duration(2)	Crops(3)
Ash, Blue Mountains	Jan - Feb	Dec - Feb	Long	**(4)**
Silvertop	Sept- Jan	Dec - Feb	Long	Several
White	Dec - Jan	Sept- Feb	Long	Several
Peppermint, Narrowleaved	Oct - Jan	Dec - Feb	Long	Several
Stringybark, Blueleaved	Mar - Aug	Dec - Feb	Long	Several
Yellow	Nov - Mar	Dec - Feb	Long	Several

(1) Optimum season for collection, but timing not so important with any of these species: see Notes (2) and (3)
(2) Long duration indicates some seed available at most time in year.
(3) No. seed crops usually present on tree.
(4) Boland et al. do not record Blue Mountains Ash as carrying more than one seed crop, but in fact it does (Glasby, 1981).

All species recorded normally carry several seed crops in their crowns, and some seed is available throughout the year. Silvertop Ash usually carries fruit from 3 to 4 years' flowerings, and Bridges (1983) records the dominant species in the Silvertop Ash types at Eden - Ash itself and both White and Blueleaved Stringybarks - as being *"regular and often massive seed producers."* For Blue Mountains Ash, Glasby reports flowering in mid-January-February, from buds initiated a year or so earlier. In winter three classes of capsules could be recognised: green, from flowering 6 months earlier; purple, from 18 months previously; and grey from 3 or more summers ago. The green capsules contained unripe seed; the seed in the purple capsules was unripe in winter, but had ripened by October, i.e. 20 -21 months after flowering. Major seedfall occurred in autumn, coming mainly from the purple capsules. Individual trees examined by Glasby carried up to 128 000 viable seeds, equivalent to about 1.5 kg of seed.

Bridges has shown that, in the absence of fire, seedfall occurs at a low level throughout the year in Silvertop Ash, and it could be assumed that the peaks and troughs are almost certainly associated with periods of warm and dry, or cool or moist, weather respectively.

With all species seeding is triggered by fire. Even in the most severe fires, when crowns are largely consumed by the blaze, sufficient capsules always seem to remain to shed their seed, and the capsules very effectively insulate their seed from the heat of the fire. For Blue Mountains Ash Glasby suggests that maximum seedfall occurs with fires severe enough to kill the trees, with a heavy fall of seed occurring within 3 weeks of the fire. Bridges (1983) provides more detailed, but similar, information for Silvertop Ash. Within 4 weeks of a severe January wildfire, 126 kg/ha of seed had fallen - over 14 million viable seeds per hectare: quite apart from its regeneration potential, this must be a significant biological event in terms of food for insects and other small organisms. By comparison, over the same period an unburnt stand yielded only 150g/ha, or about 8 500 viable seeds per hectare. The seedfall in the burnt stand occurred very soon after the fire - 47 per cent within a day of the fire, 70 per cent within 3 days, and 93 per cent within a week. By further comparison, a light fire in May resulted in the fall of about 10 kg/ha of seed, or 668 000 viable seeds, within 4 weeks - substantially above the yield from the unburnt stand, but well below the yield from the January wildfire:

	4 weeks' seed fall (kg/ha)	**Equiv. no. viable seed**
Unburnt - Jan	0.15	8 500
Wildfire - Jan	126.40	14 300 000
Light fire - May	9.60	668 000

For White Stringybark, Alexander (1954) noted that in closely stocked stands, particularly of the smaller size classes, capsule production is limited though sufficient are usually carry heavy crops of capsules.

Information on the weights and germination features of the main species in the Dry Sclerophyll Ash types are given in Table 2, from Boland et al.

Most species have seed weights in the same general order (about 100 000 per kg); none require stratification (though Grose, 1965, showed some improvement in the speed of germination with Silvertop Ash and Narrowleaved Peppermint following stratification); most are favoured by relatively high germination temperatures and commence germination within a week. The Ash species themselves especially conform to this pattern, which seems particularly suited to pyrogenic species.

Little information is available on the longevity of seed of these species under storage, though Grose and Zimmer (1958) show that, after 21 years' storage in bags *"under the normal daily fluctuations of temperature and humidity in Melbourne",* the percentage of full seeds containing nonviable embryos was:

Silvertop Ash	60%
White Stringybark	59%
Yellow Stringybark	59%

Whilst the seed was clearly deteriorating, about 40 per cent of the seeds were still potentially viable.

In laboratory studies Cremer (1977) calculated a dispersal distance of 24.1m for Silvertop Ash, released at a height of 40m in a wind of 10km/h. This distance is similar to that calculated by Cremer for many other eucalypts. Following the loss of young regeneration by wildfire at Eden, Bridges (1981) examined the development of seedling regeneration which must have originated from trees in unlogged stands bordering the burnt coupe. Seedlings numbers declined away from the boundary, approaching zero at 55m downwind from stands with an average tree height of 33m. Bridges concluded that adequate regeneration could be expected within 40m of any unlogged boundary.

Field germination will require the seed to have a suitable seed bed, adequate light, and moisture. Under the conditions prevailing at the time of major seedfall in Nature, i.e. after fire, only moisture is likely to be lacking and despite some expected depredations by seed-eating organisms, sufficient seed should normally survive until rain falls to provide adequate regeneration - as indeed all field experience confirms.

Table 2
SEED FEATURES: DRY SCLEROPHYLL ASH TYPES

Species	No. viable seeds/kg		Germination		
	Mean	Highest	Temp.(1)(ºC)	1st Count (2) (days)	Final Count (2)(days)
Ash, Blue Mtns	80 000	129 500	25	7	28
Silvertop	110 000	210 000	25	7	14
White	120 000	208 000	25	7	28
Peppermint, Narrowleaved	54 000	80 500	15:20	10	21
Stringybark, Blueleaved	97 000	144 000	15	18	28
Brown	87 000	109 000	25:20	9	18
White	162 000	280 000	20:25	7	21
Yellow	60 000	140 000	15	10	21
Yertchuk	84 000	112 000	20:25	5	21

Notes:

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

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

6.2 Regeneration Establishment

Trees possessing the very strong regenerative powers of the Dry Sclerophyll Ash types rarely need artificial regeneration. Nonetheless it has been employed, on a small but routine scale in the Eden area, to restock the sometimes extensive log dumps where the soil has become so compacted that revegetation of any type can be slow to appear. Such sites are ripped to a depth of 40cm, and the ripped lines then planted with seedlings (especially Silvertop Ash) raised in peat pots, using the technique detailed by Horne (1979). However, if seed trees are retained around the ripped dumps the sites successfully regenerate naturally, so that planting is decreasingly used.

Artificial regeneration, either by planting or by direct seeding, has been discussed as a means of restocking young regenerated stands destroyed by wildfire, as has happened at Eden, though to a significant extent only over relatively small and scattered areas (see 6.5). Indeed because of the limited extent of failed areas, despite several severe fires in regenerated coupes, artificial restocking has only been carried out on a small scale. Nonetheless the risk of failure in such areas remains but is being countered, since the 1980 fire, by retaining seed trees in all logged coupes: these provide a high aerial seed source that should, to a large extent, survive any fire in the lower regrowth stand and thus should ensure further regeneration of the area. In Tasmania, where logged coupes are routinely burnt after logging, seed of local species is sown by air following the fire as the basic regeneration technique (Bowman and Jackson, 1981).

Species of the Dry Sclerophyll Ash types vary in their coppicing ability. The smooth-barked Ashes (White and Blue Mountains) lack this ability; even in young stands, the appearance of a coppice shoot is a silvicultural oddity, and it has no significance in managing such stands for small timber production. Stringybarks tend to be strong coppicers (e.g. Alexander, 1950 ; Silvertop Ash is rather weaker, though usually fairly reliable. Thus at Eden regenerated stands killed to ground level by fire have in many cases coppiced strongly, while at Newnes mining timber operations in regrowth Silvertop Ash stands are usually followed by widespread coppicing from the stumps. On the other hand, pulpwood thinning in 25 year old Silvertop Ash regrowth at Eden resulted in virtually no coppice growth in stands logged by felling machine, which tended to "spring" the bark on the very low stumps.

As is commonly the case, the production of lignotubers on seedlings parallels the species coppicing ability. The Stringybarks produce strong lignotubers, giving them a powerful survival mechanism; the smooth-barked Ashes lack them; and their presence in Silvertop Ash appears rather variable, and perhaps a matter of opinion or interpretation. Glasby observes that lignotubers are absent from Silvertop Ash seedlings growing under low light intensities, while R.G. Bridges has stated that he does not consider Silvertop Ash to be lignotuberous: rather its seedlings can develop a slight swelling at the base of the stem, and it is from this area that coppice shoots develop following fire.

Either way, the Silvertop Ash seedlings appear rather more persistent than those of the smoothbarked Ashes, and they commonly contribute to what Bridges (1983) has termed the "small seedling advanced growth" component of regeneration in Silvertop Ash types. This component also includes more typically lignotuberous species, such as Stringybarks and Peppermints. Its seedlings persist in a generally suppressed state under at least some canopy cover.

Mostly, however, regeneration in the Dry Sclerophyll Ash types involves the establishment of seedlings from recent seedfall.

6.3 Seed Source

As already discussed, the Dry Sclerophyll Ash types normally carry a large supply of seed in capsules in their crowns. Seed is produced from about age 4 years in Silvertop Ash, and probably slightly later in Blue Mountains Ash, where the suppressed stems in regrowth stands play a particularly important role in early seed production (see Appendix 4). There is a more or less continual slow yield of this seed to the forest floor, but massive seedfall is triggered by fire.

In unlogged stands seed, shed either in the absence of fire or after a fire in which the canopy remains intact or recovers fully, becomes a source of small seedling advanced growth. Only a small proportion of the seed that germinates under the undisturbed canopy will survive, and the length of this survival will be quite variable. However there is a dynamic replacement of this material through a continuing input of new seed producing a perpetual stocking of small seedling advanced growth in any unlogged stand.

During logging operations some to many of the trees in the stand are felled and their crowns cut off from the log. The crowns rapidly dry out, and in from a few days to a few weeks the capsules in these drying crowns open and shed their seed. The seed falls close to the crown source, though during logging some of this capsule-bearing material is broken off and more widely spread around, and subsequent rain may cause further distribution (Bridges, 1983). This is the major source of seed for regeneration after logging.

The availability of seed for regeneration following a logging operation will thus tend to depend almost directly on the intensity of logging, through the number and distribution of heads on the ground, while reserves of seed in the area will depend on the number and distribution of trees retained standing. These reserves are normally unimportant (certainly in comparison with felled heads) as a source of regeneration after logging, but they can assume considerable importance if the area is burnt subsequently, and they are increasingly relied upon at Eden to regenerate ripped log dumps. Following the 1980 fires, practice at Eden is to keep four well distributed seed trees per hectare (Bridges, 1981), sufficient to cast seed over the whole area.

6.4 Seedling Establishment and Development

To become established, eucalypt seedlings typically require access to mineral soil, ample light, and moisture. In the Dry Sclerophyll Ash types the first two requirements are met in Nature by the effects of fire, with subsequent rain providing the third. Seed is well distributed over the area from the aerial seed source, so that all suitable niches are likely to be occupied by viable seed. The result is prolific regeneration following rain, and while mortality of recently germinated seedlings must be immense, extremely high stockings usually survive: Bridges (1983) records stockings of 85 000 seedlings per hectare six months after wildfire in 1972, and this is probably not unusual. Much of the herb and shrub component in the stand is killed by the fire, so that the seedlings face little initial competition from other plants. The fire promotes germination of wattles or other legumes, and whilst these ultimately compete, the eucalypts may also gain benefits from their nitrogen-fixing capacity.

Logging operations result in rather different conditions for establishment. Some of the area is undoubtedly disturbed and free from shrub and herb growth; some is compacted; some is covered by accumulations of litter. In separate reviews, Bridges (1975, 1982) records similar, but slightly different, proportions of these sites:

	1982	1975 - Average	1975 - Range
Undisturbed	36%	43%	36 - 50
Disturbed	49%	39%	33 - 47
Bare or compacted	15%	18%	13 - 22

The earlier of these studies showed 26 per cent of millacre (4m²) plots containing crown material deposited during logging, and 34 per cent carrying a heavy cover of woody material or bark: undisturbed sites carried more accumulations of debris (which tended to be pushed off the disturbed areas). Seed availability is usually highest around accumulations of crown material, so that at least some otherwise suitable niches may not be occupied by viable seed. The result is a much lower level of seedling establishment on logged, as compared with burnt, sites: Bridges (1983) records average stockings of 5 000 seedlings per hectare of acceptable pulpwood species at between ages 12 and 18 months, plus 1 700 non-acceptable pulpwood species (e.g. Roughbarked Apple, Bloodwood) and 1 500 wattle seedlings (data based on routine regeneration assessment of 7 000 ha of logged forest). Establishment tended to be most successful on disturbed sites (65 per cent of millacres stocked at age 12 months); almost as good on undisturbed sites (63 per cent); and poorest on bare sites (39 per cent).

Most of the eucalypt stocking develops within 12 months of logging, after which it gradually increases to reach a peak between 2 and 3 years after logging. A gradual decline in stocking then begins. Densely stocked patches are common, concentrated around the felled crowns. The time to reach the peak of regeneration stocking, and the rate of subsequent decline, are dependent on associated weather conditions (Bridges, 1975).

The composition of the regenerating stand closely parallels that of the original stand. Table 3, provided from Bridges (1983), compares the composition of stands before logging with that of the regeneration present 5 years after logging, using data from research plots. The similarity in the two sets of figures is obvious, and Bridges notes that the similarity is even more closely related to species actually logged. On the other hand a stand with a high component of a species that is not logged will initially be deficient in regeneration of that species, but its proportion will gradually increase.

Table 3

COMPARISON OF ORIGINAL STAND COMPOSITION WITH SUBSEQUENT REGENERATION

Species	Prelogging Stand Composition (%)	Regeneration Composition - 5 years after logging (%)
White Stringybark	56	52
Silvertop Ash	31	26
Mountain Grey Gum	5	5
Messmate	2	9
Yertchuk	4	5
River Peppermint	2	2
Yellow Stringybark	Nil	1

Besides the young seedlings, logged areas contain other stand components: small seedling advanced growth (stems under 5cm diameter breast height); advanced growth (stems between 5 and 25cm DBH); coppice from cut stumps; and residual trees, retained either because they were unmerchantable or because they were needed for special purposes (e.g. seed reserve, habitat purposes, growth to larger size). Bridges (1983) records an average basal area after logging at Eden of 4.4m² per hectare of residual trees, while at 6 months stocked millacre plots were dominated by:

	Percentage
Seedlings	68
Small seedling advanced growth	24
Advanced growth	8

Although it is the lesser component of the small regeneration, the small seedling advanced growth (and also any coppice present) grows rapidly after logging, utilising its established root system, and tends to make up a larger part of the dominant trees in the developing stand. In one area studied, coppice made up 5 per cent of stems over 5 cm DBH in 8 years old regeneration from logging. Coppice is not a large component of regeneration in the logging of old growth Silvertop Ash stands because of the generally large diameter of the trees being logged. Nonetheless Bridges (1983) records a "vigorous coppice component" existing in 10 years old regeneration, and suggests that regeneration following a second rotation logging could be based almost entirely on a coppice system. Alexander (1954) has made a similar observation with respect to White Stringybark. As previously noted, White and Blue Mountains Ash do not coppice.

The stocking of residual trees after logging can vary considerably, and their influence on regeneration has been studied in Silvertop Ash in Victoria by Incoll (1979). Incoll states that, on average, regrowth does not survive closer than 0.42 crown diameters to an overwood tree, i.e. just within the vertical projection of the crown edge, while surviving regeneration close to a residual tree is heavily suppressed. The influence of overstorey trees on the growth of regeneration extended up to about 3 overwood crown diameters from the residual tree, though the effect between 2 and 3 crown diameters was slight (only about 4 per cent in the case of height growth). Incoll provides a table indicating the expected loss of regrowth volume from various stockings and sizes of overstorey trees, e.g. regrowth volume in a stand carrying 10 trees per hectare with a crown diameter of 10.6m will be only 61 per cent of that in a stand without residual trees.

Stands, whether resulting from fire or logging, thin themselves out with time, though stands of fire origin apparently continue to carry much higher stockings for a long period. Table 4, derived from information from Bridges (1983), both shows the development of fire regeneration with age and compares regeneration from logged and burnt sites. Sites vary in quality though the 8 years old (logging) and 9 years old (fire) stands are believed to occupy comparable sites. The figures suggest that the lower initial regeneration from logging is no disadvantage for the future management of the stands.

Table 4

DEVELOPMENT OF REGENERATION : SILVERTOP ASH TYPES

Origin **Age**	**Logging** **8 yrs**	**Fire** **9**	**Fire** **14**	**Fire** **25**	**Fire** **38**
Total Stand					
Stocking (stems/ha)	6000	37 900	26 700	2 300	1 470
Mean Dom. Ht. (m)	13.3	11.9	12.5	20.1	27.1
BA (m²/ha*)	7.2	8.8*	33.5	31.6	45.2
Underbark Vol. (m³/ha*)	14.6	16.0*	47.4	112.9	206.0
Best 500 stems/ha					
BA (m²/ha)	4.7	2.2	4.6	15.3	29.6
Mean DBH (cm)	10.4	7.5	10.7	19.5	27.0
Underbark Vol. (m³/ha)	10.3	4.0	-	-	-

* BA and volumes for the 8 and 9 years old stands are calculated for stems greater than 5cm DBH only, not for the total no. stems. Stockings of such stems are 855/ha (8 years logging regeneration) and 2 900/ha (9 years fire regeneration).

6.5 Damage to Regeneration

Damage to regeneration of Dry Sclerophyll Ash types can occur from a number of sources.

Ants, other insects and possibly small vertebrates undoubtedly consume part of the shed seed before it germinates. With the saturation seedfall that follows both fire and logging, this loss does not seem of any silvicultural significance, though it may be a factor in the poor establishment that sometimes follows apparently adequate seedfall on burnt regeneration areas.

Heavy mortality follows initial germination, due in most cases to adverse **weather** conditions - particularly hot, dry weather, though at the higher elevations frosting may also be a factor. In most circumstances the losses do not appear significant. However, following the November, 1980, fires very high losses of new germinants occurred. Collection of surface debris following the fire revealed that high levels of viable seed were present on the seedbed. This viable seed failed to produce the expected seedling regeneration. Two rainfall events in November and December, 1980, were followed by adverse climatic conditions through to February. These conditions were aggravated by drought and the exposed, blackened seedbed. it is assumed that the rainfall events stimulated the germination of most of the seed, but that the seedlings were subsequently desiccated in the cotyledonary stage. These losses were significant on those sites where a high proportion of the existing regeneration was killed outright by the fire. Similar situations have been observed in some Victorian forest stands (R.G. Bridges; personal comments).

Weeds, especially wattles, can appear in large numbers, providing additional competition for the regenerating eucalypts. R.G. Bridges has made the personal observation that, up to about age 7 years, the wattles are slightly ahead of the eucalypts in growth, but at that stage the eucalypts start to move ahead, the wattle component begins to break up, and the wattle stand itself has disappeared by about age 15 years. This is a pattern repeated in other eucalypt communities in N.S.W. Wattles are present in regeneration following logging without burning, but are much more prolific where the site has been burnt: Bridges (1983) notes that *"acacia stockings of 10 000 to 15 000 per hectare are common following fire compared to stockings of up to 2000 per hectare"* after logging in the absence of fire.

Another weed situation sometimes confronting Silvertop Ash regeneration in the Eden area concerns Black Sheoak. This is a common component in the Silvertop Ash stands of the Eden area, and on some sites has developed in dense clumps causing reductions in the eucalypt stocking and competing with those eucalypts on the site. Most of the stands containing this Sheoak component developed following the 1952 wildfires. In general it appears that the eucalypt regeneration in these stands is adequate eventually to form a dominant canopy over the Oak understorey.

As in so many other aspects of Dry Sclerophyll Ash type silviculture, **fire** is undoubtedly the dominant factor damaging or destroying regeneration. Unintentionally, but inevitably, some regrowth stands in the Eden area have been swept by wildfires of varying intensity; equally inevitably, Bridges (1981) has been on hand to record the effects.

The greatest risk from fire lies in logged areas carrying regeneration up to 5 or 6 years of age: these are liable to be completely destroyed by fire. Fire-induced regeneration in this age-range will burn less severely because much of the original fuel on the site would have been burnt in the regenerating fire, and similarly regeneration established on former log dumps will usually be less severely damaged by fire since these sites tend to be largely free of logging debris and also to carry little shrubby revegetation.

However logged sites regenerated without a post-logging burn have high fuel levels produced by the logging debris. Typical fuel loads after logging in the Silvertop Ash types are about 10 tonnes per hectare of fine fuel (material less than 25 mm diameter), and about 200 t/ha of heavy fuel, with a further 200 t in debris heaps on each log dump. Intense fires on such sites will kill much of the young regeneration outright. As the regeneration age increases, or the fire intensity decreases, the proportion of the regeneration recovering by coppice or epicormic growth will increase. In addition, from about age 4 years the regeneration will carry capsules that are capable of surviving an intense wildfire and then of shedding their viable seed on to the seedbed.

Where a high proportion of the regeneration has been killed outright by fire, the reestablishment of regeneration will depend on seedfall - from retained overstorey trees, from adjacent unlogged stands, and in the older areas from seed carried by the now killed regeneration. The seed source provided by residual and edge trees has in the past usually been an unplanned source, and the distribution of such trees can result in large areas being beyond the range of seedshed. As well as this the overall volume of this seed supply is low, resulting in generally low stockings of regeneration. Bridges quotes one area where seedling stocking 4 months after a fire in a logged coupe was 1 200/ha, rising to 2 300/ha after 2 years. At this age a comparable unburnt coupe carried 5 400 stems/ha. While these lower stockings can be acceptable, their distribution is often poor because the seedlings are clumped around residual trees and in a band adjacent to unlogged boundaries. This may create many unstocked areas within the coupe.

As its age increases, the regeneration becomes better able to cope with fire. Individual stems can survive fire of greater intensity, recovering by epicormic or coppice development, and the stand is producing an increasing volume of seed. Ironically from a management point of view, a severe fire that kills the young stems back to ground level is likely to be preferable to a lighter one that causes crown scorch. After the more intense fire, recovery is mainly by coppice growth from the base of the burnt stems. This coppice grows speedily (heights up to 5m in 2½ years from fire on some sites), and the burnt stems ultimately fall over, leaving a healthy, vigorous coppice stand. The new coppice stand generally has a lower stocking than its predecessor since a proportion of the stems are inevitably killed by the fire. In one 16 year old fire regrowth area, stocking was reduced from 27 000 stems/ha to 8 000 coppice stems/ha by wildfire.

By contrast, lighter fires cause crown scorch or the death of the upper, smoothbarked section of the stem. Whilst the milder cases of crown scorch are followed by recovery by epicormics, in many cases the new crowns become multi-leadered or carry dead spikes, which not only deform the stem but become sources for the development of heart rot. Under these circumstances removal of these stems (e.g. for mining timber) and their replacement by stump coppice is probably desirable. In older regrowth stands the recovery of the more severely damaged trees is often poor, and mortality is high: as Bridges observes, as regeneration increases in age and size its mode of recovery from intense fire swings from a vegetative phase (coppice, epicormics) to a seed phase.

Of the main species present in the Silvertop Ash types, the Ash itself is not a particularly strong producer of epicormics, but in the small sizes it coppices well; the Stringybarks produce vigorous coppice and epicormics, but dead topping is common; while the associated moister species (e.g. Mountain Grey Gum, Yellow Stringybark), along with Yertchuk, also produce strong epicormics and coppice and have the ability to restore damaged crowns with minimal dead-topping.

The other smooth-barked Dry Sclerophyll Ashes lack the ability to coppice and are weak producers of epicormics: Glasby notes that when Blue Mountains Ash produces epicormics they tend to be distributed more evenly along the whole stem, compared with its associates where most of the growth is concentrated in the upper part, and he regards this as less efficient. Both this and White Ash are very susceptible to fire, and depend upon seeding for their replacement after fire.

One further source of damage to regeneration, associated with fire, comes from **salvage logging** in heavily burnt unlogged stands. Fire promotes seedling regeneration in these stands, but the subsequent development of this regeneration is dependent on the degree of overstorey recovery. When severely burnt trees are removed by salvage logging, the fire-induced seedling regeneration is free to develop. However the logging operation creates a mosaic of ground disturbance which destroys a proportion of the existing regeneration. These disturbed areas will not regenerate because the wildfire has previously exhausted the seed-source in the stand. A number of studies have indicated the extent of this reduction in regeneration stocking. Following a 1972 wildfire, salvage logging reduced regeneration stocking from 85 000 to 19 800 stems/ha; after a 1979 fire the reduction was from 67 000 to 8 500 per hectare. Despite these large reductions in total stockings, adequate stockings still exist. In addition, the pattern of disturbance is such that, although there is some clumping of regeneration, this is usually not detrimental to the overall development of the regeneration stand.

7. SUBSEQUENT GROWTH AND YIELD

The old growth Silvertop Ash forests of the South Coast probably consist of a mosaic of differently aged stands, with some larger and more recognisably even-aged stands where fires had destroyed appreciable patches of the previous crop. However future crops will be more markedly even-aged, whether originating from fire or logging. Particularly in areas regenerated by logging, the stands will contain some older stems as well as the seedling regeneration, but essentially they can be regarded as evenaged stands with scattered residual stems whose effects have been studied by Incoll (1979) and discussed earlier (see 6.4).

The even-aged regrowth stands carry high stockings (extremely high in the case of those originating from fire), and some trends of growth in these stands have been presented in Table 4. The plots represented in that table are not strictly comparable, but still show a trend of decreasing stocking and increasing height, volume and diameter with age. Volume MAI for the 5 plots increases with age, and has reached 5.4 m³/ha/an by age 38 years in a stand still carrying over 1 400 stems/ha and with a mean dominant height of 27m.

The most comprehensive study on growth in Silvertop Ash has been made by Incoll (1974) in Victoria; this study has been conveniently summarised and reviewed by Borough et al. (1978). Using a growth simulation model, Incoll produced yield tables for stands of various site indices and stockings: his table for SI 30 (i.e. mean dominant height of 30m at age 50 years) is given in Table 5A for an unthinned and unburnt stand. In his study Incoll was able to demonstrate the major influence of fire, of even light intensity, on stand production, and Table 5B provides a yield table for a similar stand to that in Table 5A, except that it was damaged by fires of moderate intensity (half vertical extent of crown scorched) at ages 20, 35 and 45 years.

Table 5

SIMULATED YIELD TABLE FOR UNTHINNED SILVERTOP ASH - S.I.30

A. Unburnt

Age (yrs)	**Stocking** (stems/ha)	**Mean DBH** (cm)	**B.A.** (m²/ha)	**Total Volume** (m³/ha)	**Volume MAI** (m³/ha/an)
20	5 160	11.1	50.3	221	11.1
30	2 950	16.3	61.5	341	11.4
40	1 670	21.5	71.4	453	11.3
50	1 370	26.8	77.4	538	10.8
60	1 000	32.0	80.8	601	10.0

B. Burnt by Moderate Fires, Ages 20, 35 and 45 years

Age (yrs)	**Stocking** (stems/ha)	**Mean DBH** (cm)	**B.A.** (m²/ha)	**Total Volume** (m³/ha)	**Volume MAI** (m³/ha/an)
20	3 330	10.0	26.2	120	6.0
30	2 220	14.8	38.3	216	7.2
40	1 640	17.5	39.5	250	6.3
50	1 210	20.6	40.2	277	5.5
60	915	26.4	50.0	365	6.1

The N.S.W. data (Table 4) show significantly lower rates of growth than the Victorian ones, though at least for the 38 years old plot the height growth would appear comparable with that in Table 5 (27m at 38 years, c.f. 30m at 50 years), and the plot is not known to have suffered fire damage since its regeneration. Pending better information in N.S.W., caution would be needed in applying the Victorian figures to N.S.W. conditions. However it is known that site quality varies greatly in the Silvertop Ash stands in N.S.W., and on Mumbulla S.F. (Bega district), on what is recognised as one of the best Silvertop Ash sites in the State, plots in 14 years old fire regeneration have shown volume MAI's up to 18 m³/ha/an. However an MAI of 5 m³/ha is suggested for 40 years old regrowth in the Eden Management Plan (Forestry Commission of N.S.W., 1982 b).

Borough et al. also provide some figures from Victorian plots where Silvertop Ash stands have been thinned, in one case at age 6 years, and in another at age 21. In both cases the larger stems in the stands have shown a positive diameter growth response to thinning, though apparently rather less in the older stand (which was of slightly lower site index) than the younger. Basal area and volume generally decrease with heavier thinning, though in the older stand the unthinned plot (about 3 000 stems/ha) has produced less volume than the plot thinned to about 1 000 stems/ha at age 27 years: 163 m³/ha in the unthinned plot, 188 m³/ha in the thinned.

Several thinning studies have been carried out in the Silvertop Ash regrowth stands at Eden, including a major one involving a commercial pulpwood thinning of 25 years old fire regeneration, using a felling machine (Bridges, 1978?). Treatments involved the removal of all stems on strips (outrows), 4m wide, at different intervals, and also selection thinning from below, either without any strip removal or to the bands of forest retained between outrows. Yields from the strip thinning alone averaged 20-30 tonnes/hectare; with selection thinning in the intervening bands the yield could be increased to 50-70 tonnes/ha. Whilst a number of problems were encountered, largely associated with the operation of the machine, the technique was considered practicable. The average size of stems removed in the strip fellings was about 12cm, and stems of this order are suitable for pulping with bark on. The subsequent growth on the thinned plots is being followed; some windthrow has occurred, usually in local patches.

Another, and earlier, thinning trial was established in 1968 in the very high quality fire regeneration stands of Silvertop Ash on Mumbulla S.F., mentioned previously. This is the only thinning trial in the Eden area treated at an early age (4 years). A summary of the plot data at age 16 years (12 years after thinning) is shown in Table 6. The diameter MAI for the best 125 trees per hectare reached a peak at age 8-9 years in the unthinned and lightly thinned plots; for the heavier thinnings this peak was delayed till age 15 years. Basal area MAI has not yet peaked for the best 125 t.p.a., but for the total stocking ("All Trees") it reached its maximum in the unthinned and lightly thinned plots at age 15-16 years, and is expected to peak in the heavier thinnings at about age 20 years. Volume MAI has also not yet peaked, but will do so within a few years in the unthinned stand.

For the best 125 t.p.h. heavier thinning has produced a slight increase in diameter MAI (1.6cm for unthinned, to 1.9cm for 175 t.p.h. at age 16 years), and still maintains an increased diameter PAI (1.0cm to 1.9cm). At age 16 years the heaviest thinning has only 17 per cent of the BA of the unthinned stand (9.8 to 59.1 m²/ha), and only 23 percent of volume (55.8 to 243.9 m³/ha).

Table 6
THINNING PLOTS: MUMBULLA S.F.

Regeneration: mostly Silvertop Ash, following severe fire, 1964 Treatment: various intensities of thinning applied at age 4 yrs. (1968) Measurement: data at age 16 yrs (1980).

Plot Treatment	Unthinned	3 000. t.p.h	1700 t.p.h	750 t.p.h	370 t.p.h	175 t.p.h
All Trees						
Stocking (t.p.h.)	4 445	2 562	1 497	669	281	160
Dom. Ht. (m)	22.4	23.9	23.2	24.2	22.3	22.7
Mean DBH (cm)	11.9	14.9	15.2	20.6	24.1	27.2
PAI (14-16 yrs)	0.3	0.4	0.4	0.7	1.1	1.5
MAI	0.7	0.9	1.0	1.3	1.5	1.7
B.A. (m²/ha)	59.1	47.4	32.0	24.5	13.7	9.8
PAI (14-16 yrs)	3.5	2.5	2.0	1.7	1.2	1.0
MAI	3.7	3.0	2.0	1.5	0.9	0.6
Vol. (m³/ha)*	243.9	219.2	147.9	123.3	65.8	55.8
PAI (14-16 yrs)	16:0	15.4	12.5	11.8	8.1	7.0
MAI	15.2	13.7	9.2	7.7	4.1	3.5
Best 125 t.p.h.						
Mean DBH (cm)	25.2	26.5	26.1	28.7	29.5	29.9
PAI (14-16 yrs)	1.0	1.0	0.9	1.2	1.5	1.6
MAI	1.6	1.7	1.6	1.8	1.8	1.9
BA (m²/ha)	6.3	6.8	6.7	8.1	7.1	8.8
PAI (14-16 yrs)	0.4	0.5	0.4	0.7	0.7	0.9
MAI	0.4	0.4	0.4	0.5	0.5	0.6

*Volume calculated as underbark volume between a 15cm stump height and a 5cm small-end diameter.

On many of the sites in the Eden area it appears that heavy thinning is required to produce a worthwhile response on the larger retained stems: this is similar to the responses determined by Horne (1981, undated) for Blackbutt regrowth on soils of lower nutrient status.

Management plan prescriptions for regrowth stands at Eden, (Forestry Commission of N.S.W.., 1982 b) require that thinning should not reduce the residual stand B.A. to below 14 m²/ha.

No information appears available on the growth of White Ash though, as a species producing distinct annual rings, stem analysis should readily provide some useful trends. One only growth plot exists for Blue Mountains Ash, in a stand that regenerated on Newnes S.F. after the 1952 fires and that has subsequently been twice thinned. Data from this plot is shown in Table 7, and in terms of growth it shows somewhat better development than many of the Eden Silvertop Ash stands (c.f. Table 4), though poorer than the very high quality Mumbulla plots (Table 6). Glasby has developed a height/age curve for Blue Mountains Ash (based on determinations of age from annual rings), noting that two thirds the maximum height growth is gained in the tree's first 20 years. Glasby's curve predicts somewhat lower height growth than is shown by the Newnes plot.

Table 7
GROWTH, PLOT SUMMARY: BLUE MOUNTAINS ASH, NEWNES S.F.

(Stand originated following wildfire, 1952. Growth plot established and thinned at age 5 years (1957); plot rethinned at age 25 years (1977).)

Age (yrs)	Stocking	Mean Dom. Ht. (m)	BA (m²/ha)	Mean DBH (cm)
5	-	5.5	-	-
7	-	8.5	-	-
11	2 026	-	11.7	8.4
14	2 026	18.3	18.1	10.4
15	2 026	-	21.1	11.1
25	2 199	-	37.0	14.3
	420	-	14.4	20.5
29	420	25.8	21.4	24.9

Glasby estimates that the largest trees of Blue Mountains Ash are rather more than 100 years of age. No estimates of longevity for other species in the Dry Sclerophyll Ash types are known, though extrapolating from the growth rates of Silvertop Ash regrowth it would seem that the larger stems of that species could be in excess of 200 years.

The old growth Silvertop Ash types vary considerably in structure and yield. Table 8 shows details of this variability from 10 permanent growth plots so far established in the southeastern part of Eden district. These plots are located on soils derived from sedimentary parent materials, of Ordovician, Devonian and Tertiary ages: soils derived from Ordovician sediments tend to have above average nutrient status for the Eden area, whilst those derived from Tertiary sediments rank amongst the poorest. The composition of these plots suggests that the content of Silvertop Ash is rather less than is typical for the Eden area (c.f. Tables 3 and 8). Average yield from integrated logging in such areas at Eden is about 80 tonnes/ha, plus about 10 m³/ha of sawlogs, but again the figures vary greatly with the best sites providing about 120 tonnes/ha of pulp and 25-30 m³/ha of sawlogs. Provided fire can be adequately managed, yields from the regrowth stands should be well above these old growth stands. Once again no information is available on White Ash types, while the Blue Mountains Ash stands are so scattered and affected by repeated logging and fires that average figures have little meaning.

Only one outstanding tree has been identified in these types:

White Stringybark, Yambulla S.F.: Ht. 40.7m, DBH 1.15m, Vol. 15.18 m³

Table 8
COMPOSITION OF OLD GROWTH STANDS, EDEN DISTRICT

(Based on 10 growth plots in Nadgee and Timbillica Sections; all trees larger than 10cm DBH measured.)

	Mean	Range
Stocking (trees per ha)	217	100 - 270
DBH (cm)	35.4	10.0 - 119.0
BA (m²/ha)	27.8	16.3 - 41.9
Bole Vol. (m³/ha)	204.7	109.8 - 371.5
Dom. Ht. (m)	25.9	22.5 - 34.9

Species Composition (by tree no.)

Blueleaved Stringybark	31%	Black Sheoak	6%
Silvertop Ash	19%	Woollybutt	3%
Yellow Stringybark	13%	Roughbarked Apple	3%
White Stringybark	12%	Mountain Grey Gum	1%
Yertchuk	10%	River Peppermint	1%
Narrowleaved Peppermint	1%		

8. DAMAGE TO OLDER STANDS

8.1 Fire

8.1.1. General

Need more be said? These are types that have evolved and developed in an environment of repeated and severe fire, which affects and often dominates all aspects of their life and management. It controls their regeneration in Nature, determines stem form, influences growth rate, contributes to subsequent fungal and insect attack, and probably in most cases directly finishes the old trees off. Under organised management it is the factor that proves hardest to control, and that ultimately determines whether or not management can succeed. Its effects have already been discussed: see 2.4, 6.5 and Appendix 4.

Management of these types consequently has to acknowledge that wildfire will almost certainly ultimately occur, and then take appropriate steps to minimise the damage when it does. It epitomises one of the major problems and debates of Australian forestry throughout this century. This is not the place to explore these issues, but some of the silvicultural implications of different approaches to fire control should be noted.

Prior to 1981, fire management in the Eden area was based on the following principles (Bridges, 1983):

- Broadscale hazard reduction burning in the unlogged blocks of forest. These blocks diminished each year as logging expanded out.
- Burning of debris heaps on log dumps. This practice was already under review due to a number of fire escapes from the smouldering heaps up to 18 months after their initial ignition.
- Exclusion of fire from regeneration areas.

A severe fire in November, 1980, burning some 46 000 ha, including nearly 13 000 ha of regeneration, caused this policy to be critically questioned and modified, leading to the introduction of a new fire policy for the area (Forestry Commission of N.S.W., 1982c). This policy is attached as Appendix 6. In particular, greater use of deliberate burning to reduce hazard, coupled with the avoidance of large debris heaps and the spreading of such debris to smaller heaps through the coupes, has been introduced or examined. Any wider use of deliberate burning carries a need to increase the size of coupes: logistics of available manpower and the limited periods when deliberate burning can be effectively performed make it impossible to cope with a large number of very small coupes, yet prior to the 1980 fire logging at Eden was generating about 250 coupes, of average size 15 ha, each year. As a result of the revised fire policy, coupes in the future are expected to average about 50-60 ha, and to be proportionately fewer in number.

Three separate conditions for deliberate burning can be recognised (Bridges, 1981, 1983): in mature stands, immediately after logging, and in developing regeneration.

8.1.2 Burning in Mature Forest

The mature stands normally carry rather low fine fuel levels (herbs, shrubs, fine litter), so that burning usually has to be performed under moderately warm, dry conditions when the margin between a successful hazard reduction and a damaging fire is slight. Damage is most likely in patches carrying an advanced growth component, along the lines described earlier - crown scorch; possible development of spikes and dead-topping, leading to malformation of the tree; some tree deaths. Some such damage, hopefully of very limited extent, is likely in any burning that effectively reduces fuel levels in these stands.

Even light fire will trigger some seedfall, and with more intense fires the quantity of seed released increases. Where crown damage occurs not only is most of the seed reserve shed (or destroyed), but further flowering will be delayed for several years while a new crown is formed, thus delaying new seed production for up to 5 years. This is normally of no significance unless logging occurs after the fire-induced germinates have died (usually about 18 months, if no permanent canopy opening has occurred), but before new seed is available. Even then the significance is unlikely to be great unless excessively large areas have been damaged to the extent of losing their seed reserves.

In discussion, R.R. Richmond has observed that the desire to avoid the various undesirable effects of hot slash fires (see 8.1.3) has resulted at Eden in a much greater emphasis on pre-logging burning than the current fire policy (Appendix 6) suggests. He states:

> *"The object of pre-logging burning is to reduce post-logging burning to a simple top-disposal exercise. In fact the secret in this, as in all fuel management burning (in commercial forestry, anyway), is to remove fuel in many small doses instead of one large one. In this there are a number of practical advantages, like less dependence on weather and highly skilled staff, as well as environmental ones.*
>
> *This policy is heading towards full swing, having had to weather criticisms focussed on the apparently low fuel weight . . . and the consequent doubt on the efficacy of any type of burning, without much regard for its vertical distribution or for the contribution made to fire behaviour by other fuels such as fibrous bark or xerophytic shrubs, all of which are heavily modified in pre-logging burning.*
>
> *There has been a worry about premature seedfall, but this has not emerged in practice even though some pre-burning has been a little hotter than necessary."*

8.1.3 Post-logging Burn

This is the most contentious practice, and has sparked the Tasmanian debate previously mentioned (see 2.4). Unlike the other prescribed burning activities, which have their direct counterparts in Nature, burning immediately after logging introduces new factors, including loss of most of the seed source (little will survive from the crowns on the ground), more intense patches of fire than would otherwise occur (from accumulations of logging debris), and greater subsequent exposure of site (even standing dead trees provide some site protection). Wildfire in a young, previously unburnt regeneration area tends, of course, to duplicate all these features (see 6.5).

In Tasmania, where post-logging burning on large (200-400 ha) coupes in these types is normal practice, regeneration is obtained from aerial seeding (Bowman and Jackson, 1981). If direct seeding is not to be practised, regeneration has to come primarily from seed on any retained stems (or adjacent unlogged coupes, whose value diminishes as the size of logged coupes increases), with possibly some supplementation from existing advanced growth and coppice that manages to survive the fire. Thus routine post-logging burning has to be coupled with either artificial regeneration or the retention of productive seed trees.

Post-logging burning stimulates the growth of some shrubs, especially wattles. Bridges (1983) records that wattle stockings of 10 000 to 15 000 seedlings per hectare are common following fire, compared with stockings of up to 2 000/ha in the absence of fire. Bridges suggests that such fires will remove about two thirds of the fine fuel, but less than half of the heavy fuel, so that over 100 tonnes/ha of heavy fuel remain, while the growth of wattle and other understorey species, particularly in the absence of overstorey, speedily restores the fine fuel levels.

An alternative that is often practised to broadacre post-logging burns is top-disposal burning, where just the isolated heads from logging are burnt. However with intensive logging activites, as occur with integrated operations at Eden, the continuity of fuel is such that this may not be a real alternative, but rather may have the same result as the broadacre burn. Where it can be practised it tends to avoid some of the disadvantages of wider scale post-logging burning, and would appear to have advantages when burning under the developing regeneration is to be carried out.

Burning immediately after logging can have obvious benefits for the manager, but some of these are rather ephemeral, the practice introduces some still unknown, or uncertainly known, factors, and it is not without its risks. Its widespread use still warrants a most cautious approach.

8.1.4 Burning in Developing Regeneration

Probably the greatest protection need in any silvicultural treatment that produces large areas of even-aged eucalypt regeneration is to develop effective hazard reduction practices in these young stands. As yet, however, these practices can hardly be said to exist. Fuel levels, perhaps particularly in previously unburnt logging regeneration, can be high, and the young stands are particularly susceptible to damage from fire, leading to dead topping and the development of multiple leaders. To avoid such damage fire intensity needs to be kept low, and the burning must be delayed until stands are high enough to have a reasonable chance of avoiding most damage - probably heights of 10 to 15 metres, equivalent to ages of say 8 to 15 years, though there are at least some examples of successful burning in stands only 6 metres high. Some mortality must be expected, particularly at the time of the initial burn; subsequent hazard reduction fires should be less damaging. In view of the stocking of most regeneration areas, some mortality, particularly of the smaller sizes, can be accepted.

Referring to burning under regenerating stands, R.R. Richmond has commented: *"The whole thrust of whatever burning takes place during conversion is aimed at reducing the time (and hence the probability of major losses), that must elapse before extensive fuel management in developing regeneration can take place. The vulnerability in a commercial sense of older regeneration that merely dies back vis a vis younger material that coppices vigorously is recognised. Unfortunately this vulnerability does not fall off within the present (likely) rotation age . . . "*

8.2 Fungi

The fungus, *Phytophthora cinnamomi,* is known to be pathogenic on Silvertop Ash and certain of its associates in eastern Victoria (Weste and Taylor, 1971; Marks et al, 1975). Since elsewhere in Australia environmental changes associated with logging are believed to be associated with increased hazard from the fungus, considerable attention has been paid to the occurrence and effects of *Phytophthora* in the Eden area.

Phytophthora occurs through this area, and can be recovered regularly from local soils, particularly moist gully heads, though trees apparently affected by it are rarely seen. In one detailed study extending over 5 years, and comparing logged and unlogged sites on granite soils in stands dominated by Silvertop Ash and several susceptible Stringybarks, conditions were favourable for the survival and growth of *Phytophthora* (Bridges et al., 1980). However following logging no deaths apparently due to the fungus occurred, no increase in its incidence was detected, no spread of the fungus could be attributed to the movement of vehicles within or between coupes, and no deaths of regenerating, susceptible seedlings were observed. This confirms observations elsewhere in the area, though contrasting with at least some Victorian experience in similar sites.

No other potentially serious fungal diseases are known from these types, except for wood-rot fungi which affect the hearts of most of the larger stems and stems carrying dead spikes.

8.3 Other Damage Agencies

Older stems are commonly infested by termites, which degrade the wood. No other major insect pests are known from these types.

Glasby (1981) has observed that old trees of Blue Mountains Ash, weakened by fire, rot and termite, often finally succumb to strong winds, which blow them over. Some wind damage has also been noted in thinned stands of Silvertop Ash (see 7).

9. PRESERVATION

Stands of the Dry Sclerophyll Ash types are widely preserved in National Parks in southern and central districts of N.S.W. Silvertop Ash, sometimes on an extensive scale, occurs in most coastal and escarpment parks between Wollemi in the north and Nungatta and Ben Boyd in the south; Yertchuk types have a similar occurrence, though relatively less widespread towards the north; Blue Mountain Ash types are well represented in the Blue Mountains and southern Wollemi N.P.'s, and also occur in Mt. Warning N.P. and proposed extensions to the Border Ranges N.P.; and White Ash types occur from Morton N.P. southwards in escarpment parks. In addition, the two rare dry sclerophyll Ashes, Budawang and Jilliga Ash, occur respectively in Morton and Budawang N.P.'s and in Deua N.P.

The types are also represented in 3 Flora Reserves and 18 Forest Preserves under the Forestry Commission's Native Forest Preservation programme. These areas are briefly described in Appendix 7, and the total preserved areas involved cover an area of over 5 000 ha, 2 500 ha as Flora Reserves and 2 800 ha as Forest Preserves.

10. MANAGEMENT ASPECTS

10.1 Objectives

The Dry Sclerophyll Ash types occur in both the coastal and tableland forest zones of N.S.W., and their management on State Forests is determined within the provisions of the Forestry Commission's Indigenous Forest Policy (Forestry Commission of N.S.W., 1976). In relation to these forest zones, this Policy states:

"5.4.2 Coastal Hardwoods

This major group should be managed so that long term production in any major supply zone is concentrated within areas of good terrain and accessibility. These areas may be surrounded by steeper extensively managed forest which contribute to supplies for the zone ....

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 ....

The more mountainous and less accessible forests behind the coastal plain should be logged for sawlogs to the limit of economic accessibility. 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 ....*
> *5.4.3 Tableland Hardwoods*
>
> *... Where softwood plantations are not definitely planned, management should aim at logging the existing crop to the limits of economic accessibility at a rate which could be sustained under extensive management, involving no investment in silvicultural treatment. This management will require the retention of good growing stock which could become merchantable within the next 30 years."*

Major features of this Policy are the concentration on sawlog production and the limitations on direct silvicultural treatment other than in the coastal lowlands. The first of these carries with it the implication that, in the Eden area, the forests generally should be regarded as continued producers of sawlogs, and not just as a pulpwood resource, not withstanding the regional significance of the woodchip industry. This has to be balanced against the relatively low quality of a large proportion of the types, so that much of the cellulose produced by them will only be suitable for use as pulpwood or small timber.

10.2 Management Problems, Principles and Practices

The dominant factor, and problem, in the management of these types is fire. The influence of fire in these types extends beyond just the need for adequate protection. Even with the best feasible protection system it would seem that occasional wildfires, sometimes burning under extreme conditions, will continue to be experienced for some time yet, if not forever. Management has to recognise this likelihood, take appropriate steps to minimise the risk while maintaining the productivity of the forest, respond to the effects of wildfire when it does occur, and if possible utilise fire beneficially in the treatment of the forest.

The types regenerate well, and usually prolifically, following opening of the stand, whether by fire, logging or possibly sometimes storm damage. Regeneration is primarily from seed, supplied either from surviving standing trees or from heads on the ground. A suitable seedbed of mineral soil appears necessary, and the developing seedlings need freedom from overhead shade; retained trees within a regeneration area have an undoubted inhibitory effect. Because of past fire damage, and possibly also of the inherent nature of the types, the trees are often defective and poorly formed. Harvesting for sawlogs alone tends to be selective and to remove only a small proportion of the stand, leaving a large residual overstorey of essentially unmerchantable trees; a market for pulpwood allows much of this residual material to be profitably utilised.

Small openings, from the removal of one or a few trees, will regenerate, but the seedlings will be suppressed and retarded by adjacent overstorey trees. In Nature such small clumps are probably usually burnt in each successive fire, and subsist as local patches of small advanced growth. Sometimes they may contribute to locally more intense patches of fire which may finish off some of the neighboring trees and thus enlarge the clump. The clump then effectively starts growth again from ground level, even though some of the stems will shoot from coppice or lignotubers. The resultant more vigorous regrowth may then grow large enough to survive the next fire in the area, though possibly not without damage to stem form.

However, because of the inhibitory effects of overstorey, the likelihood of fire and the consequent desirability of introducing regular hazard reduction burning, selective logging, developing towards a group selection system of silviculture, does not seem advisable in these type. Operations resulting in more recognisably even-aged stands over manageable areas are to be preferred, but with some retention of overwood trees, at least as a seed reserve.

Nonetheless, when there is no market for pulpwood or similar material to allow for this heavier standard of logging, culling after harvesting can hardly be recommended unless the stands are very economically located: in most situations the economics of culling must be dubious in these relatively low quality stands, while any future extension of pulpwood markets could allow much of the currently unmerchantable material to be harvested. The culling of unsaleable trees from stands where pulpwood harvesting has been carried out may however be well warranted.

Post-logging burning after the heavier harvesting operations should be regarded very cautiously until more information is gained about its effects, though more selective top-disposal burning may be desirable. Efforts should be made to introduce low intensity hazard reduction burning into regeneration areas as soon as burning can be safely carried out in these stands; such fires will inevitably cause some damage, and further study is needed to allow the burning to be carried out with minimum risk to the regenerating stand.

Thinning can be carried out in regeneration areas to produce merchantable yields of small timber or pulpwood, and promote the growth of remaining stems. Species such as Stringybarks and Silvertop Ash may coppice after thinning, and this will reduce the benefit to the residual trees but may provide the basis for a subsequent further thinning from below. Coppicing will not occur with White or Blue Mountains Ash.

Wildfire in the more intensively managed Silvertop Ash stands may need to be followed by remedial silvicultural treatment, including artificial sowing (or possibly planting) in young regeneration areas (under about 6 years) where there is no reserve aerial seed source present, and possibly treatment (preferably commercially based, e.g. a mining timber operation) to remove dead-topped trees in older regeneration areas and to allow them to coppice from the still live stumps.

Guidelines for the management of Dry Sclerophyll Ash types can be developed within the framework of these silvicultural requirements.

10.3 Further Research

The most pressing research needs for these types appear to relate to fire, rather than to more orthodox silvicultural features. In particular better information on the control and behaviour of fire in regenerating stands and on the effects of post-logging burning is needed to assist in developing effective protection programmes.

The operations based on the Silvertop Ash types at Eden are the largest scale harvesting operations in native forest stands in N.S.W., and have been in the public spotlight almost since their inception. This has undoubtedly assisted in promoting a far-reaching research programme covering not only silviculture but many environmental aspects of the management practices, including hydrology, soil erosion, nutrient cycling and wildlife. This research should be continued.

Although neither the Blue Mountains Ash nor the White Ash types are major forest communities in N.S.W., they are ones of some local significance. As with Silvertop Ash types their ecology and silviculture is dominated by fire. Studies similar to those of Glasby are required on the ecology of White Ash, and for both types some improved information on their silvicultural requirements is needed - regeneration habits, responses to logging, growth rates and thinning responses (particularly to the types of thinning carried out as a mining timber operation in Blue Mountains Ash).

However in all cases the first requirement of research appears to relate to fire.

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J. Freeman	G. Mitchell	S. Shaw

D. Hamilton	C. Nicholson	G. Stone
P. Harper	B. Peick	

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Appendix 1

PLANT SPECIES MENTIONED IN TEXT

Apple,	Smoothbarked	Angophora costata
	Roughbarked	A. floribunda
Ash, Alpine		Eucalyptus delegatensis
	Black (see Silvertop Ash)	
	Blue Mountains	E. oreades
	Budawang	E. dendromorpha
	Cliff Mallee	E. rupicola
	Coast (see Silvertop Ash)	
	Jilliga	E. stenostoma
	Mountain	E. regnans
	Silvertop	E. sieberi
	White	E. fraxinoides
Blackbutt		E. pilularis
Bloodwood, (Red)		E. gummifera
Brown Barrel		E. fastigata
Gum,	Brittle	E. mannifera ssp. maculosa
	Broadleaved Scribbly	E. haemastoma
	Manna	E. viminalis
	Mountain Grey	E. cypellocarpa
	Narrowleaved Scribbly	E. racemosa
	Scribbly	Eucalypts of Pryor & Johnson subseries Haemastominae (MATK)
	Shining	E. nitens
	Spotted	E. maculata
	Western Scribbly	E. rossii
Mallee, Blue Mountain		E. stricta
Messmate		E. obliqua
Peppermint		Eucalypts of Pryor & Johnson series Piperitae (MAT), excluding subseries Haemastominae
	Black	E. amygdalina
	Broadleaved	E. dives
	Narrowleaved	E. radiata
	River	E. elata
	Sydney	E. piperita
Sheoak, Black		Allocasuarina littoralis
Stringybark		Eucalypts of Pryor.& Johnson series Capitellatinae (MAH)
	Blueleaved	Eucalyptus agglomerata
	Brown	E. blaxlandii
	Red	E. macrorhyncha
	White	E. globoidea
	Yellow	E. muellerana
Turpentine		Syncarpia glomulifera
Wattle	Acacia spp.	
Woollybutt		Eucalyptus longifolia
Yertchuk		E. consideniana

Appendix 2

NOTES ON APPROACHES TO CLASSIFYING COMMUNITIES IN DRY SCLEROPHYLL ASH TYPES

Davis (1936, 1941): Bulli Area.

- Silvertop Ash[2] Association

Pidgeon (1937, 1941): Central Coast and adjacent areas.

Mixed *Eucalyptus* Forest Association (In reference to the higher Blue Mountains Tableland, Pidgeon noted that this contained individual *"forest types ... too numerous to mention",* but including, from the Dry Sclerophyll Ash types:

- Silvertop Ash
- Blue Mountains Ash
- Silvertop Ash-Sydney Peppermint-Brittle Gum-Narrowleaved Scribbly Gum
- Silvertop Ash-Narrowleaved Peppermint-Sydney Peppermint Blue Mountains Ash-Sydney Peppermint-Silvertop Ash)

Pidgeon (1942): Eucalypt communities of Eastern N.S.W.

- Broadleaved Scribbly Gum-Red Bloodwood-Sydney Peppermint Association (from Central Coast and adjacent areas; includes some Silvertop Ash communities)
- Silvertop Ash-White Stringybark-Yellow Stringybark Association (from South Coast)

Costin (1954): Monaro district.

- Brown Barrel-Manna Gum Alliance, which includes:
  - White Ash Association
  - Narrowleaved Peppermint-Silvertop Ash Association
- Red Stringybark-Western Scribbly Gum Alliance, which includes:
  - Silvertop Ash Association
  - Broadleaved Peppermint-Silvertop Ash Association

Story (1969): Queanbeyan-Shoalhaven district.

- White Ash Community (wet sclerophyll forest)
- Wet Silvertop Ash Community Intermediate
- Silvertop Ash Community
- Dry Silvertop Ash Community

(The Silvertop Ash Communities occurred respectively as wet, "intermediate" and dry sclerophyll forest. Of these, Story noted: *"In structure (tall, straight, massive trees) the dry, intermediate and wet E. sieberi communities have no clear dividing line. The differences are mostly in the undergrowth, which in the dry communities is extremely sparse and without ferns and fungi. As is the rule with E. sieberi, the transition to other eucalypt communities is abrupt.")*

[2] Most of these writers used botanical names in identifying communities, but for consistency these are transcribed as common names here: see Appendix 1.

Hayden (1971), Specht et al. (1974): Vegetation of N.S.W.

- o Silvertop Ash-White Stringybark-Red Bloodwood Alliance (from Southern Tablelands and hills of the South Coast)
- o Sandstone Complex (from Central Coast; can include Silvertop Ash)
- o Brown Barrel-Manna Gum Alliance (from tablelands; may include Silvertop and White Ashes)
- o Northern Tablelands Complex (from Northern Tablelands; shown as sometimes including Blue Mountains Ash, which is oddly omitted from the Sandstone Complex though it does occur there)

Austin (1978): Clyde, Moruya and Tuross valleys

Group	Type	Community
Brown Barrel	Narrowleaved Peppermint-Manna Gum- Brown Barrel	Brown Barrel- White Ash White Ash-Shining Gum
	Silvertop Ash-Brown Barrel-Mountain Grey Gum	Silvertop Ash River Peppermint-Silvertop Ash
Yellow Stringybark	Blueleaved Stringybark-Yellow Stringybark-Mountain Grey Gum	Blueleaved Stringybark Silvertop Ash
		Yellow Stringybark-Silvertop Ash
	Yertchuk-Sydney Peppermint-Yellow Stringybark	Silvertop Ash-Yertchuk
		Silvertop Ash-Sydney Peppermint
Red Bloodwood	White Stringybark-Bloodwood- Smoothbarked Apple	White Stringybark-Silvertop Ash
		Yertchuk- Bloodwood
	Bloodwood-Silvertop Ash-Turpentine	Bloodwood-Yertchuk
	Bloodwood-Blackbutt-Spotted Gum	Silvertop Ash-Bloodwood
		Silvertop Ash-Blackbutt

(This classification is part of a more comprehensive system derived from the numerical analysis of data from a large number of plots. Austin notes: *"The communities recognised are an abstraction from a continuum."*)

Turner et al. (1978): Eden area (as part of soil nutrient-vegetation relationship study)

- o Yellow Stringybark, Mountain Grey Gum, Silvertop Ash
- o Yellow Stringybark with Silvertop Ash and/or Roughbarked Apple
- o Blueleaved Stringybark variously with Silvertop Ash, Yertchuk or Roughbarked Apple
- o White Stringybark, Silvertop Ash, Yertchuk, Roughbarked Apple, Black Sheoak
- o Silvertop Ash with Black Sheoak and/or Roughbarked Apple

Recher et al. (1980): Eden area (as part of a wildlife study)

- o Dry Ridge Forest, including:
    - o Silvertop Ash-White Stringybark-Blueleaved Stringybark Type
    - o Silvertop Ash-White Stringybark-Bloodwood Type
    - o Silvertop Ash-Messmate-Broadleaved Peppermint Type
- o Low Forest with Banksias, including:
    - o Yertchuk-White Stringybark

Appendix 3

CLIMATIC AVERAGES - DRY SCLEROPHYLL ASH TYPES

Station Localities

Altitude (m) **Latitude**

33° 34° 35° 36° 37°

1200

1000 ∀Newnes

∀ Bondi

800

∀Moss Vale

600 ∀Nerriga

400

200

∀Olney ∀Lucas Hts

0 ∀Narooma

∀Merimbula

OLNEY. **Latitude:** 33º6'S **Longitude:** 151º15'E **Elevation:** 152m

Temperature (Cº)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Daily Max. Mean	25.5	26.3	23.5	22.7	17.2	15.4	14.2	15.4	19.1	20.1	23.2	23.6	20.6
Daily Min. Mean	14.0	16.4	13.4	11.5	8.1	7.1	5.0	6.3	8.5	11.5	12.7	15.1	10.8

Rainfall (mm)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Rainfall Mean	152	197	177	152	129	214	71	103	74	104	111	130	1614
Raindays Mean (No.)	12	12	12	10	7	9	8	7	8	9	8	10	112

NEWNES PRISON CAMP. **Latitude:** 33º21'S **Longitude:** 150º15'E **Elevation:** 1033m

Temperature (Cº)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Daily Max. Mean	23.3	22.7	20.9	18.0	13.5	10.6	10.0	11.1	13.8	18.0	19.7	22.5	17.0
Daily Min. Mean	10.4	11.2	9.8	5.7	3.1	0.1	-1.1	0.5	2.0	7.6	8.7	11.9	5.8

Rainfall (mm)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Rainfall Mean	122	120	88	74	73	93	64	81	66	91	87	93	1052
Raindays Mean (No.)	17	19	13	7	9	11	11	14	9	13	17	15	155

LUCAS HEIGHTS. **Latitude:** 34º3'S **Longitude:** 150º59'E **Elevation:** 159m

Temperature (Cº)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Daily Max. Mean	25.6	25.8	24.7	22.4	18.8	16.4	15.9	17.0	19.6	21.7	23.1	25.2	21.4
Daily Min. Mean	17.0	17.4	15.9	13.3	9.9	8.2	6.6	7.5	9.4	11.9	13.5	15.5	12.2

Rainfall (mm)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Rainfall Mean	123	89	117	87	62	100	44	85	52	82	103	117	1061
Raindays Mean (No.)	15	16	13	9	8	11	8	8	6	11	14	11	130

MOSS VALE. **Latitude:** 34º33'S **Longitude:** 150º22'E **Elevation:** 672m

Temperature (Cº)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Daily Max. Mean	24.5	24.4	22.4	19.3	14.6	12.1	11.3	12.7	15.9	18.9	21.1	23.4	18.4
Daily Min. Mean	13.0	13.3	11.4	8.0	4.7	3.2	1.6	2.8	4.6	7.3	9.2	11.2	7.5

Rainfall (mm)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Rainfall Mean	96	95	90	84	89	99	84	63	59	77	71	83	990
Raindays Mean (No.)	11	11	11	10	10	10	9	9	9	10	10	10	120

NERRIGA P.O. **Latitude:** 35º7'S **Longitude:** 150º5'E **Elevation:** 625m

Temperature (Cº)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Daily Max. Mean	25.1	23.5	22.2	19.6	15.8	12.5	12.0	13.5	18.1	19.9	20.2	25.7	19.0
Daily Min. Mean	13.0	13.4	11.2	7.5	4.0	1.5	0.5	1.3	4.6	6.0	7.7	11.4	6.8

Rainfall (mm)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Rainfall Mean	70	66	67	54	59	59	67	49	53	61	59	73	737
Raindays Mean (No.)	9	9	7	6	7	6	6	9	8	10	9	8	94

NAROOMA. **Latitude:** 36º13'S **Longitude:** 150º8'E **Elevation:** 26m

Temperature (Cº)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Daily Max. Mean	23.9	24.2	23.1	21.4	18.2	15.8	15.4	16.3	17.9	19.5	20.9	22.6	19.9
Daily Min. Mean	15.4	15.8	14.8	12.1	8.8	6.7	5.7	6.7	8.2	11.0	12.1	14.2	11.0

Rainfall (mm)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Rainfall Mean	94	88	95	81	79	85	50	52	54	67	70	76	891
Raindays Mean (No.)	10	10	11	9	8	10	7	8	9	12	11	11	116

MERIMBULA. **Latitude:** 36º54'S **Longitude:** 149º54'E **Elevation:** 2m

Temperature (Cº)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Daily Max. Mean	23.8	24.7	22.8	21.4	17.8	16.2	16.0	16.5	18.2	19.8	20.1	23.2	20.0
Daily Min. Mean	15.3	15.7	13.3	10.1	6.9	4.5	3.4	4.6	5.7	9.3	11.1	13.2	9.4

Rainfall (mm)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Rainfall Mean	132	129	50	24	36	22	23	63	34	50	116	79	758
Raindays Mean (No.)	13	12	9	8	8	7	8	8	4	13	12	9	111

BONDI S.F. **Latitude:** 37º9'S **Longitude:** 149º9'E **Elevation:** 914m

Temperature (Cº)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Daily Max. Mean	22.9	25.3	21.8	18.4	14.0	10.6	9.8	10.0	13.6	17.2	19.9	21.2	17.1
Daily Min. Mean	7.0	8.4	6.1	1.5	-0.9	-2.6	-4.1	-2.0	-0.1	3.9	4.8	5.7	2.3

Rainfall (mm)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Rainfall Mean	79	93	69	85	90	121	88	85	71	85	96	99	1061
Raindays Mean (No.)	10	9	10	10	12	14	13	14	12	14	13	12	143

Appendix 4

LIFE-CYCLES OF TWO DRY SCLEROPHYLL ASHES

A. Blue Mountains Ash (Information from Glasby, 1981)

On the Blue Mountains, Blue Mountains Ash is rare on exposed ridges and occurs chiefly in somewhat sheltered sites, particularly with easterly or southeasterly aspects. It can grow with a number of associates, and usually with a sclerophyllous understorey. It may occur as isolated, prominent stems up to 35m high; in dense, almost pure stands; or in mixed stands. Largest trees reach about 100cm in diameter, corresponding (by ring count) to an age of somewhat over 100 years.

The tree is very fire sensitive, while its bark shedding habit tends to accentuate fire intensity in the vicinity of trees. A severe fire will kill even large trees, but at least some stems will survive lighter fires, though possibly receiving damage allowing fungal and termite attack that can weaken them. The tree can produce epicormics after defoliation, but these are less effective than on most eucalypts; similarly the sapwood carries much lower starch levels than most eucalypts, suggesting that the tree puts most of its resources into growth, rather than food reserves.

Individual trees may carry up to 3 viable seed crops at any time, with significant seed reserves held in the crown: from 60 000 to 130 000 viable seeds per tree in stems from about 30 to 100 years of age. In the absence of fire, maximum seedfall occurs in the autumn, but seedfall is triggered by fire and occurs within 3 weeks of the fire, being heaviest where the tree has been killed. Fire may not be essential for regeneration, but regeneration does usually follow fire, and may form dense stands, reaching heights of about 1 m within 18 months of the fire. Shadehouse studies show that Blue Mountains Ash seedlings grow more strongly at low light intensities than Silvertop Ash or Sydney Peppermint, giving it an advantage over those other species in the more shaded, southfacing sites.

It does not produce lignotubers.

Young regenerating stands rapidly segregate into distinct crown classes. The dominant stems do not start to bear appreciable quantities of seed until nearly 20 years of age, but the suppressed and intermediate stems are heavily in fruit before age 10 years. Figures from an 11 years old stand, for a 10 x 10 m plot, were:

Condition	No. stems	DBH(cm)	Ht.(m)	No. w. capsules	No. viable seed
Suppressed	86	0 - 2	2.7	86	21 500
Intermediate	80	2 – 5	5	65	15 000
Dominant	28	5 +	8	3	320

This attribute appears of considerable biological importance to the species:

- It effectively reduces the flowering and fruiting age of the trees, providing an early seed source;
- It probably hastens the thinning of the suppressed trees, which put more of their growth resources into seeding;
- It allows the species to survive in sites where the fire frequency is greater than the time for the dominant stems to reach reproductive maturity.

Stands may carry a number of different age classes, with the younger stems corresponding in age to fire scars on the older stems. This reflects patchy fire intensity, allowing some stems to survive while others are killed and replaced by patches of regeneration.

B. Silvertop Ash (Information mostly from Bridges, 1980, 1981, 1983)

On the far South Coast Silvertop Ash stands cover an extensive area with the Ash sometimes in virtually pure stands, but more often with various associates. On the most favoured sites mature stems may reach 40m in height and up to a metre or so in diameter. Whilst obviously even-aged stands covering appreciable areas do occur, though usually with scattered older trees present, it is likely that most of the older, mature stands in fact carry a range of age classes.

The rough bark that forms on the trunk and larger branches as the trees develop confers considerable fire resistence on the trees, though the smooth-barked section of the stem is sensitive to fire, particularly in the younger stems. The area itself is one that is very prone to severe fires.

High intensity fires will defoliate patches of forest, either by scorch or by consuming the leaves. Some mature trees will die following such a fire, but others recover by epicormic development; small poles are likely to be killed in the head, but to produce epicormics from the roughbarked section of the stem; smaller stems will normally be killed back to ground level, but some may recover by coppice. Areas of lower intensity fire produce less mortality.

At any time trees carry a number of annual seed crops, each with viable seed, and some seed is shed almost continuously throughout the year.. Massive seedfall is however triggered by fire: in four weeks after the January, 1979, fire at Eden one Ash stand released 126 kg of seed per hectare, equivalent to about 14 million viable seeds. Most of this seed fell in the first few days after the fire.

This seedfall produces dense regeneration: stockings about 6 months after fire have ranged between 43 000 and 85 000 per hectare. Where the overstorey trees recover from the fire, virtually all this regeneration will ultimately die; where mortality in the overstorey is high, the regeneration will continue to develop. The effects of the post-fire regeneration will thus range from dense, actively growing stands where the overstorey has been killed, sometimes in small patches and sometimes over considerable areas, through to scattered suppressed advance growth surviving in areas where the overstorey canopy has recovered.

The dense stands gradually thin themselves out as they develop, though stockings may remain high for a long period:

Age (yrs)	**Stocking** (stems/ha)	**Mean DBH** (cm)	**Mean Dom. Ht.** (m)
14	27 000	3.6	12.5
25	2 300	12.1	20.1
38	1 400	18.4	27.1

Regenerating stands start to produce seed from about age 4 years. While all size classes share in this seed production, *"suppressed trees often carry more capsules than leaves".* The period when the stand is at risk from a further fire is minimal.

Appendix 5

PROPERTIES OF MAJOR TIMBER SPECIES: DRY SCLEROPHYLL ASH TYPE

(Derived from K. R. Bootle: "Commercial Timbers of N.S.W. and Their Use")

Abbreviations: L-S, Lyctid susceptible; G, green; S, seasoned; B, basic (re density)

Common Name	**Ash, Blue Mountains**	**Ash, Silvertop**	**Ash, White**	**Peppermint (various)**
Botanical Name	Eucalyptus oreades	Eucalyptus sieberi	Eucalyptus fraxinoides	Eucalyptus radiata Eucalyptus elata And others
General Properties	Straw coloured with pink tonings. Well defined growth rings. Straight grain. Moderately coarse texture.	Lght brown. Distinct growth rings. Occasionally interlocked grain.	Straw to light brown. Moderately coarse, but uniform texture. Straight grained.	Light brown. Often wide sapwood. Moderately coarse texture. Generally straight grained. Gum veins common.
Density kg/m³	G: 1040 S: 590 B: 500	G: 1200 S: 830 B: 670	G: 1040 S: 670 B: 545	S: 720 B: 580
Durability	4 Sapwood lyctid resistant	3 L-S	4 L-S	3 sometimes L-S
Strength	C/S4	B/S3	C/S3	C/S3
Sawlog Group	B	C	B	D
Uses	Joinery, mining timber (both round and sawn)	General construction Handles, flooring, pulpwood.	Joinery, flooring, general construction.	General construction where heavy shrinkage can be tolerated.
Other Notes	Prone to collapse and surface checking. Quarter saw and re-condition.	Surface checking on back-cut surfaces. May need reconditioning.	Liable to check on back-sawn surfaces. Re-conditioning required.	Liable to distortion and collapse. Re-conditioning desirable.

PROPERTIES OF MAJOR TIMBER SPECIES: DRY SCLEROPHYLL ASH TYPE

(Derived from K. R. Bootle: "Commercial Timbers of N.S.W. and Their Use")

Abbreviations: L-S, Lyctid susceptible; G, green; S, seasoned; B, basic (re density)

Common Name	**Stringybark, Blueleaved**	**Stringybark, Brown**	**Stringybark, White**	**Stringybark, Yellow**
Botanical Name	Eucalyptus agglomerata	Eucalyptus blaxlandii, Eucalyptus capitellata	Eucalyptus globoidea	Eucalyptus muellerana
General Properties	Light brown, sapwood slightly paler. Some interlocked grain. Moderately fine texture.	Light brown. Moderately fine texture. Relatively easy to work.	Light brown, sometimes light pink. Moderately fine texture. Generally straight grained. Fairly satisfactory for bent work.	Light yellow- brown. Moderately coarse texture. Grain sometimes interlocked. Not suitable for bent work.
Density kg/m³	S: 930 B: 610	G: 1150 S: 900 B: 690	G: 1090 S: 900 B: 690	G: 1105 S: 870 B: 690
Durability	2? Sapwood lyctid resistant	3 Seldom attacked by lyctids	2 Sapwood lyctid resistant	2 Sapwood seldom attacked by lyctids
Strength	B/S3?	B/S4	B/S3	B/S3
Sawlog Group	B	C	B	B
Uses	General construction.	General construction.	General construction, poles.	General building construction, flooring.
Other Notes	Slow in drying – needs care. checking. Re-conditioning desirable.	Slow drying, some distortion and collapse. Re-conditioning may be desirable.	Not difficult to season, but some collapse.	Care needed to avoid checking in early stages of drying. Some collapse may occur.

Appendix 6

FIRE MANAGEMENT POLICY - EDEN REGION

1. GENERAL

1.1 This policy is aimed at containing timber production losses from fire damage in the Pulpwood Supply Zone in the Eden Region to a maximum per rotation of the productive capacity of 40 000 ha of mature regrowth.

1.2 To meet this objective realistically:

(a) Forest management strategies will give priority to facilitating fire protection.

(b) Suppression and fuel management practices will be developed to minimise damage from uncontrolled wildfires in regrowth stands.

2. DIRECT FIRE PROTECTION MEASURES

2.1 Fuel Management

Significant losses are the direct result of the incidence of high intensity (crown) fire. This type of fire will occur in "Extreme"[3] weather conditions following drought and when widespread inflammable fuel has accumulated.

To avoid this accumulation, fuel reduction by burning is a primary objective and will receive continuing priority. Its purpose is threefold :

(i) Primarily to reduce fire intensity within productive stands and thereby to minimise the damage caused by fire that penetrates them.

(ii) Secondly to limit spread rate which, assisted by easier and safer suppression that is simultaneously made possible, will limit the ultimate size of wildfires.

(iii) To reduce the chance of fires starting.

2.1.1 Fuel reduction will take place in four phases. Because of practical limitations imposed by weather and resources, it is necessary to establish an order of priority as follows:

(a) 1st priority. Burning at 3 - 5 year intervals in all regrowth stands. Development of guidelines and the establishment of the necessary expertise to carry out this work is a matter of prime importance.

(b) 2nd priority. Burning after logging in pre-determined, clearly defined, wide strategic fire-break areas covering, eventually, about one-third of the area of the forest. Some of these fire-breaks will be permanently fixed, concentrated within lower site quality forest. Others will change their location in response to changing forest characterictics in the developing stand.

(c) 3rd priority. Low-intensity burning at 4 - 7 year intervals in all over mature unlogged stands.

(d) 4th priority. Burning prior to logging in all stands except filter strips and wildlife retention areas.

2.1.2 In all four phases, treatment priority will rank downwards from areas within strategic fire-breaks and areas of inflammable aspects and elevations, to lower and moister sites.

[3] Fire Danger Index greater than 50 on McArthur Meter.

Some pre-logging and post-logging burning is a necessary precursor to effective regrowth burning. Where this applies its priority will be advanced accordingly.

2.1.3 Burning techniques will be developed which maximise the benefits whilst minimising the risk of escapes.

Training of personnel at all levels will be carried out to ensure a suitable level of expertise, together with widespread understanding and acceptance of objectives.

2.2 Fire Suppression

2.2.1 Initial Attack

It will be the aim of the suppression organisation to mount an initial attack on any fire before it assumes dimensions beyond which control is impossible. A combination of detection effectiveness, response efficiency and resources mobility will be developed to ensure that initial attack is adequate to contain the fire in accordance with this aim.

In unmanaged fuels and extreme weather, 0.25 hectares is considered to be the upper limit to which a fire can grow for direct attack to succeed. A fire of this size will probably develop in no more than 10 minutes in these conditions and therefore demands a corresponding response time. Training of initial attack personnel to meet this demand accompanied by a searching examination of detection effectiveness is a matter of priority. Helicopter transport for first attack will be developed as funds permit, together with the acquisition of other appropriate fire fighting equipment.

2.2.2 Campaign Fires

Fires which extend beyond 24 hours and encounter "Extreme" or near "Extreme" conditions are recognised as inevitable events in which coordination of the fire fighting resources of the community in the Region must fall to the Commission. An on-going leadership role to develop a cooperative framework, independent of declared emergencies, is seen as the best way of achieving orderly campaign fire fighting. The development and maintenance of a reliable and well-drilled infrastructure by the Commission is necessary as a basis.

2.3 Community Co-ordination

There is a need for the Commission actively to co-ordinate its activities with those of other fire Authorities in the Region. This will be done by :

(a) Maintaining surveillance of fire use everywhere in the Region through an efficient detection and reconnaissance system.

(b) Maintaining continuous liaison with other fire authorities for the interchange of information on fire incidence, legality and suppression intentions.

(c) Taking a lead in the co-operative removal, with neighbours, of fire hazards in areas of mutual concern.

(d) Engaging in fire fighting in the community interest in any part of the Region in support of Brigades and other Authorities.

(e) Assisting other Authorities to maintain public awareness and compliance with the fire laws.

3. FOREST MANAGEMENT

3.1 Strategies which minimise potential losses from any one major fire event will be given serious consideration. Extension of the rotation beyond 40 years is of importance, but dispersal, spatially, of logging and regeneration is the most significant and will be pursued to the limit of fundsavailable for early extension of the roading pattern.

3.2 Strategies which simplify burning and allow greater use of the finite limits imposed by weather and skilled labour will be favoured. An increase in average coupe size to 100 ha or thereabouts is necessary if postlogging burning is to be successfully accomplished. Departure altogether from clear-felling in coupes towards selection systems will be considered in order to enable safe post-logging burning. Multi-stage logging may also offer some advantages but its consideration is not a high priority.

3.3 Extension of access throughout the Management Area as soon as possible is vital both to fuel management and fire suppression as well as to regeneration dispersal (see (a) above) and will be pursued.

3.4 Adoption of more intensive silvicultural practices than is usual in native forests, will receive serious consideration in order to provide a level of activity sufficient to employ a high quality work force adequate for the intermittent but demanding needs of fire suppression and fuel management, neither of which can be met by more than the minimal employment of casual staff or licensees. An eventual increase by 50% at the workface within the Region is appropriate. Practices such as regrowth thinning, which also has an intrinsic protection benefit, will be seriously considered.

4. RESEARCH AND INVESTIGATION

4.1 In order to reduce fuel loads, investigation and implementation of more intensive utilisation of logging residues by on-site chipping or similar means will be vigourously pursued, together with the possibility of utlising the waste from regrowth thinning in the same way.

4.2 Collection and study of weather and climatic records will receive continuing emphasis, together with investigation of the occurrence of meteorological events relevant to fire management planning.

4.3 Fuel accumulation and fire ecology studies investigating the impact of fire on the whole forest environment will continue.

11th May, 1982

Appendix 7

PRESERVED AREAS OF DRY SCLEROPHYLL ASH TYPES ON STATE FORESTS

Flora Reserves

Brown Mountain F.R. No. 73032. Glenbog S.F. 955 ha. Includes White Ash on exposed ridges, and some extensive dry slopes with Silvertop Ash-Stringybark.

Mt. Dromedary F.R. No. 79948. Bodalla S.F. 1 255 ha. White Ash on higher prominences; Silvertop Ash types also present.

Tennyson Creek F.R. No. 79968. Bondi S.F. 380 ha. Carries extensive stands of Silvertop Ash with Stringybarks and Peppermints on eastern section.

Forest Preserves

1. Currowan F.P. Currowan S.F. 17 ha. Includes some Silvertop Ash.

2. Birds Rock F.P. Newnes S.F. 447 ha. Some very good stands of Blue Mountains Ash, associated with Brown Stringybark; also some Silvertop Ash stands.

133. Little Sugarloaf F.P. Dampier S.F. 30 ha. Silvertop Ash-Stringybark present.

134. Boot Hill F.P. Dampier S.F. 100 ha. White Ash on higher ridges; Silvertop Ash-Stringybark.

141. Lyrebird F.P. Currowan S.F. 93 ha. Silvertop Ash-Stringybark on ridges and west-facing slopes.

144. Pinkwood F.P. Dampier S.F. 57 ha. Some Silvertop Ash type.

145. Parkers Gap F.P. Tallaganda S.F. 96 ha. Some White Ash, here at about western limit.

146. Milo F.P. Monga S.F. 81 ha. Some White Ash present.

149. Wallaby F.P. Currowan S.F. 70 ha. Silvertop Ash type on ridge.

150. Mogood F.P. Clyde S.F. 188 ha. Some Silvertop Ash-Stringybark on ridges.

158. Illawamba F.P. Murrabrine S.F. 83 ha. Includes small areas of Silvertop Ash-Stringybark.

177. Careys F.P. Doyles River S.F. 110 ha. Mostly rainforest, but includes one of the North Coast occurrences of Blue Mountains Ash.

182. Jilliga Ash F.P. Dampier S.F. 65 ha. Ridge of Jilliga Ash at eastern-known limit; some Silvertop Ash.

183. Jerrabattgulla F.P. Tallaganda S.F. 32 ha. Includes some White Ash.

185. Watergums Creek F.P. Nadgee S.F. 242 ha. Silvertop Ash type on higher slopes.

187. Maxwells F.P. Nadgee S.F. 384 ha. Includes Silvertop Ash on ridges.

188. Bondi Gulf F.P. Bondi S.F. 450 ha. Silvertop Ash types included with a range of other types.

190. Stingray Swamp F.P. Penrose S.F. 265 ha. Sandstone ridges carry Silvertop Ash types.