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

10. CYPRESS PINE TYPES

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10. CYPRESS PINE TYPES

1. INTRODUCTION

White Cypress Pine[1] is the main timber tree of the western districts of NSW - a relatively small tree, growing with various eucalypts and other trees, and providing a scented timber that is famed for its termite-resistance. Stands containing White Cypress Pine or the less valued Black Cypress Pine (often simply referred to as "White Pine" and "Black Pine") are the most widespread of all major plant communities occurring on State Forests in NSW. The stands cover some 12 percent of the total State Forest area and over the past decade have produced between 5 and 7 percent of the total Crown sawlog yield.

By and large the White Pine forests of today are very different in structure and appearance from those seen by the early European settlers a century and a half ago. Over much of the Cypress Pine zone they are also now merely the remnants of a once vast forest belt, existing as forested islands in a sea of wheat and pasture - a fact that gives them considerable landscape and habitat value, supplementing their value as sources of wood and herbage.

Silviculturally the types exhibit features of great interest: for the first half of this century many of them were regarded as a terminating and non-renewable resource, due to an almost complete failure to establish new regeneration; the stands now present have in most cases been established during two great waves of regeneration, one dating from before the 1890s and the other since the 1950s; and the regrowth stands, often with very high stockings, have a strong tendency to "lock", and for even the dominant stems to grow extremely slowly, unless the stands are heavily thinned. They grow in a semi-arid climate, with long, hot summers, frosty winters and a generally unreliable rainfall. Together, these provide silvicultural and management problems and challenges unusual in the Australian forest context.

2. FOREST BOTANY AND ECOLOGY

2.1 Taxonomy and Nomenclature

2.1.1 Cypress Pines

The Cypress Pines belong to the genus *Callitris* in the conifer family Cupressaceae. In 19th century writings they are often, though incorrectly, placed in the genus *Frenela*, erected because an early French botanist thought the correct name might be confused with the Myrtaceae heaths, *Calythrix*.

Closely related genera are the Western Australian *Actinostrobus* (distinguished by a number of whorls of bracts at the base of the cones), New Caledonian *Neocallitropsis* (8 cone scales, in two whorls of 4; stiff, incurved leaves in 8 vertical rows), North African *Tetraclinus* (4 only thin cone scales, branchlets flattened, leaves in whorls of 4) and Southern African *Widdringtonia* (4 thick cone scales, opposite leaves). All, at various times, have been included in *Callitris*, and they together form a tribe of the Cupressaceae.

Garden (1956), in her review of the genus, recognised 16 species, one with 3 subspecies. Two species were from New Caledonia and the remainder from Australia. Nine of the species were listed as occurring in NSW, and a tenth is now also known to be present (*C. oblonga*). The three subspecies of *C. preissii* and hybrids between two of these and White Cypress Pine were also recorded within the State.

[1] For botanical names of plants mentioned in text, see Appendix 1. See also Section 2.1.1 for discussion on Cypress Pine nomenclature.

Many of the botanical names, which had been in common use prior to her review (eg. Baker & Smith, 1910; Maiden, 1917) were replaced by Garden, including those of the two main commercial species, Black and White Cypress Pine. Unfortunately in the case of White Pine she got it wrong, and the botanical name of this well-known species has remained in a state of confusion. This tree had been called *C. robusta* by Maiden (a name later restricted to a Western Australian species, and subsequently dropped by Garden), and *C. glauca* by Baker & Smith, a name that was both most appropriate and, by the 1950s, universally accepted. Garden considered that this name had not been validly published, and replaced it by *C. hugelii*, dating from the 1850s. However, there were doubts about what species this name did apply to, and at about the same time Blake (1959) suggested that White Cypress Pine and Coastal Cypress Pine (*C. columellaris*) were actually the same species, since in Queensland the two forms merge together. Consequently for the next quarter century White Cypress Pine was widely known as *C. columellaris* "inland form". In the meantime some botanists still found no problem in staying with *C. glauca* (eg. Boland et al., 1984) while Beadle (1981) hedged his bets and referred to it as *C. "glauca "*. Thompson (nee Garden) & Johnson (1986) have attempted to resolve the problem by redescribing the tree as *C. glaucophylla*, and this is the name accepted by the NSW National Herbarium, though those who consider *C. glauca* was validly published will presumably continue to use that as the name of White Cypress Pine.

So much for the stability of botanical, as opposed to common, names for plants!

More recently Adams & Simmons (1987) have disputed parts of Garden's classification in relation to Cypress Pines in Victoria. Using both morphological features and essential oil chemistry they reinstate Mallee Pine (Garden's *C. preissii spp. verrucosa*) as a full species, *C. verrucosa*. They also consider that the recognition of the other two subspecies of *C. preissii* is not justified. Further than this they were unable to find any consistent basis of separation between White Cypress Pine and *C. preissii*, and suggest that these *"may best be described as two extremes of a single variable species".* However, taking a realistic line sometimes lacking in taxonomic matters, they note that the taxonomic difficulties only arise in the small area where the ranges of the two species overlap, and conclude, *"there are pragmatic arguments for retention of specific status".* God bless the ladies!

Based on the classification of Garden (1956), as modified by Adams & Simmons (1987), the species of Cypress Pine known from NSW are listed in Table 1, with other commonly used botanical names and an indication of their area of occurrence. Garden (1956) provides a key to identify the various species, and a very usable key to the main species is also given by Anderson (1968). Besides White and Black Cypress Pines, Slender Cypress Pine and Mallee Pine occur in the general area dealt with by these Notes.

Black Pine has a somewhat more easterly distribution than White Pine, but the two species can occur together over a wide belt, with the Black Pine generally found on steeper sites and more skeletal soils than White. Where occurring together they can usually be distinguished by foliage colour - dark green in Black Pine, pale ashy green in White, though occasional specimens of White Pine with dark foliage occur in many districts. Black Pine normally has a different and distinct stem form and a more coarsely patterned bark, while in the open cones White Pine has a single, often fairly long columella, whereas Black Pine has a short 3-lobed columella (or even 3 separate columella). Black Pine tends to retain its old, open cones on the branches, whereas in White Pine they are shed after seedfall and are usually common on the ground beneath the trees.

South of the Murrumbidgee River, White Cypress Pine is often called "Murray Pine", while in districts where only White Pine occurs, old heavily branched specimens may be locally known as "Black Pines". In some districts Black Pine may be called "Red Pine", "Kerosene Pine" or, in some old references, "Mountain Pine".

Table 1
CYPRESS PINES (CALLITRIS SPP.) OF NSW

Common Name	Current Botanical Name	Other Botanical Name	Occurrence
Coastal Cypress Pine	Callitris columellaris	C. columellaris "coastal form", arenosa	Far N. coast; S. Qld
White Cypress Pine	C. glaucophylla	C. glauca, C. robusta, C. hugelii, columellaris "Inland form"	Western NSW, Snowy R. Valley other mainland States
Slender Cypress Pine (Rottnest Island Pine)	C. preissii	C. robusta (not NSW), C. gracilis, preissii spp. preissii, C. propinqua, C. preissii spp. murrayensis	Murray valley, Bylong district, WA, SA, Vic
Mallee Pine	C. verrucosa	C. preissii spp. verrucosa	Central W. NSW (also hybrids with white Pine, eg. Narrabri district where the species itself is not known; Vic.
-	C. baileyi	-	Isolated, Far N. Coast & S. Old
Brush Cypress Pine	C. macleayana	Genus Octoclinis	Rainforest margins, N. Coast
Mueller's Cypress Pine	C. muelleri	-	C. & S. coast
-	C. oblonga	-	Tas.; rare N. NSW
Steelhead	C. monticola	-	Shrub. N. Tablelands
Port Jackson Pine	C. rhomboidea	C. cupressiformis	Coast & Tablelands; Qld., Vic Tas., SA
Black Cypress Pine	C. endlicheri	C. calcarata	Tablelands & W. Slopes, rarely coast; Qld., Vic.

2.1.2 Eucalypts

White and Black Cypress Pines rarely occur naturally in pure stands, but rather are usually associated with various eucalypts and often other, smaller growing trees and shrubs as well (see Section 2.2).

The more common eucalypt associates of the Pines (including Angophora spp.) are listed in Table 2, showing their botanical relationships as indicated by Pryor & Johnson (1971). Other species may also occur, notably with Black Pine in its more easterly occurrences. The predominance of Red Gums, Boxes and Ironbarks as associates in these western forests is clearly shown.

2.2 Forest Types

The types covered by these Notes are those comprising the Black and White Cypress Pine leagues (Forestry Commission of NSW, Research Note 17 - Forest Types of NSW). The descriptions of these leagues are:

2.2.1 Black Cypress Pine League

This league has some forestry value both for productive and protection purposes. It typically contains Black Cypress Pine, usually as a clear dominant in the stand, and it occupies steep slopes and ridges where there is commonly only shallow soil depth. It is most widespread in the Western Slopes districts and at lower altitudes on the western parts of the Tablelands.

Structurally the league shows features of both savannah woodland and dry sclerophyll forest communities, the more open stands resembling the former and more closed stands the latter. Height development is usually poor, rarely exceeding 15m, but nonetheless the stands may be logged for the Cypress Pine stems.

Table 2

EUCALYPTS ASSOCIATED WITH CYPRESS PINES

Botanical Relationships
(from Pryor & Johnson, 1971)

Subgenus	Section	Series	Subspecies	Species	Code	Common Name
Angophora	Liberia	Costatae	Floribundinae	floribunda	AAABB	Roughbarked Apple
			Costatinae	costata spp. leiocarpa	AAADAB	Smoothbark Apple
Corymbia	Rufaria	Gummiferae	Polycarpinae	polycarpa	CAFIB	Pale Bloodwood
			Gummiferinae	trachyphloia	CAFW	Brown Bloodwood
Monocalyptus	Renanithera	Piperitae	Haemastominae	rossii	MATKF	Scribbly Gum
Symphyomyrtus	Exsertaria	Tereticornes	Tereticorninae	blakelyi	SNEEF	Blakely's Red Gum
				chloroclada	SNEEH	Baradine Red Gum
				dealbata	SNEEJ	Tumbledown Gum
				dwyeri	SNEEL	Mallee Gum
				camaldulensis	SNEEP	River Red Gum
	Adnataria	Largiflorentes	Largiflorentinae	populnea	SUDEA	Bimble Box
		Intertextae		intertexta	SUH:A	Western Red Box
		Moluccanae		woollsiana	SUL:D	Western Grey Box
				pilligaensis	SUL:F	Pilliga Box
				albens	SUL:G	White Box
		Crebrae (Pruinosae)		fibrosa spp. nubila	SUB:AB	Blueleaved Ironbark
				crebra	SUP:S	Narrowleaved Ironbark
				melanophloia	SUP:V	Silverleaved Ironbark
		Polyanthemae		conica	SUT:B	Fussy Box
				polyanthemos	SUT:D	Red Box
		Paniculatae		caleyi	SUV:K	Caley's Ironbark
		Melliodorae		melliodora	SUX:A	Yellow Box
				sideroxylon	SUX:IA	Red Ironbark

2.2.2 White Cypress Pine League

This is the most important league found in the interior of NSW where it originally occupied extensive areas. Because many of the sites that it occupies have proved suitable for pastoral and agricultural purposes, the league has been destroyed over wide areas, and considerably altered by man's activities elsewhere. Even so it still occurs over a greater area of State Forests than any other league.

The league occurs throughout western NSW with the more important and productive stands found on the Slopes and Plains between about the 400 and 600mm isohyets. It shows a general preference for rather light, well-drained soils.

The league is typified by the presence of White Cypress Pine as a dominant or indicator species in the stand. This is associated with a wide variety of other species.

The original structure of the White Cypress Pine stands appears to have varied from tall woodland in the more favoured sites to shrub woodland in the drier areas, with the eucalypts normally attaining a slightly greater height than the Pine, with stand heights of up to about 25m. This structure still exists in many areas, but elsewhere it has been considerably altered by

(European) man's activities, often resulting in much denser Cypress Pine stands than would appear to have been normal in pre-European times and sometimes resulting in a marked reduction in the component of large eucalypt trees.

2.2.3 Individual Forest Types

Twelve individual types are recognised in the Commission's classification, five in the Black Pine league, six in the White Pine league, and one common to both:

Type 180 Black Cypress Pine. Clear dominance of Black Pine, though other species usually also present. Widespread on steep slopes and skeletal soils.

Type 181 Black Cypress Pine-Ironbark. One of the western Iron barks is associated with the Black Pine, along with other species. Drier parts of league's range on shallow, skeletal soils, particularly in north of State.

Type 182 Black Cypress Pine-Box. One of several species of Box, including White, Western Grey and Red, occurs with the Pine. Usually more easterly sites than Type 181.

Type 183 Black Cypress Pine-Red Gum. Dominance shared between Black Pine and usually Tumbledown Gum or less commonly Blakely's Red Gum, with other species present. Probably most wide ranging of the Black Pine types.

Type 184 Black Cypress Pine-Scribbly Gum. Usually found in higher altitude sites on soils of low fertility. Other species besides Black Pine and Scribbly Gum may be present, including Brown Bloodwood, Red Stringybark and Red Box.

Type 188 White Cypress Pine. Stands clearly dominated by White Pine, though occasional stems of other species of similar or greater height may also occur. Apparently rare under natural conditions.

Type 189 White Cypress Pine-Narrowleaved Ironbark. Bull Oak usually also occurs with the dominants, and other species may be present. Widespread in northern part of State, usually on sandy soils with underlying hardpan.

Type 190 White Cypress Pine-Brown Bloodwood. Occurs on poor, sandy soils in more upland areas. Other associates often include Iron barks and Tumbledown Gum. Generally of low site quality and little productivity.

Type 191 White Cypress Pine-Western Ironbarks. White Pine occurs with some Ironbarks other than Narrowleaved, and usually with other species. Mostly in more northern districts, though stands with Red Iron bark occur as far south as the Temora district. The type is usually regarded as producing rather poor quality Pine, though some stands where the Pine is associated with Silverleaved Ironbark are of good quality.

Type 192 White Cypress Pine-Red Gum. The Red Gum is usually either Blakely's, or, in the Pilliga Scrub, most commonly Baradine Red Gum. Associated species may include Apples. Characteristic of deep sands, often with large Pine.

Type 193 White Cypress Pine-Box. A very variable type with Pine and one or more of a number of Boxes, and with corresponding range of site conditions. Yellow Box, as an associate, is usually found on light, sandy soils; Bimble and Pilliga Box occur on heavier soils; Western Grey Box replaces Pilliga Box south of the Warrumbungles and may also extend to lighter, loamy soils, often with Dull Oak as an associated species; White Box occurs on rather gravely soils; Western Red Box is found in the lower rainfall sites, usually on rather sandy soils.

Types 185 & 194 White Cypress Pine-Black Cypress Pine. The two Pines occur together, usually with other tree species also present. Stands usually limited in extent, and occurring in sites of broken relief.

Type 195 White Cypress Pine-Hillside Red Gum. A type of limited commercial value found on stony, hilly sites with shallow soils, mostly in the central districts. The Red Gums present are usually either Tumbledown Gum or Mallee Gum (Dwyer's Red Gum).

The types listed above can often usefully be divided into subtypes to indicate the actual species of eucalypt associated - particularly in the cases of Types 191, 192 and 193.

The classification given above was largely based upon, and simplified from, that developed by Lindsay (1967) - a system that forms the basis of most type maps still used in the Cypress Pine districts, and that has proved extremely useful for management purposes. Descriptions of these types, taken directly from Appendices A & B of Lindsay's publication and thus including Imperial measure and some names no longer in use, are reproduced as Appendix 2.

Lindsay's classification separated types where the Pine component was dominant from those where the eucalypts were dominant, eg. his type 11, PPf, cf. 33, PfP; type 2, PCO cf. 22, COP; type 8 PBA cf. 28, BAP. Dominance was ostensibly conferred on the component with the larger BA or volume, but Lindsay modified this in the case of Pine-dominance to classify Pine as predominant in all stands carrying a stocking of 100 or more stems per hectare of Cypress Pine 10cm DBH or larger, or an equivalent BA of smaller stems. *"The basis for this definition was that stands with the minimum stocking described were considered suitable for management as Pine areas."*

As with most forest areas in NSW, the Cypress Pine types occur in a mosaic both of various Pine types and of types lacking a significant Pine presence. The non-Pine types may include areas dominated by species that rarely, if ever, are associated with Pine, eg. Broombush, Mallees, Belah, Brigalow, River Red Gum. More commonly, however, in the forest areas the non-Pine types are dominated by eucalypts that elsewhere occur as associates of Cypress Pine (types 44 - 56 in Lindsay's classification), and that form the Western Box-Ironbark and the Yellow Box-White Box-Red Gum leagues in the broader Forestry Commission classification (1965). The transition from Pine-eucalypt to eucalypt-Pine to eucalypt type is a common pattern in many Cypress Pine forests. It should be noted that the boundaries between these types are often quite dynamic, with human activity tending to convert eucalypt-Pine to Pine-dominant, and in some cases to introduce Pine regeneration into types previously lacking the conifer.

In general the Black Cypress Pine stands have probably altered little in appearance since European settlements, and occur as a form of dry sclerophyll forest. By contrast many of the White Pine stands have undergone substantial change (see Section 5), and there is much evidence that these initially appeared as relatively open woodlands (ranging from tall woodland in the more favoured easterly sites to scrub woodland further west) with a clear dominance of eucalypts and a scattered occurrence of often large Pines which, nonetheless, were usually lower in height than the eucalypts. Changes in fire regime, grazing patterns and deliberate efforts to reduce or even eliminate the eucalypt component have resulted in the present forests with fewer eucalypts and often dense, even-aged Pine stands.

The classification of the Cypress Pine types by the Forestry Commission contrasts strongly with the treatment of these communities by more traditional ecologists. Whereas foresters have concentrated on the Pines, as the species of major commercial significance, the traditionalist approach has been to emphasise the taller eucalypt component and regard the Pine as usually a minor (rarely a co-dominant) element in the community. As a result the more orthodox ecological reports covering the Cypress Pine forests tend to recognise a plethora of alliances or equivalent communities, each dominated by a single eucalypt. An outline of some of the more important of these classifications, as they affect the Cypress Pine zone, is given in Appendix 3: classifications of Beadle (1948, 1981), Moore (1953), Costin (1954) and Specht et al. (1974, based on Hayden, 1971) are included.

It might be added that, despite these considerable differences between the two approaches and the communities that they provide, neither approach should be regarded as "right" or "wrong". Vegetation classification is carried out to serve various purposes, and both approaches used in the Cypress Pine zone serve their respective aims. From the Commission's point of view, the recognition of the Pines as the major component in these stands merely reflects the use that these types receive, as well as the distinctive appearance of the types.

2.3 Environment

Climatic details are given in Appendix 4. The first 9 sites typify the White Cypress Pine zone, with Black Pine also nearby in the case of Warialda, Baradine, Gunnedah, Wagga and Parkes, and the last 3 represent primarily Black Pine sites. White Pine is only present as isolated trees or clumps in locally favoured sites near Broken Hill; at the other sites it occurs in forest stands.

2.3.1 Rainfall

Features of the climate of the White Cypress Pine types are the sub-humid to semi-arid conditions with a rather continental aspect, giving hot summers and cool winters with occasional to frequent frosts. Annual rainfall in the forested areas ranges from about 700mm to 350mm; over much of the State the distribution of rainfall appears fairly uniform, tending towards a summer maximum in the north and a winter maximum in the south, but in reality unreliability of rainfall is probably the most distinctive feature of its distribution, and drought periods are common.

Black Cypress Pine types are rare where annual rainfall drops below about 500mm, but extend into higher altitude sites where cooler winter temperatures are experienced.

2.3.2 Soils

White Cypress Pine *"occurs on a wide range of* ***soil*** *types; good stands are found on very infertile soils with ph ranging from 5 - 7.9, from terra rossa and solodized solonetz to alluvial sands with little profile development. The most common soils have a sandy or loamy surface, often with clay-loam at depth"* (Boland et al. 1984). Lindsay (1967) notes that it may be completely absent on heavy soils and is not found on alkaline soils.

Soils of the Pilliga Scrub were studied by Waring (1950) who demonstrate a close relationship between soil types and vegetation in the area, which is the largest remaining occurrence of Cypress Pine stands in NSW. The area overlies Mesozoic sediments (mostly sandstones) which outcrop in the east and south (Warrumbungle Range) and which were subjected to laterisation during the mid-Tertiary. Erosion of the sediments has resulted in most of the Pilliga Scrub having surface deposits which have buried much of the earlier strata and which provide a very flat land surface. Former streams that flowed across this landscape have mostly silted up with sand, and are recognisable as low, meandering ridges made up of deep deposits of coarse sand: these are known as "sand monkeys", "monkey" apparently being derived from an Aboriginal word, "moongie”.

The general surface deposits have produced **solodized solonetz** soils, which exhibit a bleached A_2 horizon *("loose snuffy powder mixed with sand"),* often above a cement-like A_3 horizon and overlying a heavy textured B horizon showing columnar structure. Waring named the main form of these soils as Merriwindi Sandy Loam, with the similar Yarrie Sandy Loam (distinguished by free $CaCO_3$ in the profile) occurring in lower topographic positions. Solodization is a soil-forming process akin to podsolization, but occurring under lower rainfall conditions and influenced by the presence of Na in the profile. Neither soil type occurred on slopes greater than 1° 40'.

The sand monkeys carried soils virtually without profile, and were classed by Waring as **deep sands.** Most he named Moongie Sand; those with a somewhat greater proportion of fine material he called Culgoora Loamy Sand.

Soils classed as **grey and brown soils of heavy texture** occurred in the lowest topographic positions, often as wide, flat areas. Here Waring recognised both gilgaied and non-gilgaied soils. The non-gilgaied soils had sodium in the exchange complex and produced hard clays that he named Wooleybah Clay Loam. The gilgai soils carried calcium in the exchange complex and had a better structure; they were variable in profile and other characteristics and were grouped by Waring as the Gilgai Complex. The sandstone ridges carried skeletal **Lithosols**, and some of the ridges showed **lateritic** profiles in various stages of erosion.

Table 3

SOIL - VEGETATION RELATIONSHIPS - PILLIGA SCRUB
(after Waring, 1950)

Soil	Vegetation
Laterite	Typically "Broom Plains"
Lithosol	Blueleaved Ironbark, Brown Bloodwood and Black (sometimes white) Cypress Pine
Deep Sands	
Moongie Sand	White Cypress Pine-Red Gum, often with Roughbarked Apple
Culgoora Loamy Sands	White Cypress Pine-Silverleaved Ironbark
Solodized solonetz	
Merriwindi Sand Loam	Pine-Narrowleaved Ironbark-Bull Oak
Yarrie Sandy Loam	Bimble or Pilliga Box-Pine
Grey and Brown Soils of Heavy Texture	
Wooleybah Clay Loam	Bimble or Pilliga Box (way have Pine)
Gilgai Complex	Belah, Brigalow, Box

A simplified outline of the relationship between these soils and various plant communities is given in Table 3, though rather more variability exists than is indicated. Waring commented that a vegetation map of the Pilliga could be accepted as an approximate soil map, but noted that Lindsay's types were not fully satisfactory in this regard. He also observed that some species served as useful indicators of particular soil characteristics. Thus:

- **Bull Oak**, with no known exception, occurred only on solodized solonetz soils.
- **Narrowleaved Ironbark** avoided heavy soils or soils with $CaCO_3$ in the profile, preferring soils with acidity to a considerable depth.
- **White Cypress Pine** favoured sandy soil.
- **Boxes** were usually on heavier soils.
- **Broom plains** - areas of heath dominated by Broombush and Common Fringe Myrtle, and scattered, sometimes over extensive areas, within the Pilliga Scrub - often occurred on eroded laterities, but could also appear on solodized solonetz soils.

The common factor in all broom plain soils sampled by Waring was the absence of calcium among the exchange bases, whereas in the Merriwindi and Yarrie Sandy Loams supporting forest growth the exchange complex at the soil surface was always predominantly calcium.

Generally similar patterns can be identified in other Cypress Pine areas, though details of the soil types vary considerably. Probably in NSW as a whole the most important major soil group supporting Cypress Pine was that of the **red-brown earths,** but these today are comparatively rare in forest areas, having been extensively cleared for pasture or agricultural use. Nonetheless these soils, distinguished by their red surface colour (due to iron) and the clayey B horizon, usually with free $CaCO_3$, probably still support the main stands of Cypress Pine in the southern half of NSW, particularly in sites where the A horizon has a high sand content (eg. Moore, 1953). Soils classed as **podsolics** support Cypress Pine in the more easterly areas, and tend to merge into the solodized soils further west. In essentially all cases, however, White Cypress Pine soils are characterised by light textured surface horizons (range sand to loam), though the types may occur on clay loams where there are compensating drainage features such as sloping topography, gravel in the profile or low annual rainfall (Lacey, 1973). The tree will not tolerate impeded drainage, but occurs over a wide range of soil ph and fertility levels.

2.3.3 Topography

Black Cypress Pine occurs most commonly on skeletal Lithosols, and in consequence is usually found in areas of rather rugged topography, on stony ridges or relatively steep slopes. As Baker & Smith (1910) remarked, *"It is the pine which has given rise to the term 'Pine ridge' so commonly applied to hills in NSW."*

By contrast, over much of its range White Pine is found on land of very gentle relief, though it extends into steeper land, eg. in the isolated occurrence of the Snowy River valley in southeastern NSW (Costin, 1954; Clayton-Green, 1981), on the lower slopes of the Warrumbungle and Nandewar Ranges, and on the hills of the Gwydir valley near Bingara . In the Gwydir valley Pine is commonly associated with Silverleaved and Caley's Ironbarks, and in the Snowy valley with White Box - all of them notably glaucous-foliaged trees. Referring to the Snowy valley occurrence, Clayton-Green observes: "*White Cypress Pine and White Box form a woodland, with the two species occurring in various ratios depending on aspect and altitude. Pine forms almost pure stands on north aspects at altitudes below 550m, whilst on south aspects or at elevations greater than 650m White Box often forms a pure community."* (Common names substituted). On other aspects at lower altitudes mixtures of both species occur, with or without a shrubby understorey.

Another interesting occurrence of White Cypress Pine is on the ancient sand dunes lying within the flood plain of the Central Murray valley. In general, however, the White Pine stands are typified by little topographic relief.

2.3.4 Fire

As in other Australian forest communities, fire is an important factor in shaping the White Cypress Pine forests. Pine is fairly susceptible to fire damage, particularly as regeneration or under conditions where all its foliage is killed. However it produces little litter and so, because of insufficient ground fuel, fire is virtually unable to penetrate pure Pine stands. On the other hand where eucalypts are present, with their heavy litterfall, or where a very open canopy has led to increased grass growth, fire will burn under Pine. Clayton-Greene (1981) states that grass fires, because of their transitory nature, are normally not sufficient to kill White Pine once it is above the seedling stage. Although true of mild fires, this is certainly not true of hotter fires, particularly where the grass is sufficiently tall to carry the flames into the crown of the young Pines.

There is considerable evidence that the Pine stands of Aboriginal times were maintained as open, grassy woodlands by frequent burning (see, eg. Rolls, 1981; pp. 245-251). Haynes (1985) has provided a fascinating account of Aboriginal use of fire in Arnhemland (NT), and particularly its significance in relation to the occurrence of Northern Cypress Pine, a very close relative of White Pine. Lessons that emerge are firstly the widespread use of fire, conforming with early accounts of Aboriginal burning in southeastern Australia, and secondly the ability and skill of the Aborigines in controlling fire behaviour and extent by their knowledge of seasonal conditions - an ability that could allow particular areas of Pine to remain unburnt, and for regeneration to become established, for lengthy periods if they so desired. Whilst Arnhemland is over 2 000km from western NSW, there is much evidence to suggest that similar skills, relevant to their own territories, had been acquired by most Aboriginal groups, and that similar practices shaped many forests, and certainly the Cypress Pine forests, throughout Australia. Besides the deliberate Aboriginal fires, wildfires (eg. from lightning strikes) would undoubtedly also have occurred, probably often occurring under conditions when Aboriginal burning would have been curtailed.

The responses of different species to fire are among the biotic factors of the environment. In the Cypress Pine types other such factors include the low litterfall from Pine compared with eucalypts, the low ability of Pine to recover from fire compared with eucalypts, and the generally greater tolerance of young Pine to shading and competition.

2.4 Other Environmental Features

Cypress Pine stands, and particularly those retaining a component of eucalypts, support a relatively rich fauna - a feature noted by Costin (1954) and graphically presented by Rolls (1981) in his descriptive history of the Pilliga Scrub. Rolls lists over 200 species of birds from the Pilliga Scrub and its immediate environs. However, limited studies in the Narrandera district suggest that the smaller "island" forests show an absence of small terrestrial fauna. On the other hand, isolated Cypress Pine forests are sometimes regarded by neighbouring landowners as acting as harbours for kangaroos that then damage adjacent farmlands.

3. OCCURRENCE

White Cypress Pine as a tree has a wide distribution through western NSW and it occurs east of the Divide in two areas; one in the upper Hunter valley where its distribution is merely an easterly extension through the Hunter Gap, and the other a very isolated occurrence in the Snowy valley - an occurrence described by Costin (1954) as *"one of the most remarkable on the Monaro".*

The main stands of commercial significance occur in a broad belt through the Western Slopes and the eastern part of the Western Plains, extending to higher altitudes in the north, where they edge closer to the Tablelands, than in the south. The broad pattern is portrayed fairly accurately in the NSW forest types map (Forestry Commission of NSW 1978), though this omits the stands south of Gunnedah. Forestry districts where Cypress Pine features as a major type are Inverell, Tamworth, Baradine, Gilgandra, Forbes, Condobolin, Griffith and Narrandera. By far the most important area, with some 400 000 ha of State forest (not all Cypress Pine types), is in Baradine district and makes up the Pilliga Scrub. Over much of the remaining area the Pine forests tend to occur as scattered patches (some of large extent, eg. Buckingbong State Forest of over 11 000 ha) in a landscape that is otherwise largely devoid of forested land.

Black Cypress Pine has a more easterly occurrence, ascending in places to altitudes of about 1 000m, typically in steep, rocky sites. It is found east of the Divide in a number of places, with its most coastal occurrence being in the Pokolbin-Broke district of the Hunter Valley. Westerly outliers of Black Pine occur in the Condobolin and West Wyalong districts. Its distribution is not shown separately on the NSW forest types map: this reflects the rather scattered, albeit well defined, nature of the Black Pine stands.

The area of Cypress Pine types in NSW was assessed by Hoschke (1976), and these figures have recently been revised. On the best current estimates the total area of the types in NSW is about 1 800 000 ha: 1 500 000 ha of White Pine and 300 000 ha of Black, with 370 000 ha of White Pine and 30 000 ha of Black on State Forest. Other major tenures for White Cypress Pine stands were leasehold (640 000 ha) and private (500 000 ha), while the largest area of Black Pine was in private ownership (120 000 ha), with significant areas also in leasehold and vacant crown land (90 000 ha) and national park (40 000 ha).

The area of Black Pine is probably little less than that present at the time of European settlement: Black Pine sites do not lend themselves to alternative land use. By contrast the area of White Pine has been substantially diminished, and is today possibly only a tenth of what it was a little over a century ago.

Garden (1956) gives distribution maps for both species in Australia as a whole, her White Cypress Pine map being essentially reproduced by Boland et al. (1984). Such maps, based on herbarium collections, can suffer from over - or under - collecting in particular regions, and the White Cypress Pine map shows an under-representation of sites in southern Queensland, where White Pine has a presence and importance similar to those in western NSW. A more accurate portrayal is given in the Atlas of Australian Resources Forest Resources map (Dept. of National Development, 1967).

Referring to Cypress Pine in Queensland, Johnston (1987) notes that there are 3 main occurrences: a southern development south of Dalby, with the main forests at Inglewood and Millmerran; a mid-western development centred at Yuleba and extending north-west to Barakula and Taroom; and a far western development extending from Injune to Augathella and south to Mitchell. The far western occurrence, associated with an inland bend in the Great Divide, is *"arguably the largest naturally occurring concentration of the species in the country",* with some 6 million cubic metres of harvestable timber known to occur in a compact area about 200km across.

Besides the Queensland occurrence, White Cypress Pine occurs in all mainland States and in the southern part of the Northern Territory, but usually in relatively small and localised stands of botanical, rather than commercial interest. An account of the Victorian occurrences has been given by Adams & Simmons (1987).

Black Pine occurs into both Queensland and Victoria as extensions of its NSW range, being found as far north as Wide Bay. However, its distribution in both States is limited, and it is essentially a NSW species.

4. UTILISATION

The Cypress Pine types are the main timber producing forests of western NSW and details of the properties of some of the species are given in Appendix 5 (from Bootle, 1983).

White Cypress Pine is by far the major species, current sawlog production in NSW averaging about 100 000m^3 a year, with some 80 percent coming from Crown sources. Production in the past has been considerably higher, reaching a post-war peak of 275 000m^3 in 1954-55, when two thirds of the total production was from private property: this almost entirely represented the clearing of forest stands to provide agricultural land. In that year, Cypress Pine contributed over 15 per cent of all sawlogs cut in NSW; it now makes up about 6 percent.

Logs cut in the early days were of large diameter (over 60cm) and relatively knot-free (Baker & Smith, 1910; Rolls, 1981), and planks cut from such logs can still be seen in old buildings. Today's logs are much smaller, and the tight knots are one of its most characteristic features: *"cat's eyes reflecting the western sunlight"*, as they were described by E.H.F. Swain, in a bid to increase the popularity of the timber.

The timber has a beautiful aroma that envelops all settlements where Cypress Pine is milled and its sawdust and off-cuts are burnt. Another feature is its high resistance to termite attack. Markets for small stems of Cypress Pine are always sought but seldom available, though the Pine milling industry accepts much smaller logs than are usual elsewhere in NSW [2] . However, in the Riverina forests small trees can often be sold for vineyard posts. Cypress Pine is not regarded as particularly suitable for pulpwood (Logan et al. 1985), though mill residue from Narrandera is chipped and used as a contribution to the resource of a medium-density fibreboard plant.

Black Cypress Pine timber is used to a much less extent, even where locally plentiful, and this has apparently always been the case (Maiden, 1917), although it can be found in many old homes. The trees tend to be smaller, often with more sweep and with more numerous and looser knots, and the wood is less durable. Nonetheless it can produce a very showy timber: *"in fact many of the planks are so gorgeous in appearance that care is required in using it for decorative purposes lest it should have too overpowering an effect"* (Maiden, 1917).

Apart from the Ironbarks, the hardwood component in the Cypress Pine forests usually receives only limited and local use for fuel, fencing or similar purposes. The Ironbarks, and particularly Narrowleaved Ironbark, are much more highly regarded, supporting sleeper and pole industries, and in recent times also being milled with the main product being droppers used with electric fences. Despite the glowing description given by Bootle (Appendix 5), Bull Oak receives virtually no use other than for local fuel.

Baker & Smith demonstrated the suitability of Cypress Pine barks as a source of **tannin**, but these do not appear to have been used for this purpose commercially.

[2] One of the compilers of these Notes recalls being in a group of students deposited in Merriwindi State Forest in 1950 and told to pitch their tents. When the foreman returned later in the day he was most irate that mill logs had been used as tent poles.

The inner bark of cut stems of Cypress Pines exudes **sandarac**, an oleoresin collecting in small "tears" which harden and become opaque. Sandarac obtained from the related North African tree, *Tetraclinis articulata*, has been used since Roman times, and the Australian product is essentially identical. Most current use is for pharmaceuticals and confectionery, and there is a minor industry in collecting the tears from stumps in the Cypress Pine stands.

Many of the eucalypts of the Cypress Pine types are highly regarded as honey producers. Other species, and some of the associated shrubs, are useful in producing pollen as feed for bees. As a result, apiarists seek after many Pine areas with a component of Ironbarks or Boxes.

Most of the Cypress Pine forests received their first use by European settlers for **grazing**. This use continues to the present, with grazing on the State Forests being regarded as a valuable management tool to lessen fuel loadings and to reduce excessive stockings of regeneration, as well as a source of revenue. Not all forests are grazed, lack of water and subdivision fencing, unsuitable stand conditions or types, and on occasions frequent shootings from nearby towns acting as deterrents. Grazing is also usually precluded or reduced on areas where regeneration is sought: inability to prevent grazing is regarded as a reason for unsatisfactory regeneration of Pine on some of the more remote western forests. (eg. Steam Plains Management Area - though rabbits also are significant here.)

Both sheep and cattle are grazed, usually under lease or occupation permit, sheep being regarded as the more effective in preventing new regeneration establishment. Goats have also been used, generally under more direct Forestry Commission supervision, in efforts to reduce the secondary regeneration that may follow thinning in Pine stands and that can interfere with the growth of the larger trees. Stockowners are often wary of grazing sheep in forest areas during summer because of the prevalence of Corkscrew and similar Grasses, whose seeds can damage soft tissues and lead to flystrike.

Wells (1974), working in the Cobar district, quantitatively demonstrated the increase in herbage production that follows thinning. Greatest weight of herbage was found under stands where BA was reduced to about 1.3m^2 /ha (40 trees of 20cm DBH per ha), from the original level of about 9m^2/ha; after 3 years without grazing, the thinned stands carried 7 times the herbage of unthinned stands. Stock fodder can also come from other sources, including many of the small trees and shrubs associated with Cypress Pine, and trees such as Kurrajong and Western Rosewood are commonly lopped during droughts to provide stock feed - a practice sometimes observed within State Forest, though more common on private property where such species are frequently retained as shade trees and a fodder reserve.

Outside the State Forests, grazing is the main use made of the 1.1 million ha of White Cypress Pine types under freehold and leasehold tenures. Kingma & Sinden (1971) and Sinden & Kingma (1972) have examined aspects of the economics of multiple use management (timber and grazing) on these lands, and the effects of leasehold constraints on their management.

Cypress Pine types are often regarded as having a generally negligible role in catchment protection, though in some of the steeper northern forest areas (eg. catchments of Keepit and Copeton Dams) their importance increases. The Gunnedah Management Plan notes that in the Keepit catchment thinning the stands improves their catchment value by allowing the establishment of ground cover and thus reducing erosion from storms. However the protective role of the Cypress Pine forests is undoubtedly greater than this infers. Even on flat lands the forest provides protection to the soil under conditions both of hot, dry, windy weather, when neighbouring fields and paddocks suffer wind erosion, and of heavy rain, when water erosion is likely. The Pilliga forests protect a major intake region for the aquifers of the Great Artesian Basin.

As often the main or even only remnants of the original vegetation communities in their districts they have an important role in providing natural habitat for both plants and animals, and also in landscaping and to some extent in providing a recreational resource.

5. HISTORY OF USE AND MANAGEMENT

The Black Cypress Pine types have probably altered little since the time of European settlement, and their use, on the often steep and stony ridges, has been selective and limited.

Not so the White Pine types.

Eric Rolls (1986), whose book "A Million Wild Acres" should be obligatory reading not just for Baradine staff but for all western foresters, has summarised the changes as they affected the Pilliga:

> *"What did it look like? The men who took up the present area of forest, national park and nature reserve were not fools. The water supply was reasonable and most of the area, although obviously inferior to the blacksoil plains, was attractive grazing country. The southern section was chequered with low scrubby ridges, a remarkable coastal growth of all that is still there. But the growth did not extend to the flats as it does now. There was plenty of grass. South-west of Narrabri a big arc of Brigalow extended between Bohena Creek and Coghill Creek at Cuttabri...*
>
> *All the rest of the area was open grassland dominated by either big Narrowleaved Ironbark or old White Cypress Pine spaced about fifty metres apart. Among both the pine and the ironbark grew a scattering of other species of eucalypts, of casuarina, acacia, cassia, and hopbush - a small showing of the modern profusion. It was broken in places by patches of dense scrub.*
>
> *The grasses were dominantly summer grasses but they were prime stockfeed...*
>
> *The fifty-odd runs in the area of the present forest were successful for about forty years. One hundred and thirty years ago it supported about 300 men, 50,000 cattle and a good many thousand sheep, then, twenty years later, when cattle had gone out of favour after one of the periodic slumps in the market, about half a million sheep. The ground hardened quickly and nasty vicious-seeded cousins of the good grasses took over - Spear Grass, Wire Grass, and Red Leg Grass. But the Pilliga still fed a lot of stock until the big drought of the 1870s. The Namoi River dried up to a chain of muddy waterholes, all the red soils powdered into dust. Sheep and cattle died in thousands, so did native mammals. When it rained, pine seedlings leapt away as they do after fire. There were not enough native mammals left to eat them. They all grew. It did not happen only in the Pilliga. White Cypress Pine sprang up down the Lachlan, Bimble Box on every bare little hill in the central-west. Brigalow clumps grew into Brigalow scrubs in Queensland, single wattles into tangled masses. This growth ruined many landholders. It was priceless for Australia. It acted like a protective net thrown over plants and animals that would otherwise have disappeared.*
>
> *It took the trees about ten to fifteen years to drive out most of the squatters and selectors from the Pilliga forests. Some native animals went with them. Bridle Nail-tailed Wallabies were common enough into the 1900s but the new forest did not suit them at all. Bilbies had gone a few years earlier.*
>
> *In the Pilliga the forest won and the once open, grassy woodland became the Pilliga Scrub."*

Over most of the Cypress Pine zone, however, the forest ultimately lost. David Hutchins (1916), reporting on the state - or absence - of forestry in Australia wrote:

> *"But perhaps the cruellest thing for the countryside is the destruction of Cypress Pine! It will hardly be credited outside Australia that, after 127 years of occupation, the Cypress-pine forests of New South Wales have never been demarcated; and, as a result all the best of them are now destroyed. Millions of acres of it have been ring-barked and burnt.*

The destruction of the Cypress-pine forests remains as a deep stain on the page of Anglo -Saxon colonisation. Amongst all the black deeds of Spanish colonisation, I do not think there was anything in wanton and reckless waste to quite equal the destruction of the Cypress-pine forests. They are so precious, from their situation, the only timber to supply all the dry country beyond; they furnished such valuable timber in the very first-class of timber; they were softwoods in a country where softwoods were very scarce. Their conversion to cultivated forests of immense importance is so easy.

Of the three Australian States that are concerned in the iniquity of destroying good Cypress-pine forests, New South Wales is certainly the worst. There was no forest demarcation to discriminate the good forest from the scrub, and all were burnt together in a senseless orgy of ignorant waste."

In fairness, it should be added that the destruction of the Pine forests did give NSW much of its finest sheep and wheat lands and, as Curtin (1987) has observed, the survival of as much forest as still exists, despite the pressures for settlement land after the 1861 Robertson Land Act and in the face of the major shift to wheat growing this century, *"is really remarkable".*

Areas of Cypress Pine were in fact among the earliest Forest Reserves gazetted in NSW, though with little security of tenure. The first Annual Report of the Forest Branch for the years 1882 and 1883 lists over 600 000 ha of Forest Reserves where Cypress Pine (as Lachlan Pine, Murray Pine, etc; occasionally also Black or Red), is among the main species present. Not all of these Reserves survived, but those that did provided the basis for the main Cypress Pine State Forests. The report also refers to *"the alarming spread of pine scrub in portions of the Murrumbidgee and Lachlan districts".* In the 1884 Annual Report an appendix by Dr R. Lendenfield details the life history of the Cypress Pine Jewel Beetle, which he suggests has the ability to clear the pine scrub, a result that would be of *"great advantage to the Colony".* These early reports also refer to the thinning of pine scrub on some Forest Reserves, carried out by the lessees under the supervision of Forest Rangers. Thus in 1884 some 3 900 ha of Reserves in the County of Urana "*were thinned and cleared of scrub, the pine saplings being left at distances of 12 feet (3 .7m) apart".* This was some of the first silvicultural work ever carried out in NSW

The Pine scrub that occurred at this time provides the great bulk of the commercial Pine stands present today, and it is commonly referred to as" '90s regrowth", though as can be seen much of it predated the 1890s by 10 or more years. This wave of regeneration following the drought of the 1870s happened just in time. By 1900 rabbits had spread throughout western NSW in such numbers that, for the next half century, new regeneration of Cypress Pine was almost totally non-existent in the southern half of the State, and by the end of that period management of the Pine stands had become largely an exercise in stringing out, for as long as possible, a resource that appeared to have become quite non-renewable.

With the passage of the 1909 and 1916 Forestry Acts Reserves were progressively dedicated as State Forests, where possible new lands were added to the forest estate, staffing improved. In 1911 the redoubtable E.H.F Swain became District Forester (equivalent to present Regional Forester) at Narrabri, where he introduced the first steps towards a stumpage appraisal system and organised extensive forest assessments. His staff conference in 1915 produced a series of papers - by de Beuzeville, Julius, Simon, Burrows and others - that dealt with the Cypress Pine forests of the north-west and that still make most interesting reading.

As elsewhere in NSW, the Great Depression of the 1930s ultimately proved a boon for many of the Cypress Pine forests, and particularly those of the Pilliga, with unemployment relief labour being used in thinning the dense ' 90s regrowth, in removing the useless overstorey culls, in fencing and in the construction of access roads. The Minister laid the foundation block for the district office at Baradine in 1937.

In 1940 A.D. Lindsay was appointed to Baradine, and later was moved to Head 0ffice as management officer for Cypress Pine forests generally, initiating intensification of management and of data collection that continued till his death in 1964 and persevered subsequently.

Through this period regeneration - or its absence - became the great issue of the Cypress Pine forests, and was the subject of one of Lindsay's few published papers (as opposed to voluminous file reports), in a journal that only ever appeared as a single issue (Lindsay, 1948). Curtin (1987) has provided an excellent account of conditions towards the end of this period and in the early years following the reappearance of Pine regeneration, and some points from this follow.

In the north of the State, where the Pine tended to occur on poorer soils and where rabbits were never as numerous as they were further south, some regeneration did occur, though on many of the better forests (eg. Pilliga West State Forest) it was virtually absent. The southern forests were generally on better soils and were highly regarded for grazing; they were also subject to heavier and more continuous rabbit attack. Neighbouring landholders sought to use the State Forests for grazing, and the Commission was only too pleased to oblige, as this put the responsibility for rabbit control on the Occupation Permittees. Whilst some permittees were more effective at rabbit control than others, the effect on Cypress Pine regeneration tended to be the same, as the permittees who controlled rabbits increased the stocking of sheep to maximise use of the forest pasture; apart from the financial returns, heavy grazing made rabbit control easier.

Myxomatosis was released in the summer of 1950 - 51 and spread rapidly through southeastern Australia, in many districts almost eliminating rabbits in its initial virulence. The wet conditions that aided the spread of myxomatosis by mosquitoes also favoured the germination of Pine regeneration, but where stock grazing continued this was not able to survive. 1951 and early 1952 were dry, with stock numbers down and wet conditions later in 1952 resulted in another spate of germination, much of which initially survived until stock numbers again increased. Fenced plots showed the effects of grazing exclusion on survival, and over the next few years, despite opposition from the graziers and some Commission staff, much of the State Forest area was withdrawn from grazing.

Where conditions were suitable Pine seedlings now appeared in wheat field proportions and Cypress Pine forestry took on a new dimension. By the late 1950s and through the 1960s emphasis was directed towards developing techniques for reducing the density of this regeneration to manageable proportions by 'dozing, ploughing, brushing or other method.

In the late 1960s the removal of cull trees, typically eucalypts, became a major activity, aided by the use of 245T and picloram as arboricides. Some culling was (and in many places still is) necessary but often the treatments were applied to excess, so that few old eucalypts remain over large areas of some Cypress Pine forests: the value of "possum" trees was recognised somewhat too late in these areas, though there is some evidence that hollow-dwelling animals have benefited from the increased number of dead trees.

And thus were the Cypress Pine forests of today shaped. These forests often still carry occasional "Old Greys," the large and ancient Pines that represent remnants of the woodlands, which the first European settlers saw. The merchantable trees, making up most of the stands, are mainly 1890s regrowth, while younger regeneration, some from the 1950s and some more recent, is widely present on most forests wherever the overstorey is sufficiently open. Notwithstanding the culling of the 1960s, eucalypts are present in most areas, usually as trees that slightly overtop the Pine, their proportions relative to the Pine varying with site conditions and treatment history. Bull Oak also is widely present, sometimes developing into dense thicket stands.

6. Regeneration Requirements

6.1 Seeding Habits

The seeding of White Cypress Pine has been studied and reported by Lacey (1972, 1973), who quotes Baird (1953) on the flower and fruit development of Cypress Pines (based on *Callitris preissii*, but believed to apply equally to White Cypress Pine):

"The young male cones and the small branches which bear the primordia of the female cones can be recognised in November or December. There is little change through late summer and autumn and the pollen does not ripen until the following spring.

Trees shedding pollen can be found from early August to late October but on any one tree the cones ripen almost simultaneously and pollen is shed over a period of ten to fourteen days with a peak of two to three days when pollen is released in dense clouds. The majority of (female) flowers are pollinated in September. During the next few weeks the sporophylls thicken slightly and almost cover the ovules but there is little increase in diameter. These minute cones, 2-3 millimetres in diameter, remain unchanged for a year or more before growth is resumed some time between September and November. Once started growth is comparatively rapid… cones have almost, if not quite reached their full size at fertilisation….fertilisation occurs in April and developing embryos are found through May and June."

Rolls (1981) graphically describes the time of pollen shed:

"A yearly marvel is the pollination of the pines. The trees bud in early August. By mid-September they are brown and weighted down with pollen. Then the pines begin to release it. The pollen cones burst open in groups and spurt streams of pollen a metre into the air. The grains drift as a little brown cloud.

The spring of 1973 amazed men who had seen eighty years of pine flowering. In the early morning thousands of trees exploded together. Dense clouds rolled up from the forest. So much pollen drifted into a shearing-shed on the edge of the forest the shearers found it almost too dark to shear by early afternoon."

These clouds of pollen can travel far. Adams & Simmons (1987), quoting a 1980 Monash University honours thesis by K.M. Strickland, report that up to 40 per cent of pollen collected from pollen traps on the Baw Bay Plateau, in Victoria, came from Callitris: these traps were about 500km to the south and south-east of the main Cypress Pine distribution and the pollen was presumably blown in on north-westerly winds.

Baird states that the period between Pollination and the actual fertilisation of the ovules is 18 -20 months for Black Pine and probably longer for White Pine.

The cones dry out and open in the summer following fertilisation, ie. some 3 years after the flower primordia are first discernible, with most of the seed falling in a 4-weeks' period in November and December.

The seed is light brown and 2- or 3- winged. Small cones carry 18 to 24 seeds, and large cones up to 36 seeds. Seed weight also increases with cone size, with a range of from about 60 000 seeds/kg from large cones up to 120 000/kg from small cones.

Seed production varies considerably from season to season, and Hawkins (1966), in southern Queensland, showed that the amount of seed shed could vary by an order of nearly 100 between good and bad seasons. Over a period of 5 seasons he recorded 2 good seed years, 2 poor and 1 intermediate, with seed traps in the best season collecting the equivalent of 70kg of seed/ha, or over 5 million seeds/ha. As Lacey (1973) comments, good supplies can be expected at frequent intervals: even in the poorest season documented by Hawkins, some 60 000 seeds/ha fell to ground. Qualitative records extending over 15 years in the Dalby (Qld) district, also presented by Hawkins, show a surprisingly regular pattern of heavy seedfalls every 3 years, with light to medium seed crops in the intermediate years.

Table 4
FLOWERING AND SEED FEATURES: CYPRESS PINE TYPES

Species	Flowering	No. viable seeds/kg		Germination		
		Mean	Highest	Temp (1)	1st Count (2)	Final Count (2)
Cypress Pine, White	Aug - Oct	c. 80 000	120 000	20	7	28
Box, Bimble	Feb - Mar	1 550 000	3 430 000	(25)	5	14
Box, Pilliga	June - Aug	754 000	1 750 000	20	7	14
Box, Western Grey	Mar - Nov	1 140 000	2 620 000	(25)	5	21
Box, White	Mar - May	256 000	599 000	(25)	5	10
Box, Yellow	Sep - Feb	352 000	1 120 000	25	5	21
Gum, Baradine Red	Sep - Nov	540 000	-	(25)	5	14
Gum, Blakely's Red	Aug - Dec	687 000	2 080 000	30;25	7	21
Ironbark, Broadleaved	Nov - Feb	211 000	400 000	(25)	5	14
I'bark, Narrowleaved	May - Jan	582 000	1 176 000	30	5	14
Ironbark, Red	May - Feb	226 000	735 000	20	5	14
Ironbark, Silverleaved	Sep - Feb	151 000	284 000	25	5	14

Notes: (1) Temperatures recommended for germination tests. Where figure is bracketed, eg. (25), this temperature is satisfactory, but others have not been tested; where two or more figures are given, eg. 30;25, all have been found satisfactory.

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

Seed production is also strongly influenced by stand density, and Lacey (1972) provides figures on seed production in plots in a thinning trial:

Stocking (stems/ha)	**Basal Area** (m^2/ha)	**Weight of Seed** (kg/ha)	**No. Seed** (/ha)
790	14	6.7	778 000
345	7	23.0	1 796 000
150	4.5	54.6	3 993 000

He notes that at BAs of over 18 m^2/ha seed production is usually negligible, whereas an open grown tree in Forbes district produced over a million seeds in a single season. Suppressed trees usually produce little seed, but can come into production when released by thinning.

Seeding can start at an early age, and Lacey records a 3-year old nursery seedling of White Cypress Pine bearing a single developed cone when only 60cm tall, and notes that in the field coning has been observed on 6-year old seedlings less than 1.2m tall.

Unfortunately Boland et al. (1980) omit details of flowering and seed collection times for most eucalypt associates of White Cypress Pine, but in Table 4 some details of flowering and seed features are given, taken from Lacey (1972) for Pine, from Blakely (1965) for eucalypt flowering, and from Boland et al. (1980) for eucalypt seed features.

Hawkins (1954) gives some details of flower and fruit development in Narrowleaved Ironbark, based on records obtained by the Queensland Forestry Department and on personal observations from the Ironbark-Cypress Pine zone of south-western Queensland. Buds are first discernible from mid-summer to autumn and lead to flowering usually about November and lasting about two months in any district: over a range of seasons, the start of flowering varied from September to November, with flowering in some districts as early as June. Some capsules are mature two months after the end of flowering (say from January), and ripening continues for another 12 months with some seedfall occurring for a further 6 months, i.e. till something over two years from bud initiation. Hawkins also reports an observation by J. Kluver that the leaves on Narrowleaved Ironbark are biennial, with flushes of new leaves appearing at two yearly intervals and the leaves then lasting for two years. Flowering is also biennial, with the new leaf crop and the flowering occurring in alternate years.

It would be expected that most eucalypt capsules would open during the hot season, from late spring onwards.

6.2 Regeneration Establishment

Clayton-Greene (1981) has contrasted the regeneration behaviour of White Cypress Pine with its eucalypt associates. He considered Pine has the ability to regenerate, more or less continually, in its own community, whereas the eucalypts show widely spaced pulses of regeneration, and have an inability to grow through even the light shade of the woodlands, so that any seedlings that manage to establish between pulses remain as suppressed individuals for indefinite periods. He continues:

> *“The possession of a lignotuber by the eucalypts would appear to be the main feature which ensures their survival. By having a lignotuber the eucalypts have an "insurance" against their more extravagant use of resources. Therefore after dieback due to drought or fire (of which fire may be promoted by high litterfall) the eucalypts have the capacity to resprout either from epicormic buds on the stem or from the lignotuber. Fires and drought and possibly insect plagues appear to be the main perturbations which affect these stands.*
>
> *In contrast C. columellaris appears to have only a very limited ability to resprout after either fire or drought. C. columellaris has not evolved a coppicing ability, probably due to the reduced likelihood of death due to fire and/or drought, as a consequence of its low litterfall and transpiration. The inability of severe fires to penetrate pure C. columellaris stands (due to insufficient fuel) has been clearly shown .....*
>
> *C. columellaris regeneration arises from pulses due to good rainfall years, which are usually of 3-5 year intervals. However, good eucalypt regeneration appears to occur only after site disturbance (typically by fire) followed by good rainfall or after very wet years. These regeneration pulses for eucalypts are at much wider spaced intervals than those for C. columellaris and probably have a periodicity >100 years. Eucalypt regeneration between these pulses is sparse and intermittent. After a major site disturbance, followed by rains, seedling regeneration of both eucalypts and C. columellaris would occur. However, the dense regeneration of C. columellaris which frequently occurs following disturbance and good rainfall, would cause intense competition which may lead to partial or complete suppression of both eucalypts and C. columellaris. Evidence from seedling experiments suggests that, under these conditions, root growth and hence potential to survive drought, is decreased in the eucalypts more than in C. columellaris. Therefore it is suggested that, following fire, fast growing coppice, from the surviving emergent eucalypts and also the previously suppressed individuals, gives rise to the emergent eucalypts in the "new" woodlands. Coppice growth is considerably faster than that from seedlings and thus these re-coppiced plants can maintain a height and growth advantage over the seedling regeneration. Under all conditions height growth has been shown to be faster in eucalypts than C. columellaris.”*

Clayton-Green worked in stands in the Snowy River valley and in the southern Riverina, but the pattern he describes has a broader applicability in the Cypress Pine zone, though the period between pulses of eucalypt regeneration appears usually to be less than he suggests. One such eucalypt regeneration event was evident on forests in the Forbes district following the breaking of the 1979-82 drought: bare earth, ample rain and low stock numbers resulted in widespread eucalypt regeneration.

The mechanics of natural regeneration establishment will be examined more closely in the succeeding section.

White Cypress Pine has been planted to a small extent overseas, mostly on a trial basis (Streets, 1962). Plantings in NSW have also been small scale only, but include some relatively unsuccessful efforts to plant it in higher rainfall areas (eg. plantings at Ourimbah, Wallaroo and Maria River S.Fs. and at Bo Bo Plantation) - a project dear to the heart of E.H.F. Swain. There have also been some plantings in the Cypress Pine zone (eg. Buckingbong and Backyamma S.Fs, grounds of Baradine office). Even where growth has been good (as at Baradine), the form of the trees is invariably very poor, with multiple leaders, stocky shape and heavy branching. Planting seems to have little role in the management of the natural Cypress Pine forests.

6.3 Seedling Establishment

6.3.1 Seed Supply and Dispersal

Except in very dense stands, where establishment would not in any case be expected or needed, seed supply is seldom a limiting factor in Cypress Pine regeneration (see Section 6.1).

The dispersal of Cypress Pine seed around parent trees is fairly effective. In the Riverina Clayton-Greene (1981) noted a triangular-shaped spread of seedlings extending eastward and north-eastward from the seed source. Trees were usually surrounded by dense regeneration for 20 - 30m from the trunk, and the usual limiting distance of dispersal was 50 - 70m, with isolated seedlings up to about 100m (110m in furthest dispersal noted). Lacey (1972), in the Narrabri district recorded seedlings up to 350m from open grown parent trees. He suggested that some of the seed might be transported from where it first falls by whirlwinds, which are not uncommon during summer in the Cypress Pine zone.

A proportion of the seed shed is empty, and Lacey gives figures indicating that from a quarter to half the seed collected in one study was unfilled, but that remaining filled seed had a very high (90 - 100%) viability. The percentage of empty seed was largely a consequence of insect damage (mainly small wasps) occurring in the cone.

6.3.2 Germination and Viability

The optimum temperature for Pine germination appears to be about 20°C, and the germinative capacity falls rapidly at higher temperatures. Lacey quotes laboratory tests where the germinative capacity was about 100% at 15°C and 20°C, but fell to 9% in one case, and to nil in another, when the temperature was raised to 25°C.

Although most of the seed is shed in early summer, Lacey states that there are no confirmed observations of germination occurring in the months of October to January and only few in February. The high temperatures and low frequency of effective rainfall make it unlikely that summer germination would occur. Similarly in a study in Victoria, Adams (1982) found that two species of Cypress Pine (Mallee Pine and Slender Cypress Pine), occurring in the same area of north-western Victoria though on different soil types, both had a narrow range of favourable germination temperatures with the optimum achieved at about 18°C.

Field germination of White Cypress Pine is commonly observed in autumn and early winter (late March to June) following high rainfall, when soil moisture conditions are good; germination following low rainfall tends to be only scattered. Less germination occurs in late winter and early spring, even when soil conditions are suitable. This suggests both a loss of seed viability with time (virtually all seeds collected by Lacey in spring were infertile) and possibly more importantly a loss of viable seed through insect or other predation. Lacey infers that no seed carries over in the field from one season to the next, but Curtin (1987) believes Lacey was unduly pessimistic about the duration of seed viability and comments that, during the 1950s, germination often occurred well into the spring if rainfall was adequate. However other observations suggest that most such germinates are eliminated during the subsequent summer.

Details given by Lacey show that in laboratory tests at 20°C germination commenced at about day 7 and was effectively complete by day 21 or shortly after. Moist cold storage for 4 weeks before sowing (stratification) resulted in some seed germinating by day 1, though germination was still not complete until after day 21: apparently some seeds responded to stratification and some did not. From field studies in Queensland, Hawkins (1954) also considered that germination took about 21 days under favourable conditions.

6.3.3 Seed Bed and Moisture Conditions

Within the forest seed bed conditions are probably rarely limiting except in the more marginal Pine sites (eg. Box flats, where occasional seedlings become established) where there may be a major factor limiting Pine occurrence. The more typical, lighter textured soils appear to provide a favourable seed bed when moisture conditions are suitable. In Queensland, a seed bed consisting of a mixed litter of eucalypt and Pine leaves appeared to give better germination than one consisting of Pine needles only (Hawkins, 1954).

However, it is moisture conditions which largely determine not only the extent of germination but also the subsequent fate of the germinated plants, and moisture needs to be maintained through the summer following germination if a reasonable survival of the seedlings is to be obtained.

Lacey (1972) refers to a study on Backyamma SF where from 4 to 35% (average 19%) of the previous season's seedlings survived the 1968-69 summer, which was generally mild and with good rainfall in December, February and March. By contrast the same summer further north was severe, and on Killarney SF, where 1968 germinates had been present at stockings of 200 000 to a million per ha, mortality was virtually complete by January 1969. As might be expected, the earlier germinates (late summer, autumn) tend to have a better survival rate through the following summer than do those germinating in late winter or spring.

6.3.4 Overstorey Density

Overstorey density has a major effect on survival, and Lacey notes that stands with a BA in excess of 14 m^2/ha will produce little or no regeneration, while the establishment of regeneration tends to increase from this stocking down to very low stockings of the overstorey (below 1.6 m^2/ha). He suggests that, in typical older stands, BAs of about 7-9 m^2/ha will allow regeneration to occur while preventing the establishment of excessively high regeneration stockings.

6.3.5 Ground Cover and Insolation

The overstorey density is also inversely related to the amount of grass and herb cover, so that heavy Pine regeneration is frequently associated with abundant grass cover - a feature shown in the following figures from Merriwindi SF (Lacey, 1972):

BA (m^2/ha)	**Grass Weight (kg/ha)**	**No. Pine Seedlings (/ha)**	**Ht. Pine Seedlings (cm)**
14.2	430	0	-
7.3	1000	339	66
4.6	2190	717	79

Lacey (1973) suggests that the grass *"probably has a favourable influence"* on the Pine regeneration in providing shade, while since the grass is ephemeral and hays off quickly in summer, it is unlikely to compete with regeneration for moisture over the critical summer period. On the other hand a dense grass cover may physically prevent much Pine seed reaching the soil, and may shade out many germinates during the winter and spring period.

Notwithstanding Lacey's rather tentative endorsement of the beneficial aspects of grass, there is much field evidence to indicate that protection of the young seedlings from excessive insolation during the first summer or two can be important to their survival and establishment. Seedlings not only are more plentiful in sites with grass cover, but are very frequently established close to grass plants, rather than in the open spaces between them. Similarly establishment is often seen close to the base of eucalypts, where litter accumulates (this is particularly the case on sand monkeys and similar very sandy sites, where Pine seedlings are often seen growing close to the shelter of a Red Gum stem); in the shelter of the heads of logged trees; or in other micro-sites where the seedlings are protected from high insolation rates (including reflection or radiation from bare soil).

Thus in the Pine-covered sand dunes found in parts of the River Red Gum forests of the Murray, Pine regeneration is largely confined to clumps of Common Fringe Myrtle, while in some of the more western Cypress Pine areas, where obtaining regeneration is still a problem, some protection from insolation is commonly regarded as essential for Pine establishment (Hamilton, 1987).

6.3.6 Grazing

To some extent the features that protect seedlings from insolation also provide protection from grazing, especially from larger animals, though this obviously does not apply to regeneration growing in grass clumps. As has been seen (Section 5) protection from grazing is another essential factor in ensuring the establishment of Pine regeneration, and it was inability to control this grazing, by both domestic stock and rabbits, that caused the dearth of regeneration during the first half of this century: Lindsay (1948) outlined the problem at this time. Rolls (1981) suggests that in Aboriginal times rat-kangaroos (Rufus Bettongs?) were sufficiently numerous to destroy much regeneration. (from South Africa, Manders (1986) lists destruction of seedlings by native rodents, hyracids and baboons as one of the reasons for the decline of the related *Widdringtonia cedarberaensis* in Cape Province.)

Protection from grazing by domestic stock can be important in obtaining regeneration establishment. Jones (1963) records the establishment of White Pine regeneration in fenced enclosures on properties in the Hay district, in an area where it had been thought impossible to obtain regeneration. Inability to exclude stock (because of lack of fencing) is regarded as a major reason for the absence of Pine regeneration in the Steam Plains M.A. (Hamilton, 1987; Curtin, 1987), though it appears that rabbit infestation was the major cause of the problem in this area.

Although grazing is usually excluded from areas where regeneration is required, limited grazing by domestic stock is sometimes used to restrict the quantities of Pine regeneration established. Some foresters familiar with Cypress Pine strongly believe that the manipulation of grazing levels is the main feasible approach to reducing the excessive regeneration levels that are often obtained. Quoting from one: *"If we are only looking for say 300 - 500 trees/ha and commonly achieve 250 000 stems/ha without grazing, then it stands to reason that added grazing pressure and manipulating the type of stock would lead to an improvement over that which exists now",* and from another: *"Our experience, even in drought, is that stock will not eliminate regeneration, they will only control it".* It would seem, however, that close control over seasonal stocking rates is necessary to achieve the appropriate level of control, and this in turn infers direct control of the grazing stock by the forest manager, rather than indirect control through lease or permit. Other foresters, it should be noted, hold the contrary view that total exclusion of grazing by sheep and rabbits for up to 5 years is necessary in order to obtain regeneration.

Referring to the lower rainfall areas, Curtin (1987) notes that extensive regeneration has occurred since the 1950s. In these areas grazing intensity tends to be much less than in more easterly forests, and where wet conditions follow, as they often do, a drought, stock numbers will be low and take several years to build up. In the absence of large rabbit populations, regeneration can become established during these initial moist years. Though subsequently grazed, the Pine seedlings are tough and can withstand considerable grazing and then assume more active growth when grazing pressure is again reduced. Curtin concludes that in the Western Division there is a strong correlation between successful regeneration and a light grazing regime in the first two or three years after germination.

6.3.7 Cypress Pine Establishment

Assuming the presence of a seed supply and suitable soils, obtaining White Cypress Pine establishment bears some resemblance to playing a poker machine - you need to obtain a row of aces to score the jackpot, with the aces represented by good moisture conditions over at least one (and in more western areas, two) summer; protection from insolation; and freedom from grazing. The jackpot is harder to pull on the more westerly areas than it is further east, and probably also is harder in the southern districts (with their lower likelihood of summer rains) than further north.

When these conditions are favourable, extremely dense regeneration can result. Lacey (1972) quotes germination on 3.3 m^2 quadrats on Backyamma State Forest in 1968 at rates ranging from 900 000 to 3 250 000 per ha, and averaging 1 664 000/ha. Survival on these quadrats after the first summer averaged 19% (discussed above) and left an average stocking of 377 000 seedlings per hectare. And this would by no means have been unusual. Elsewhere Lacey (1973) observes that *"over widespread areas, 20 years after germination regeneration densities in excess of 125 000 stems per hectare are commonly encountered".*

It should however be realised that not all regeneration has been of wheatfield densities, and particularly in the more northern forests an in-filling of small openings has occurred in stands maintained at BAs of over about 7 m^2/ha. Whilst wheatfield regeneration has occurred since the 1950s in all parts of the Cypress Pine zone, producing a new even-aged crop to replace the 1890s regrowth, in many areas a more uneven-aged stand is present, and this appears to be the norm in Queensland where the absence of regeneration prior to 1951 was never as marked as it was in NSW: Hawkins (1954) could write: *"In Queensland there has ... been little work carried out on regeneration problems of Cypress Pine and, until recent years, it has not been considered that any major regeneration problem exists - provided fires can be excluded."*

6.3.8 Establishment of Eucalypt Component

The establishment of the eucalypt component in the Cypress Pine types has not been studied in NSW even though this may be of considerable economic, as well as environmental, significance. However, field observations suggest that, even where culling has eliminated the eucalypt overstorey, eucalypt regeneration is usually present from coppice or lignotubers, at stockings that would certainly replace the original hardwood element.

Plots established by Van Loon & Love (1971) to assess fuel equilibrium in Pine-Narrowleaved Ironbark-Bull Oak stands on Pilliga East S.F. failed to identify any Ironbark in the understorey, though it formed part of the overstorey at each of the 10 selected study sites, but the plots used in these studies were of very small size. More positively, continuous inventory plots in the Ironbark types of the Pilliga M.A. show the existence of an excellent sapling crop of Narrowleaved Ironbark.

Working with Narrowleaved Ironbark in south-western Queensland forests, Hawkins (1959) quoted some observations by A.R. Trist that the apparent combination needed for the successful establishment of regeneration would not occur often: fair spring rains coinciding with a seed crop. Hawkins suggested that the most important factors in Ironbark seedling survival were protection from the sun up to the 6 - 8 leaf stage and good follow-up rains in the immediate post-germination period, together with mild temperatures. These would seem fairly general requirements for eucalypt establishment in these western areas, and the jackpot may well be less frequent than with Cypress Pine, as inferred by Clayton-Greene (1981) in the quotation given earlier.

Hawkins stressed that a large proportion of the seedlings that did survive occurred in local micro-sites (small hollows, alongside branches, etc) where moisture retention and protection from the sun would be more effective. Growth in the established seedlings was slow: Hawkins recorded an average seedling height of 17cm (range 2.5 to 50cm) at age 21 - 23 months from germination, and he suggested that over this period most development was going into lignotuber formation and root extension. Hawkins (1954) also quotes observations by V.N. Robinson suggesting that Narrowleaved Ironbark regeneration usually stagnates for at least 10 - 15 years while it forms its lignotuber, and it will then start vertical growth at about 30cm a year.

By contrast, coppice growth studied by Hawkins showed growth rates averaging about 60cm a year over the first four years after coppicing on stools of 5cm in diameter, and about 75cm a year on stools up to 10cm in diameter. After four years the average annual height growth diminished to about 30cm a year at age 17 years.

6.4 Regeneration Damage

The main factors damaging or destroying regeneration in the Cypress Pine types have already been mentioned.

Insects can destroy seed in cones and Lacey (1973) indicates that the main agent is a wasp, *Epimegastigmus sp*., whose larvae develop and pupate in the seed, leaving an empty shell to be shed. Lacey states that the viability of Pine seed when ripe can range from under 20 to over 70 percent, but does not commonly exceed 45 percent, though it tends to be higher in heavy seedfall years. Most of the loss of viability is due to insect damage. Poor seed supply can also be associated with attack by the Cypress Pine Aphid (*Cinara tujafilina*) (Hawkins, 1966).

Once shed, the seed appears to be liable to further predation and loss on the ground.

Older, established regeneration may be defoliated by the Cypress Pine Sawfly (Moore, 1963), while leaf damage or defoliation by insects appears to be a regular hazard to eucalypt regeneration in these dry forest areas.

Climate is one of the main factors influencing Pine establishment and insolation and adverse moisture conditions can lead to the complete loss of young seedling crops. In a Queensland study, Johnston (1969) has suggested that insolation is the major cause of seedling mortality in areas grazed by sheep and rabbits, but with grazing indirectly involved through its removal of ground vegetation that would otherwise shelter the young seedlings. Once established Pine regeneration shows considerable tolerance of dry periods, though during severe droughts patches of regeneration may die, particularly in unthinned stands on shallow and rocky sites and also on some deep sands (see also Section 8.1).

Cypress Pine is not particularly well adapted to withstand fire, and scattered regeneration growing amid grass can be wiped out by fire. On the other hand dense stands of regeneration tend to be immune to fire because of the small amount of litter and the absence of ground vegetation. While plants on the outside of such dense stands will flare up and be killed, fire will rarely penetrate far into the stands (Lacey 1973). Fire is sometimes used on a small scale to prevent the establishment of regeneration beneath relatively open older stands of Pine and would have a role in preventing the excessive invasion of Pine into good quality Ironbark or other eucalypt-dominant stands (Hawkins, 1959). It has also been suggested as a means of controlling the invasion of western grazing lands by Cypress Pine and other scrub species (Hodgkinson & Harrington, 1985).

In Baradine district efforts have been made to use top disposal burning, following seed tree logging, as a means both to reduce fire hazard and to reduce the stocking of the remaining wheatfield Pine regeneration. The results to date have not been particularly satisfactory, with minor changes in weather conditions resulting either in a crowning of the fire, destroying all regeneration, or in very limited areas burnt.

Again, the role of grazing in destroying regeneration has been discussed (Section 6.3.6). Destruction can come from domestic stock, from rabbits and possibly from native animals. Rabbits were undoubtedly the major destructive agency prior to 1951, and can still be locally significant. Clayton-Green (1981), working in the Riverina (Savernake), states that rabbit grazing resulted in seedling stems 1cm wide and only 10cm tall, existing *"in a perpetual cycle of shoot growth followed by browsing. These heavily browsed seedlings appear able to persist for many years."* More usually, however, heavy rabbit infestations result in the complete elimination of seedlings.

Sheep can equal the effects of rabbits. Use is made of this in places to prevent secondary in-fill regeneration in forests where the 1950s regeneration has been thinned out, allowing grass development, and their possible role in limiting Pine regeneration to manageable proportions was referred to in Section 6.3.5.

Cattle are less destructive than sheep, but need to be excluded from sites where regeneration is required. Goats are deliberately grazed in some areas, again usually to prevent secondary regeneration in thinned stands: they are probably more effective than sheep in destroying established plants, but less in their effects on young regeneration (browsers rather than grazers). Harrington (1979) has queried the value of goats for scrub control generally, noting that fairly intensive fencing patterns and high rates of stocking are needed. Confirmation of this view comes from Baradine district, where the cost of fencing needed to retain the goats is prohibitive, and where regular herding is needed; they appear a more manageable proposition in "island" forests surrounded by grassland. Beyond this, the historic record of goats as environmental destroyers in the semi-arid lands of the Mediterranean and elsewhere should give cause for caution about their extensive use in western NSW. Nonetheless, grazing cycles involving goats have been devised as a means of controlling unwanted Pine regeneration. One, favoured by A.E. Edwards, former Regional Forester at Dubbo, involved the introduction of goats, at stockings in excess of 2 per hectare, to stands following the thinning of Pine regrowth. The purpose would be to reduce scrub growth, thus improving the grazing for sheep, and to lessen fire risk (whilst notably omnivorous browsers, goats do not appear to favour eating Bull oak; most other scrub species will be eaten first).

Lacey (1973) comments that the browsing of native animals was apparently never sufficiently intense to prevent regeneration, though Rolls (1981) believes that the Rufous Rat-kangaroos (Bettongs) had a significant role in limiting the extent of Pine regeneration.

One difference between the native and the domestic browsers should be recognised. Hoofed animals are all exotic to Australia, and there is increasing realisation that many of the problems of soil degradation in Australia, general or localised, come from the impact of their hooves on soil and vegetation that were unprepared for such traffic. By contrast the native macropods are much more benign in their effects, and there are growing numbers who argue that it is the kangaroos and their relatives, rather than sheep, cattle and goats, that should be farmed (eg. Flannery, 1986). It is an argument relevant to the Cypress Pine types.

6.5 Early Development

6.5.1 Growth Patterns

Lacey (1973) has described the early growth of White Cypress Pine:

“Following germination - in late summer to early winter - the cotyledons expand to approximately 7.5mm. The first true leaves formed are in a single opposite pair. These are followed by four-ranked juvenile leaves which are completely free from the main stem. When the seedlings are several inches high branching occurs and the juvenile foliage is replaced by the mature, three-ranked decurrent leaves.

Initial seedling growth is usually quite slow and after the first summer from germination, seedlings may be from only 2.5 to 10cm high and it may take three years for them to reach a height of 60cm.

Initial root growth is much more pronounced than shoot growth. Zimmer (1960) found that a seedling 160 days old and 12.5cm high had a root penetration of 1.07m. Depending upon the competition, top growth may continue to be very slow for an extended period and seedlings less than 15cm high 17 years after germination have been recorded. However, in good conditions a height growth increment of between 30 to 45cm per annum is reached in about 6 years. In one thinning trial, regeneration that was 6 years old at the time of thinning showed a height increment of 40cm per annum and a diameter increment of 9mm per annum for a 7 year period following thinning to 4.9m spacing.”

Clayton-Greene (1981) examined seasonal shoot growth of young Cypress Pine in the winter-rainfall area of the Riverina, and found that shoot extension typically commenced in September-October and continued till December, at which time available soil moisture was depleted. However, if spring moisture was limiting, growth was delayed till adequate rain occurred, and in one case this resulted in the burst of growth being from autumn until mid-winter. When moisture was adequate, additional bursts of growth occurred in response to above average temperatures in autumn and winter.

The seasonality of growth does not appear to have been studied in more northern areas, but Lacey (1973), much of whose work was in the Pilliga, noted that very little growth occurs in winter months, and growth at other times is dependent on favourable soil moisture conditions.

An indication of current growth in young Pine can usually be obtained from the condition of the leading shoot, with a long, drooping leader indicating good increment. Lignification of the tissue subsequently leads to the leader assuming an erect stance.

6.5.2 "Locked" Stands

One of the most striking and distinctive silvicultural features of White Cypress Pine is the capacity of stems to tolerate extreme competition, surviving for long periods while making negligible growth. Associated with this is a slow and poor assortment into dominance classes, and the result of these two features is the virtual "locking" of dense even-aged stands, with low mortality despite high stockings and with negligible growth on any stem (or, in consequence, the stand as a whole). The process of locking is never absolute: some mortality does occur, particularly during periodic droughts, and the larger and stronger stems do grow, albeit slowly. Nonetheless the phenomenon is typical of Cypress Pine in dense stands and it affects both young regeneration and older stands.

An extraordinary example of a locked stand occurs on Strahorn State Forest and resulted from 1947 regeneration in a netted enclosure where grazing could be excluded. Forty years later this stand still carries patches with a stocking equivalent to about 100 000 per ha, and with a stand height of about 2m. Few dominants are evident, and there has been a tendency for some of those that have developed to die during drought periods. Stem DBH rarely exceeds 3cm. Elsewhere on the same forest, on similar sites, regeneration of slightly younger age has been thinned and carries stems with heights approaching 10m and with diameters of 15cm on the dominant stems.

Clearly the thinning of the dense regeneration that has occurred since the 1950s is needed if the stands are not to lock up in the manner described, or at least not to remain locked, and potentially unproductive, for long periods. Recovery from locking does occur, and probably typical is experience from Yarrigan SF where a stand of 1950s wheatfield regeneration, thinned to a spacing of 6 x 6m in 1983, showed the development of deeper crowns and visible signs of vigorous growth after 3 years. The response may be delayed for 5 or more years where the trees have been long locked together and have developed poor, feather-duster crowns: the time before response is evident presumably relates to the time needed for stems to produce new, larger crowns.

The general question of thinning Cypress Pine will be considered further in Section 7, but the methods adopted in dealing with dense young regrowth have included axe thinning, mostly to spacings that proved far too close, in the 1890s stands. When the 1950s regeneration appeared various approaches were used, early ones often using mechanically drawn wide ploughs or slashers to cut broad swathes through the "wheatfields" leaving bays of unthinned pine to be subsequently treated by hand. The mechanical treatments depended on reasonable access through the regeneration blocks, and ploughing tended to be more successful than slashing as young pine can coppice or sucker until the stem develops rough bark.

Subsequently mechanical brush-cutters have developed as the standard technique for thinning regrowth thickets, with the operation carried out by small gangs working in areas of advanced regeneration, commonly with stems 2-3m high. The brush-cutters can handle stems with a diameter up to 10 to 15cm near the ground, and the cut stems are left where they fall. In most districts the spacing adopted is 6 x 6m, to give a stocking of about 280 stems per hectare (see Section 6.5.3). The thickets themselves are rarely evenly stocked throughout, and the final stocking will usually reflect this variability.

The brush-cutter operation is not cheap. Returns for 1986-87 show that some 1 300 ha were thinned during the year at an average cost of $230/ha, and a further 1 000 ha received a joint thinning and culling treatment at an average cost of $197/ha. However these costs are averages for sites that were variously calculated for gross or net area; on a net area basis the cost of thinning dense 1950s regeneration appears to be close to $400/ha.

Where the regeneration occurs beneath merchantable Pine it is desirable to time the regrowth thinning about halfway through the cutting cycle: there is a risk of damaging retained stems if the thinning is carried out shortly before logging, while the presence of logging slash increases costs if the thinning follows too soon after logging, and the small stumps are likely to puncture the tyres of the tractors used for snigging if logging occurs within 4-6 years of the thinning operation. The final felling of the old crop above established regeneration usually provides excellent access for the subsequent thinning of the regeneration. Culling of unwanted overstorey trees, if required, may be carried out at the same time as the thinning or else as a separate operation several years later.

Throughout the Cypress Pine areas of NSW it has been found that the dense, unthinned regeneration stands can promote the death of overstorey trees, both Pine and eucalypt, during droughts. It appears that the regeneration, with its roots closer to the surface, has preferential access to any rainwater reaching the soil: as Curtis (1975) observes *"significant biological activity and most root growth are restricted to the top 5-10cm of soil owing to the shallow mean depth of soil wetting by the small irregular rainfalls"*, and young plants seem better able to benefit from this than those that would otherwise seem better established. Some further evidence of this comes from Merriwindi SF where a fall of about 25mm of rain followed a dry spell. Several days later it was found that, on the solodized solonetz soils, the rainfall had only penetrated to a depth of 4-5cm; by contrast on the Moongie Sand the profile was wet to a depth of at least 1.8m. The effect of regeneration benefiting more than established trees from light rains can even be seen on the occasional dominants that may form in the regrowth stands (eg. Backyamma SF).

Because thinning greatly reduces the BA, thinned stands will be candidates for a further flush of secondary regeneration. To avoid this, grazing is usually introduced into the thinned stands, serving the multiple purposes of reducing the likelihood of unwanted regeneration, making use of the improved pasture growth, and reducing fire hazard. Breeza and Warregal S.Fs. provide excellent, though hardly atypical, examples of stands that have received this type of treatment.

It is doubtful whether anything comparable with the extensive regeneration establishment of the 1890s and 1950s occurred prior to European settlement, but smaller clumps of dense regrowth would certainly have developed from time to time and, as still can be seen in some of the Western Division forests, some natural thinning of these clumps would have occurred as a result of periodic fires. Although the clumps as a whole were fairly immune to fire damage, their edges would burn, with some stems being killed and others being singed, but recovering to profit from the now more open growing conditions, and each successive fire would result in more opening of the clump.

Unthinned stands of regeneration ultimately reach the stage where little worthwhile response will follow thinning, and most Cypress Pine foresters seem to agree that this stage has been reached with the 1890's regeneration, though the position may be obscured because most remaining unthinned stands of that age tend to be located on the poorer and lower quality sites. On better sites, the ability to respond may last longer. On Cumbine SF, close to the boundary of the Western Division, considerable natural mortality has occurred in unthinned 1890's regeneration (report by A.E. Edwards).

In terms of the management of Cypress Pine for timber production, this locking of regeneration remains one of the major problems.

6.5.3 Early Spacing

As indicated above, under the conditions of dense, even-aged regeneration, non-commercial thinning is necessary for stems to reach merchantable size - say about 18 cm DBH.

Treatments given during the 1930s and 1940s were generally far too conservative, though they undoubtedly promoted growth for a period (see Section 7.2.3), often to the extent that a small proportion of the trees would reach merchantable size without further treatment: the problem then is that each subsequent logging tends to cream off the most vigorous trees in the stand, since only these are of merchantable size, and this operation in turn allows some more to grow to harvestable size. The treatment of the stand is rather the reverse of what good silvicultural practice normally seeks.

On economic grounds pre-commercial thinning should be restricted to a single treatment that is designed to allow all the remaining trees in the stand to grow to merchantable size without further treatment. This determines the upper limit of stocking.

There is, however, a lower level of stocking also, and this is determined by the need to avoid the excessive branchiness and poor form that are likely to accompany very wide early spacing. This consideration tends to dictate that stocking should in fact be as close as possible to the higher level that will allow the stems to reach merchantable size. Little leeway is available.

Griffith and Narrandera districts have a reasonable market for small vine and fence posts, so that merchantable thinning can commence at a much smaller size than applies elsewhere in NSW. On this basis pre-commercial thinning in Pine regrowth is usually to a spacing of about 4m x 4m or a stocking of 625 stems per hectare, with the subsequent sale of the small posts allowing the stands to reach sawlog size. Lucky Albury Region.

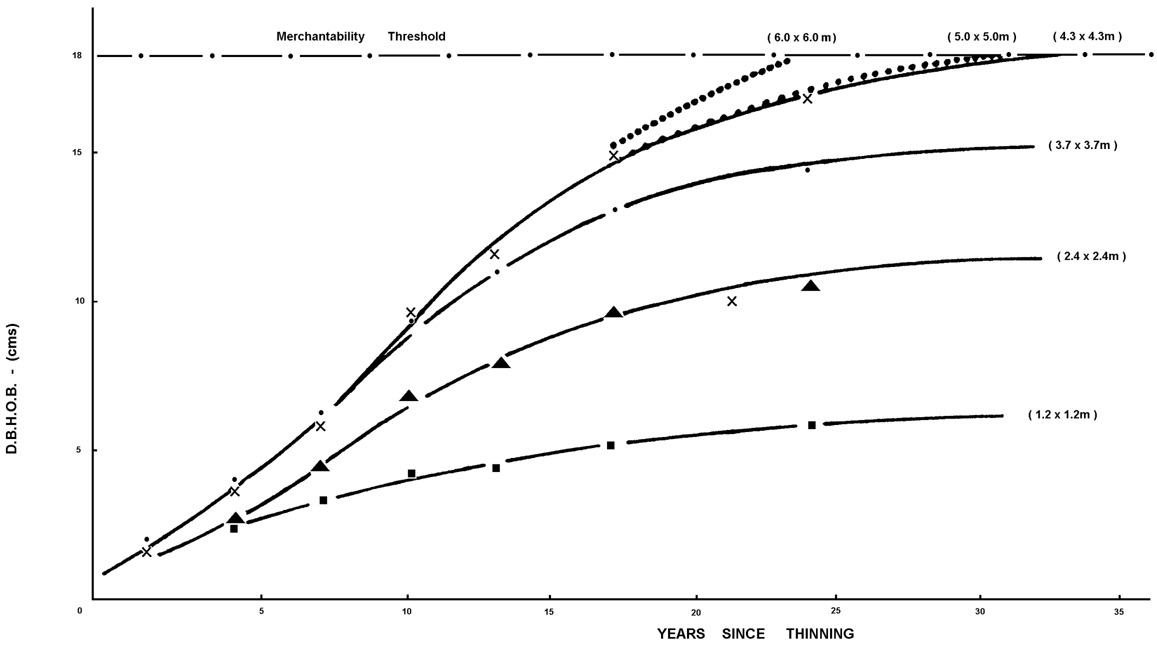

Figure 1 : Growth of Thinned Regeneration, Tonambil S.F.
(Little or no secondary regeneration present)

Figure 1 (provided by courtesy of R. Horne) shows the growth of Pine regeneration following thinning to different spacings on Tomanbil SF (Forbes district). In this study, trees in the plots thinned to 6m x 6m would have reached merchantable size of 18cm DBH about 24 years after thinning, while at 5m x 5m about 30 years would need to have elapsed. At spacings even slightly closer than 5m x 5m it would seem unlikely that stems would ever reach merchantable size unless mortality (or the subsequent sale of small stems) were occurring to reduce the stocking.

In the plots shown in Figure 1 secondary regeneration resulting from the opening of the stand after thinning was controlled and eliminated. Where this control did not occur, growth of the thinned trees was significantly reduced, to the extent that it seems unlikely that trees in even the most widely spaced plots would reach merchantable size - certainly they would not reach such size in an acceptable time span.

Plot data such as are shown in Figure 1, together with field experience (which recognises that instruction to a gang to space stems 6m apart ultimately results in an espacement of rather closer than 6m x 6m), have suggested that a spacing of 6m x 6m (280/ha) offers the best compromise in growing the dense regeneration to merchantable size, and this has become the usual spacing adopted for regeneration thinning in most parts of the State.

In Forbes district, however, pre-commercial thinning has been to 5m x 5m (400/ha). W. Horton has articulated the case favouring this closer espacement in comments during the preparation of the 1986 Forbes Management Plan:

> *"Much local thought has been put into this rather vexed problem of the "correct" spacing required to achieve merchantable sizes and the compromise of maximum volume increment versus individual tree growth rates. There is no doubt that 6 metre spacing has a marginally greater individual tree growth rate over 5 metre spacing. The value judgment however boils down to whether 5 metre spacing will produce merchantable sizes and, if so, will it do so in a reasonable length of time. Research plots of 1950s regeneration thinned in the mid 1960s to 5 metre spacing have already reached near merchantable sizes and look as if they will not exhibit any marked degree of competition for some time yet. On Back Yamma SF an 1890s regeneration stand has a plot with 5 75 metre average spacing and virtually all stems in the stand are merchantable and have reached respectable log sizes. While the site may be arguably of better site quality than the average for the district, questions of deaths from drought/insects, and recent concern that in some areas the most widely spaced cypress pine regeneration has had a greater percentage of deaths and/or dead topping through jewel beetle attack (up to 20% of the stand) indicate that the most conservative thinning which will produce sawlogs in a reasonable time span should be adopted.*
>
> *Also of concern is branch development and possible sawlog degrade associated with wide spacings. The 5 metre spacing was specified because it was the most conservative spacing which local officers considered could be guaranteed to produce sawlog sizes. It could well be that a closer spacing of between 4 and 4.5 metres could also produce sawlogs, but without an old comparison stand these closer spacings could not be justified. It is also known from 1890s stands with average spacing of 3 metres that only a few merchantable size stems can be found in these stands and most are too small for a commercial operation.*
>
> *We feel confident that growth will continue on the stand (after competition between individual stems becomes apparent), and sawlog sizes will result before there is any sign of "locking" of the stand. Commercial thinning will then enable continued growth."*

In the event the Forbes Plan provides for 5m x 5m spacing, increased to 6m x 6m on the poorer sites. More northern districts, however, continue to prefer 6m x 6m spacing as routine for regeneration thinning, with Baradine suggesting that spacing might be varied slightly around this, from 5.5m x 5.5m (330/ha) on the better sites to 6.5m x 6.5m (235/ha) on the poorer sites.

7. GROWTH AND YIELD

7.1 The Original Forests

The nature of the White Cypress Pine stands in pre-European times has already been examined in Section 5, but it needs to be stressed that the forests we have today - even in those few sections that have never been logged - are mostly very different in structure and appearance from those of Aboriginal and early settlement times. Changed burning patterns, in particular, have produced much denser stands than previously existed, with more numerous, but smaller, Pines, while on most State Forests where Pine grows the component of large eucalypts has been significantly reduced by harvesting and culling. At the time treatment on the State Forests has led generally to a reduction in the stocking of smaller Pine size classes and an increase in the larger classes, resulting in Pine stands that are in a more productive and readily managed condition that ever before. In Cypress Pine forests, perhaps more than in any other Australian forests, the stands that we now have are so different from those of pre-European times that the original forests could provide little to guide us in our understanding of the growth processes of our current stands.

7.2 Growth Relationships

7.2.1 Queensland Experience

> *"Unfortunately for management, Cypress Pine has little capacity for self-thinning; regeneration grows fairly uniformly in height, then growth ceases. Cypress Pine has the ability to remain in such an unproductive static state almost indefinitely, until some disturbance in the community removes the inhibition to growth." (Curtis, 1975).*

Unfortunate indeed, and herein lies one of the great dilemmas of Cypress Pine forestry.

A considerable number of studies involving the relationships between growth, stocking and age have been carried out with Cypress Pine, with results - or at least interpretations - that are to some extent contradictory.

The most comprehensive studies, based on a large mass of long term records of growth in treated plots, have been made by Johnston (1975) in south-western Queensland. Unfortunately most of the growth trends are not directly applicable to conditions in NSW: the Queensland stands have a greater tendency to carry a range of age classes; growth rates are greater; and optimal stockings appear much higher than any evidence from NSW plots would support. This suggests genuine differences in growth patterns between the Queensland and NSW Cypress Pine stands, and these in turn may well relate to the generally higher, predominantly summer, and also more regular, rainfalls, with their largely monsoonal origins, of the Queensland forests. It is possible that some stands in the Yetman area of NSW may behave similarly to the more northern stands (Johnston's experiment 301, on SF 79, is less than 40km from Bebo SF, near Yetman), but plot data is non-existent from the Inverell district.

Johnston's results indicated the desirability of a regime that reduced stocking to 330 stems/ha (equivalent to 5.5m spacing) at an early stage, followed by periodic thinning to maintain the stand in the BA range of 12-15 m^2/ha and a reduction to 6 m^2/ha late in the life of the stand to allow the establishment of a new crop of regeneration. Over a rotation of 110 years a merchantable volume MAI of 1.37 m^3/ha/yr would be produced, with a final crop mean DBH of 39cm. BAs up to 20 m^2/ha could be carried in merchantable stands without significant mortality losses or reductions in BA increment.

By contrast, earlier work by Henry (1960) in Queensland had suggested a somewhat lower initial stocking of 280 stems/ha (spacing of 6m x 6m), while Dale (1979), working towards the north-western limits of commercial Pine stands in Queensland, considered that the growth responses were generally comparable with those reported by Johnston. He noted that logging was reducing BA from around 12-15 m^2/ha to 7-9 m^2/ha *"which is generally regarded as the lower end of the range for routine White Cypress Pine management".*

7.2.2 NSW Data

In NSW data on growth relationships come from several sources including plots established in the Baradine and Narrabri areas between 1930 and 1940, the so called "pulpwood plots" [3] established by A.D. Lindsay in the Pilliga forests about 1940, a series of plots thinned to

[3] The "pulpwood plots" derived from a typically Swainian vision of developing a pulpmill in the area, thus providing a market for the otherwise unmerchantable mass of small Pine in the unthinned 1890s stands. The plots covered a range of thinning intensities.

different spacings established in the Pilliga forests by P.L. O'Neill in the mid-1960s, and some other, later established thinning plots in Forbes district. Other plots, whose results have yet to be analysed, were established by C.J. Lacey in the late 1960s, and there were also plots established in 1950s regeneration, and again covering a range of spacings in these younger stands (see Section 6.5.3 and Fig. 1).

Lacey (1973) examined the older plots from Jacks Creek and Yearinan S.F.s. In both areas two plots had been established, one thinned more heavily than the other. His analysis shows BA increment peaking at a BA of about 6 m^2/ha, and then falling away as BA rises. However his data, though not his discussion, also demonstrates a relationship between age and increment, with plots of younger age (in these cases, ages 40 or 50 years) showing much higher increments than plots measured at a later age in a similar BA range. The plots reported by Lacey ranged in stocking from 218 to 630 stems/ha, with BAs ranging from a low of 1.3 m^2/ha after thinning at age about 40 years in one plot to a high of 18 m^2/ha at about age 80 years in another. The stands were all regarded as dating from about 1890. Diameter increments in the first 10 years after thinning ranged from 7 mm a year in the most heavily thinned plot (mean DBH 11.5cm) to 4mm in the most lightly thinned plot (mean DBH 10.9cm), but declined to as low as 1 mm a year by age 70-80 years. Lacey noted that on another severely suppressed plot on Merriwindi SF, diameter growth had averaged only 0.3mm a year over a period of 20 years.

The pulpwood plots have not been subject to recent detailed analysis, though several series are well-established stops on silvicultural tours of the Pilliga. However the growth trends appear to resemble those of the older plots discussed by Lacey.

In comparison with this data from northern NSW, there are some indications that growth in the more southern Pine stands (eg. Narrandera district) tends to be rather slower, with 0.2cm regarded as an average DBH increment in spaced stands. Following from the observations of Clayton-Greene and Lacey, recorded in Section 6.5.1, this may be due to the greater incidence of summer rains in the more northerly areas.

7.2.3 The O'Neill Plots

The plots established by P.L. O'Neill in 1966 represented the first attempt to examine stocking/growth relationships in Cypress Pine in NSW on a statistical basis. At 5 sites in the Pilliga forests a block of 6 plots was established. Five plots in each block were thinned to 408, 345, 284, 210 and 160 stems/ha respectively (equivalent to spacings ranging from about 5m x 5m to about 8m x 8m); the sixth was left unthinned as a control, though in all but one site the stands had received pre -merchantable thinning between 1934 and 1954, and carried residual stockings of from 800 to 1 200 stems/ha. Four of the five blocks were located on solodized solonetz soils and the fifth on deep sands. Though reputedly 1890s regeneration, the plots are believed actually to have regenerated between 1900 and 1911, with 1906 now imputed as the year of origin.

Curtin (1974) had a preliminary look at the results from these plots and concluded that they showed a BA increment plateau maintained over the BA range above 8m^2/ha. He considered that pre -merchantable thinning to 6m x 6m (280 stems/ha) was necessary to allow the trees to reach merchantable size, and he noted what appeared to be significant differences in site quality between blocks.

More recently the data has been examined in somewhat more detail by Horne and Robinson (1987), and Fig. 2 summarises the BA growth trends over the period available to them. In all blocks BA increment rises with increasing BA up to a BA of about 5-6 m^2/ha. In four of the blocks (all except block 2, Merriwindi I) the increment then levels off and tends to remain close to this level over the range of BAs: a typical plateau response. In the fifth block (2) there is a different response, with the increment peaking at a BA of about 8 m^2/ha, and then falling by up to 30 per cent as the initial BA rose higher. The loss of increment with increasing BA was not associated with significant mortality, and appears a "locking" of the stand as density increases (see Section 6.5.2). The block showing this different response was the one situated on the deep sand.

Taken together, the plots show that, over the 20 year period following thinning, the maximum stand increment accrued on the fewest trees when the residual BA was about 8 m^2/ha; for practical purposes the optimal residual BA range for these stands would appear to be 6-10 m^2/ha, giving BA increments in the order of 0.3 to 0.4 m^2/ha/year.

The effectiveness of the earlier, non-commercial thinning in accelerating diameter growth, and thus speeding the time until the stands reach merchantable size, has also been demonstrated in these plots, with the largest mean diameters at the time of plot treatment being in those blocks which had received the heaviest earlier treatments (to about 800 stems/ha), and the smallest in the most densely stocked blocks.

Horne and Robinson have also been able to show that, though there is some evidence of a decline in DBH increment with age of treatment (from 30 years in the case of the Jacks Creek plot, discussed by Lacey, 1973, to 60 in the O'Neill plots), the decline is not rapid and the O'Neill plots, at age over 80 years, show a DBH CAI of over 0.3 cm/year for residual stockings of about 100-150 stems/ha (BA 6-9 m^2/ha).

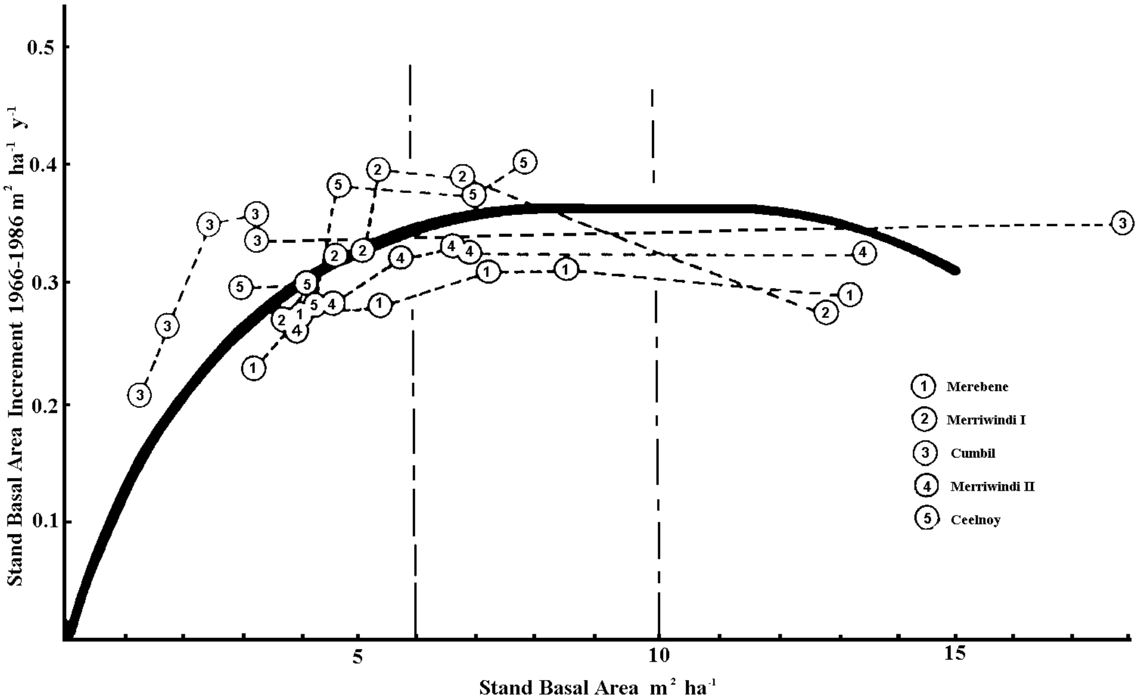

Figure 2 : Basal Area Growth Response shown by the O'Neill Plots (Baradine District) From Horne and Robinson (1987)

The O'Neill plots have proved extremely valuable in elucidating features of Cypress Pine growth in NSW, and Horne and Robinson have summarised their conclusions as follows:

1. The increment/density pattern for 20 years following thinning at age 60, in the absence of "locking", is shown to be plateau-like, ie. that increment is independent of basal area for a wide range of values.

2. In the absence of locking, the plateau of maximum basal area increment ranged over basal areas of 8 m^2/ha to 13m^2/ha at three locations and up to 18m^2/ha at one location.

3. The optimal residual basal area range for 60-year-old stands to produce the largest trees without under-utilising the site was found to be 8 m^2/ha, with a practical range of 6 to 10 m^2/ha.

4. The maximum basal area increment, reflecting the site potential of each location, ranged from 0.3 to 0.4 m^2/ha, with the single deep sand site giving higher increment than the four solodized solonetz sites.

5. The fertile deep sand plot exhibits the phenomenon known as locking at high basal area. There was a 30 % increase in increment gained by thinning the stand from 13 m^2/ha to 7 m^2/ha on this site. For the less fertile solodized solonetz sites, stand increment was constant over this range. Susceptibility of deep sand locations to moisture stress at high basal area is suspected.

6. Major adjustment to the time taken for the stand to reach merchantable diameter can be achieved by pre-merchantable thinning. Growth response to pre-treatment was shown to be affected by the intensity of the pre-treatment.

7. Diameter increment trends indicate that although diameter increment may be falling with age, Cypress Pine stands in excess of 70 years of age will show diameter growth response to further stocking reductions.

7.2.4 Site Quality

It is evident in the field that, as with other forest species, the productivity of Cypress Pine varies with site conditions. Some areas are clearly capable of relatively high rates of productivity; others appear incapable of ever reaching merchantable size. Assessing these changes more objectively has proved difficult, and Lacey (1973) summarised the position well:

"Site quality can only be described in broad qualitative terms and requires further research. Site height is of limited value for assessing site quality since there are only restricted areas where mature free grown trees or immature free grown trees of known age can be found. Total basal area has greater application, but is confined to situations where overstocked stands are present and significant mortality indicates that maximum basal area has been attained.

Maximum growth rate of Cypress Pine in New South Wales is found on soils which have good moisture availability but are nevertheless well drained. These are mostly deep sandy sites which, due to particular drainage features, have moisture always present at depth. Conversely, the poorest development is found on drier sites, such as ridge tops or shallow soils, as well as on the other extreme of sites which are poorly drained because of heavy soil texture or topographical impediments. Soil fertility appears to be of much lesser importance in determination of site quality. Very low levels of the macronutrients are often encountered on areas of high site quality, especially the deep sands. There is an approximate relationship between species associations with site quality, but species associations will only achieve real usefulness as indicators of site quality when modified by the soil characteristics mentioned As yet, this has not been seriously attempted."

In Queensland Johnston (1975) found significant differences in DBH/Height relationships between stands on two forests for which ample plot data were available, and Vanclay & Henry (1988) have subsequently examined this relationship further and have developed a measure for site quality based on the expected height of a tree of 25cm DBH. They have termed this height site form and note that it may vary from 10 to 20m, though stands with a site form of less than 14m are rarely of commercial importance. The technique has yet to be tested in NSW

Using data from the O'Neill plots, Horne and Robinson (1987) were able to compare the 5 blocks of plots using a direct measure of growth, BA increment at its peak or plateau level, and thus to rank the five sites (see Fig. 1). Here the block on deep sand (Merriwindi 1, site 2) was superior to the four sites on solodized solonetz soils, as had been indicated in more general terms by Lacey in the extract given above.

In the Forbes district, in stands of approximately the same age (1890s regeneration) and of similar treatment history, Horne and Robinson (1986) distinguished three SQ strata on the basis of dominant height at the time of 1978 plot measurement:

High SQ	Over 16m dominant height
Medium SQ	14-16m
Low SQ	Under 14m.

Unfortunately, the conditions that applied to the Forbes plots are often lacking.

7.2.5 Other Growth Relationships

Horne and Robinson (1986) used the site quality strata outlined above in an examination of diameter growth in a series of thinning plots established in Forbes district in 1974, and their results are shown graphically in Figure 3.

Two features are of particular interest here. One is the confirmatory reduction in DBH increment for similar stocking classes with decreasing SQ. The other is the way that diameter increment was maintained over the entire diameter range in the high SQ sites, whilst in the medium and low SQ sites the increment fell away rapidly as tree diameter increased. This further highlights the desirability of being able to recognise SQ, since the higher quality sites are those most likely to prove economically beneficial for treatment.

Cooney (1985), commenting on silvicultural treatment of Cypress Pine in the Dubbo region, has drawn attention to the possibility that BA fails as an indicator of stocking levels when very large trees are present: in stands with an average DBH of over 30cm, quite high rates of increment appear to be obtained in stands of high BA. He quotes one such example from Spring Ridge SF where an obviously thriving stand has a BA of 12-14 m^2/ha, with trees spaced 9-10m apart. He suggests that, because of the wide spacing, competition between the trees is limited: each tree, despite its size and the resultant high BA, has adequate room to continue growth. He speculates that this collapse of BA as an indicator happens when spacing between trees is between a third and a half of tree height.

This observation was supported in a response by the then District Forester, Gunnedah (letter dated 18.10.85): Brian Kennedy agreed that the maximum area exploited by a large Pine appeared to be in the order of 80-100m^2. These are interesting observations warranting closer study.

Growth of Pine in uneven-aged stands has been examined by Johnston (1975), who showed that, in two-storeyed stands, the understorey stems were able to make particularly effective use of their site. In one study, over a range of plots, the understorey stems contributed only 14 per cent of the total BA, but were producing 40 per cent of the BA increment. In one case selected understorey stems were contributing 25 per cent of the BA increment in a plot, from only 2 per cent of the plot BA. Removal of the understorey produced a slight increase in the growth of the remaining overstorey stems. This again is a phenomenon warranting more study.

Johnston, in his very comprehensive opus on Pine thinning in Queensland, also examined mortality in Pine. Out of 51 long established plots, 34 had suffered no mortality throughout their life. Almost all lots carrying over 1 000 stems/ha showed some mortality; only a few, located adjacent to each other in one area, showed mortality where stocking was below 1 000 stems/ha. He could find no trend towards increasing mortality with increasing plot BA, and was unable to find a

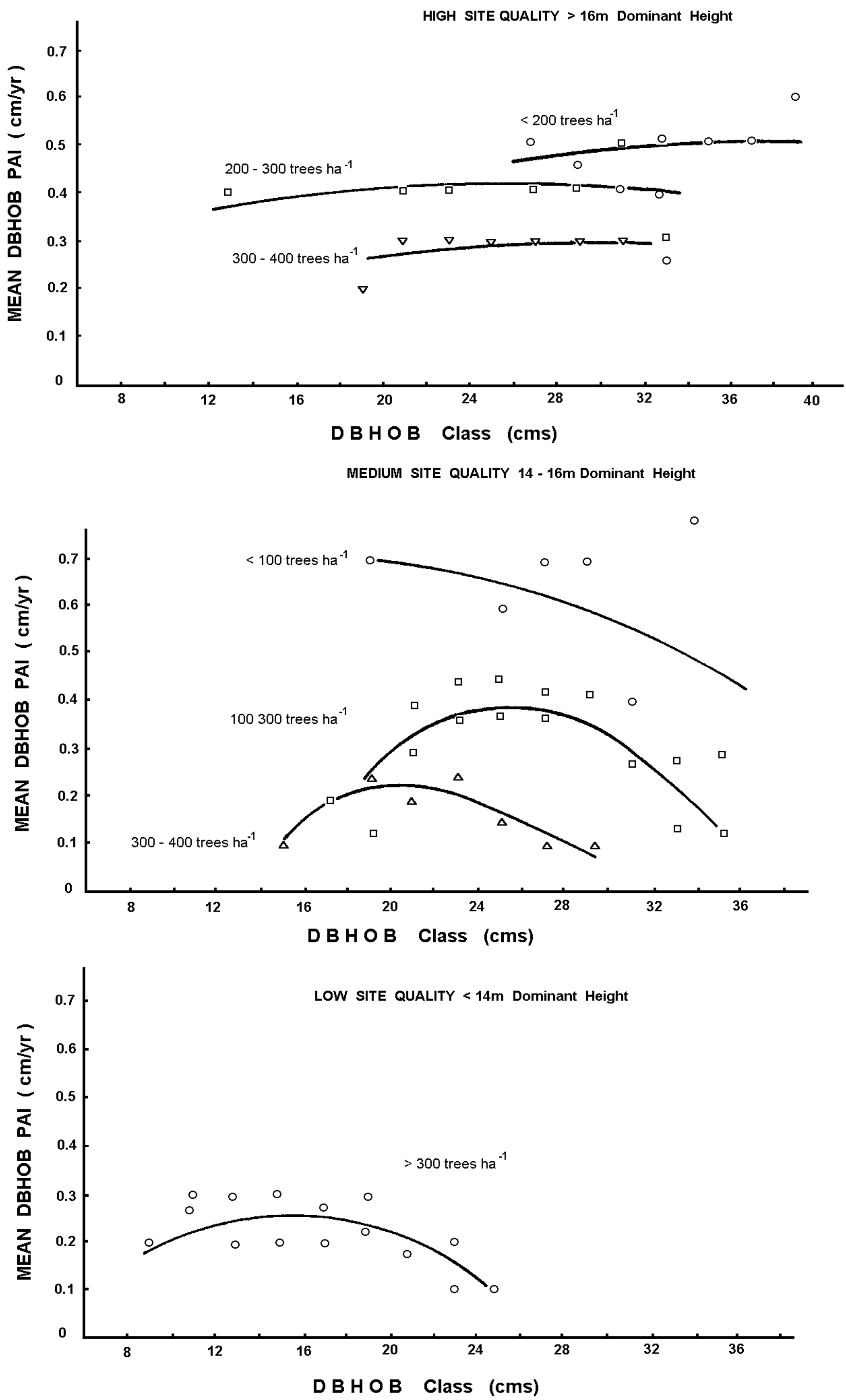

Figure 3 : DBH Growth, 1890's Regeneration, Forbes District

correlation between mortality and rainfall. The dead stems were typically the smaller, suppressed members of the stands, and Johnston attributed the mortality primarily to the suppression of weaker stems in the dense stands. By comparison, in dense regrowth on Strahorn SF it appears often to be the dominant stems that die - a kind of natural urge for stand mediocrity - while the deaths of apparently vigorous stems in thinned stands, possibly following Jewel Beetle attack, are not uncommon in NSW.

7.2.6 Effects of Culling

Much silvicultural expense in the Cypress Pine stands has been incurred in the removal of presumably competing eucalypts and other hardwoods - sometimes to the extent that large hardwoods have been virtually eliminated, converting formerly mixed Pine-hardwood stands to pure Pine.

Strangely, there appears to be little quantitative data to support this practice - an omission all the stranger since on occasions Pines can be observed growing apparently healthily in close proximity to an overtopping eucalypt, except for some crown damage caused by physical abrasion.

Nonetheless, in most areas eucalypts clearly do exercise a retarding effect on the smaller Pines. The only known study measuring the response to hardwood removal is reported from Queensland by Henry (1960), and relates not to eucalypts but to Bull Oak. In this case (in a study confounded by the treated plots also being thinned), DBH increments during the 3 years following Oak removal were 3-4 times as much in the treated plots as on comparable stems in untreated plots: increments of about 0.2cm a year in the untreated plots, compared with about 0.7cm in the treated plots, on stems averaging about 7cm DBH.

In practice, in NSW little treatment is carried out in dense Bull Oak stands because of cost and subsequent Oak regrowth, whereas eucalypt removal is still carried out where it seems necessary though on a much reduced scale and with more selectivity than during the 1960s. Some growth data to confirm the response to eucalypt culling would be useful, though there seems no doubt that in most districts the practice is desirable to improve Pine growth.

Much of the hardwood overstorey occurring with Cypress Pine is of limited commercial value, but this is not the case in stands where Ironbark, and particularly Narrowleaved Ironbark, occurs, and the treatment of mixed Ironbark-Pine stands raises obvious problems. The Ironbark is typically both taller and faster growing than the Pine, and the usual approach in such cases appears to be to thin the Pine submerchantably, disregarding the Ironbark component; to accept that some diminution of Pine growth will occur because of the Ironbarks; to harvest the Ironbarks in due course as poles or small logs; and to treat the remnant Pine stand in the usual manner.

7.2.7 Hardwood Growth

Little information is available on the growth of eucalypts or other hardwoods in the Cypress Pine forests, but CFI plots in the Pilliga M.A. suggest the rates shown in Table 5 for Narrowleaved Ironbark (from 1987 Management Plan for Pilliga M.A.).

Although hardly borne out by the increments shown in Table 5, the Plan observes that growth from seedling to pole size (30-40cm DBH) is quick, vigorous and competitive, with the less vigorous stems becoming suppressed and ultimately dying. On the basis of what appears to be even less information, the 1984 Gilgandra Management Plan estimates DBH increment at about 0.3 to 0.4cm a year, with the rotation for poles about 60 years.

From Queensland, Hawkins (1954) presented growth data for Narrowleaved Ironbark in even-aged coppice stands in the Dalby district. Growth was related to stool diameter (the larger stumps gave the faster growth, though mortality was also higher). Averaged over all measured stems the mean DBH at age 17 years was 9.5cm (MAI 0.56 cm), and the mean height 7.0m (MAI 0.42m). Height growth was diminishing as the stems became older (0.73 m/year to age 4; 0.34 m/year from age 4-17 years). Over the period the largest stem DBH was 14.1cm, and the tallest height 11.3m. Such growth rates would certainly be well above those of the associated Pine.

Table 5

NARROWLEAVED IRONBARK - GROWTH RATES, PILLIGA M.A.

DBH Class (cm)	DBH CAI (cm/yr)	Height CAI (m)
10 - 20	0.18	0.25
20 - 30	0.25	0.29
30 - 40	0.21	0.38
40 - 50	0.16	0.30
50 - 60	0.16	0.30
60 - 70	0.16	0.46
Mean	**0.20**	**0.33**

7.2.8 Volume Levels

Before leaving the consideration of growth relationships in the Cypress Pine types, it is important to remember that these are not high volume stands.

Probably the maximum merchantable volume that could be found in Pine stands would be below 100 m^3/ha. Johnston (1975) and Dale (1979) both give figures in the range 80-90 m^3/ha from Queensland, whilst a particularly good stand on Spring Ridge SF carries 60-70 m^3/ha.

Most managed stands of merchantable size appear to carry volumes in the range of 20 to possibly 50m^3/ha. Under exceptional circumstances total BA may reach 30 m^2/ha: Johnston quotes Queensland plots of over 25 m^2/ha, and a particularly fine stand of 1890's regrowth on Talbragar SF carries about 24-25 m^2/ha.

Against these low volumes, the generally very easy topography and open nature of the Pine stands makes for cheap logging, and in consequence low volume yields are considered economic. Over most of the Cypress Pine zone a yield as low as 4-5 m^3/ha is calculated to pay its way, and yields of about 10 m^3/ha are common, whilst Ironbark sawlog harvesting in the Baradine district has averaged less than 4m^3/ha over a period of 7 years, with yields of 2m^3/ha not uncommon.

7.3 Economics of Cypress Pine Treatment

Section 7.2 has presented a large volume of often rather disjointed information about the growth of Cypress Pine, and efforts to highlight the main features will be made in Section 10.3. However the main thrust is clear: the need for dense Pine stands to be thinned to a stocking that will allow the remaining stems to reach merchantable size, allowing subsequent repeated merchantable thinning of the stand until finally a new crop of regeneration has to be established and the final felling of the old crop trees can be carried out.

As Johnston (1987) has graphically pointed out for Queensland, the costs associated with this cycle can be considerable:

> *"Thus, by its efforts to improve the low productivity of these forests through fire protection, logging and silvicultural treatment, the Queensland Department of Forestry had become locked in to a self-perpetuating spiral involving rapidly escalating protection requirements on the one hand and higher management costs on the other."*

Edwards (1987) has endeavoured to calculate the economics of a Pine rotation, based on conditions in the Pilliga area, and a simplified version of his basic stand conditions and treatment cycle is given in Table 6. While features of this study are arguable, it appears to give a not unrealistic picture of the growth that might be expected under current practice. The cycle covers a period of 79 years from the pre -commercial thinning to the final felling; assuming the spacing to 270 stems/ha occurs about age 20 years, this represents a rotation of 90-100 years (depending upon how promptly the next crop of regeneration becomes established after the regeneration felling). Total volume harvested over this period is about 97 m^3/ha, giving an MAI of about 1 m^3/ha.

Edwards' financial analysis allowed $400/ha for the pre-commercial thinning; provided for a grazing return of $1/ha/year up until the regeneration felling, when it was reduced to 50 cents; calculated royalty on the current rates for an average tree at each operation; and used an investment rate of 12% and an inflation rate of 8%.

Table 6
STAND DETAILS FOR ROUTINE TREATMENT CYCLE
(Simplified from Edwards, 1987)

Treatment	Before Treatment				After Treatment		
	Stocking (st/ha)	BA (m^2/ha)	Mean DBH (cm)	Vol (m^3/ha)	Stocking (st/ha)	BA (m^2/ha)	Vol (m^3/ha)
Precommercial Thinning - 33 yrs	High	-	7.0	-	270	1.0	-
Ist Thinning - 16 yrs	270	12.2	24.0	42.9	149	6.7	23.6
2nd Thinning - 20 yrs	149	12.1	32.2	52.1	74	6.0	26.1
Regeneration Felling - 10 yrs	74	10.4	42.2	50.4	7	1.0	5.0
Final Felling	7	1.2	46.2	6.0	-	-	-

The results of the analysis on this basis showed an accumulated loss of nearly $2 000 at the end of the cycle. In order to break even it would be necessary to reduce the initial cost to $300 /ha or substantially to increase either grazing revenue or royalty - or both.

Like any financial analysis this should be regarded as indicative only, but the result tends to confirm the pattern shown by the Commission's commercial accounts for Cypress Pine, and also the gloomy prognostications given by Johnston (1987). It highlights several matters that will be considered further in Section 10.2, but one point is worth stressing here: it seems that grazing will have to play an increasingly important role in the management of the Cypress Pine forests and, in contrast to the $1/ha return allowed in Edwards' study, grazing returns in Narrandera district range from under $2/ha to over $10/ha, with the median value since 1984 averaging about $4/ha. Obviously there is scope for improvement.

7.4 Size and Longevity

Baker and Smith (1910), Lacey (1973) and Boland et al. (1984) all state that White Cypress Pine can grow to or exceed 30m in height, though no trees of this size are known to exist in NSW to-day. Lacey comments that in the Baradine district the largest tree known had a height of 28m (misprinted as 23m) and a DBH of 69cm: the tree was dead in 1973.

Among the largest standing Pines in NSW are those listed in Table 7 and taken from the Commission's register of large trees. Although lower in height than the trees mentioned above, several of these exceed the diameter limit of 90cm mentioned by Baker and Smith and by Boland et al. The table also includes several other species commonly associated with Cypress Pine.

Lacey (1973), on the basis of ring counts and feasible diameter increments, estimated that the larger Pines could be about 200 years old. More recently wood taken from the stumps of two large stumps in Gilgandra district has been subject to radiocarbon dating. Allowing for stump height and distance from stump centre, these gave the following ages:

Location	Stump Height (cm)	Stump Diameter (cm)	Pre-1950 Age (yrs)	Est. Year of Origin
Gular Common	10	99	112	1830
Tailby SF	28	90	270	1670

The Tailby SF sample indicates a greater longevity than had been previously postulated.

Table 7
OUTSTANDING TREES OF THE CYPRESS PINE ZONE

Species	Locality	Height (m)	DBH (cm)
White Cypress Pine	Pilliga West SF		
	- Kenebri Section Cpt 1	24.0	87
	- Ceelnoy Section Cpt 98	24.5	94
	- Cpt. 107 (Dry Sand Rd)	26	89
	Pilliga East SF		
	- Cpt 727	25.0	67
	- Cpt 727	23.5	68
	Tailby SF (on deep sand)	26.1	110
	Killarney SF	26.1	100
	Gulpa Island SF	13.5	120
	Parkhurst SF	19.7	92
Narrowleaved Ironbark	Pilliga West SF		
	- Merebene Section. Cpt 122	30.3	133
	- Ceelnoy Section Cpt 115	25.8	150
	- Yarraman 11 Section Cpt 42	36.5	113
	- Ginee Sect. Cpt 17	32.0	107
Brown Bloodwood	Cy. Burnett, Ph. Strathmore, Pn. 20 (CL 32.5) (Inverell District)	38.5	1.04
Kurrajong	Merriwendi S.F.	22.1	0.57
	Pilliga West S.F.		
	- Sand Monkey F.R.	19.5	0.54
	- Ginee Sect., Cpt. 15	22	1.11

Lacey commented on the difficulties of using growth rings in White Cypress Pine to determine age, and Dunwiddie and LaMarche (1980) have examined specimens from a number of species in an effort to determine species which may be suitable for dendrochronological studies in Australia. Their best results came from samples from Rottnest Island Pine growing near Perth, WA, where the reliable and strongly seasonal Mediterranean-type climate led to the formation of clear rings, though they had difficulties in obtaining trees older than about 70 years.

White Cypress Pine from NSW tended to have excessive resin staining, and when this was removed they faced the *"problem of accurately differentiating annual rings from false, intra-annual bands."* This problem was not resolved, though they believed that samples from the tree in South Australia might prove more promising, and that Black Cypress Pine might also warrant further study for this purpose.

8. DAMAGE TO OLDER STANDS

8.1 Climate

8.1.1 Drought

The Cypress Pine types can be damaged by several climatic events, but by far the most important is drought.

Pine itself is remarkably tolerant of moisture stress and *"has developed particularly efficient ways of minimising water loss through its disposition of stomata"* (Clayton-Greene, 1981); in the mixed Western Grey Box-Pine stands studied by Clayton-Greene, drought death in the Box was more frequent than in the Pine.

Dense stands of young Pine are usually surprisingly unaffected by drought, but larger stems, growing with the dense regeneration, will often die during dry periods: this is a widespread experience through most of the Cypress Pine zone, and it also occurs with eucalypts surrounded by dense Pine regeneration (see, eg. Fig. 5 in Lacey, 1972). It has sometimes been attributed to the regeneration's being more shallow rooted, and hence better able to benefit from the occasional shower, than the overstorey trees. However this is probably an oversimplification, and the more effective use of their site by understorey trees is also involved: see Johnston (1975) and discussion in Section 7.2.5.

Regeneration established on shallow soiled ridges or similar sites will die, or be severely thinned out, during drought: the drought hardiness, like the capacity for stands to lock, is by no means absolute.

Particularly towards the drier end of the Cypress Pine zone, dieback of the leading shoot of Pines is commonly observed during drought periods: this results in malformed and multiple-leadered trees, and it can significantly reduce the yield of merchantable timber and provide a prime entry point for Yellow Rot (see Section 8.4). Dieback is widespread in parts of the Western Division Pine stands in NSW (eg. Cobar and Condobolin MAs), and is reported by Dale (1979) from the more westerly Queensland stands.

Even where dense regeneration is absent, there are commonly scattered, and occasionally concentrated, deaths of apparently previously thrifty trees during droughts. The incidence of these deaths in any area may be insufficient to warrant a salvage operation, but over the forests as a whole it can represent a fairly substantial loss of merchantable timber. Moisture stress is usually shown by the development of a sparse crown and by the drying of the bark and wood, with the latter ultimately resulting in visible splitting and checking to produce "resin cracks" or "sap cracks". These can extend well into the heartwood of the tree, and although a severely affected tree can recover when moisture conditions improve the utilisation of the timber may not be possible. Elsewhere drought undoubtedly reduces growth rates generally, and it is one of the factors that predisposes Pines to Jewel Beetle attack. Describing an exceptional dry spell at Baradine in the first half of 1986 *("the driest recorded period since the early 1900s")* D.W. Nicholson (letter of 19th April,) has observed:

> *"This drought caused vigorous trees on deep sands and shallow solodized solonetz soils to split and ooze sap. About 12 months later these trees began to die, particularly on the deep sands. It appeared that the sap cracks allowed Jewel Beetles entry and it took 12 months for Jewel Beetle numbers to build up sufficiently to become the second agent, causing death. This process has now stopped, but covered several hundred hectares throughout Pilliga West and Central Pilliga."*

Sometimes Pine mortality rises following the end of a drought, eg. parts of Narrandera district in 1984 and Baradine district in 1986-87. In such cases it appears that a deep rooting habit develops during the drought and, where there is impervious subsoil, these roots become waterlogged when the drought breaks, effectively drowning the root system.

8.1.2 Wind

Windstorms occasionally damage Pine stands. Heavy wind in early 1985, following a rainy period, blew down trees on Courallie SF, and left others with a strong lean. Twelve months later many of the downed trees still had green tops. Lacey (1973) notes that storm damage can also result in stem breakage, and may cause the almost complete destruction of stands in localised areas. Storms can also produce windshakes in the wood, a defect that may not be apparent until the log is sawn in the mill. Windshakes are evident from many areas and appear to be related particularly to the exposure of widely spaced, open grown trees. For this reason some foresters question the practice of retaining individual trees, as a future sawlog resource, during clearing for cropping.

8.1.3 Hail

Hail also can damage Pine stands. H. MacDonald recalls a storm on Grahway SF in December 1984, when branches up to 2cm in diameter were broken off the trees, though the flexible tips of the trees were less damaged. Some deaths seemed certain to result from this storm, though Lacey (1973) observes that crown recovery from epicormic buds is usually rapid on hail-damaged trees (epicormic buds on Cypress Pine remain functional until the bark thickens over them). In November 1972, a combined wind and hailstorm caused significant wind-throw and hail damage to some 7 300 ha in Pilliga West SF, requiring subsequent salvage logging.

8.2 Fire

There is a curious ambivalence about the effects of fire in the Cypress Pine types. Pine itself is undoubtedly susceptible to fire damage, but it is a qualified susceptibility, well described by Lacey (1973):

> *"As mentioned previously, Cypress Pine in the absence of regular burning tends to form dense stands. These are characterised by low quantities of ground fuel which will not carry a severe fire and hence such stands tend not to be subject to extensive fire damage.*
>
> *Cypress Pine is most prone to fire damage when it occurs as scattered regeneration and is surrounded by grass cover. At this stage even quite mild fires may result in its death (figure 28). To some extent stands of regeneration remain sensitive to fire even after the site is fully occupied and the characteristic clean floor is produced. The degree of damage depends upon the height of the crown and the intensity of approaching bush fires outside the stand. Crown flaring of dense regeneration occurs on the edge of the stands in contact with the fire, but mostly the pattern is that a proportion of these stems recover and the stems within the stand are unaffected. In open stands with abundant ground cover even quite mature Cypress Pine will be vulnerable to fire and such stands may be completely devastated. Under mild burns foliage of Cypress Pine crowns may be completely destroyed but, provided the heat has not been intense enough to kill the smooth barked branches, the crowns will be reformed from epicormic buds and the trees will survive. This is a common development of trees in wheat paddocks which may experience stubble burns at regular intervals. Stubble burns may produce intense heat but this is usually of short duration. Apart from the most dramatic effects of fire in causing death in Cypress Pine stands, general vigour may be substantially reduced."*

Several additional comments might be made to this.

- The recovery of trees that have been defoliated in a light fire appears to depend on the subsequent weather conditions. If conditions are mild, with adequate rainfall, a high level of survival will occur, but if drought conditions follow the rain all or most stems may die.

- In periods of very high or extreme fire danger Pine foliage can burn explosively, leading to the flaring mentioned by Lacey and allowing damage to extend into clumps further than the ground fuel might suggest. Under such conditions both large trees and small, dense clumps of regeneration can be killed.

- Slow moving ground fires in areas with heavy ground fuels of grass and litter can kill large trees by destroying the conductive tissue at the base of the tree, thus effectively ringbarking them. This is sometimes known as "firesapping", and has been used by some landholders to remove unwanted stands of Pine.

As noted earlier, it seems that in pre-European times most Pine stands were maintained in a much more open condition by frequent Aboriginal burning (see Section 2.3). Grasses made up much of the understorey, and these could be burnt frequently by fast fires that would have caused little damage to the established trees, though they would preclude most regeneration establishment. In the changed forest conditions of to-day the denser stands produce little grass, or indeed other fuels on the forest floor: Van Loon and Love (1971), on Pilliga East SF in Pine-Narrowleaved Ironbark-Bull Oak stands, found an average of only 6t/ha of ground fuel (range 5-11t/ha) 20 years after the stands had been burnt. However this fuel will support a fire under extreme conditions, and there is usually enough understorey vegetation present to lift such a fire and to cause crown damage, with subsequent death and debilitation. Such fires occur periodically in the Cypress Pine zone, eg. the 1951 and 1982 Pilliga East fires.

Because of the low fuel levels, hazard reduction burning in the current denser Pine stands is rarely practicable; it would probably also be regarded with some concern by neighbouring landowners and by those pasturing stock in the forests. Nonetheless it has been suggested for the Queensland forests by Johnston (1987):

> *“A possible management scenario for the mid-western and southern cypress regions could include a cessation of silvicultural treatment, introduction of aerial fuel reduction burning and progressive reduction of the fire detection and suppression infrastructure which is now in place.*
>
> *Yield calculations suggest that the volume of cypress pine available for harvest would be little affected by the immediate cessation of silvicultural treatment, at least over the next 50 years. This is mainly due to the relatively poor productivity increases which are being obtained through current treatment activities.*
>
> *Furthermore, the limited fuel reduction burning trials which have been carried out suggest that, under appropriate weather conditions, cypress stands carrying even quite high levels of ground fuel can be successfully burnt with little resultant mortality in the commercial component of the crop. Thus there appears to be considerable potential to scale down the high costs associated with both the silvicultural treatment and the fire protection aspects of cypress pine management in these areas. It appears that any such scaling down could be accomplished without a substantial increase in the risk of major forest losses and without a significant impact on the projected harvest levels.”*

In the long run, this is an approach that certainly needs to be considered for NSW, though it would need to be introduced as part of a wholesale revolution in the management of Cypress Pine. It would certainly not be easy to introduce, in part due to the mixed stand structure in many compartments, to the development of scrub layers in many stands, and to the demonstrated difficulty of burning successfully in dense young regeneration (see Section 6.4).

Fire can cause obvious damage to both regeneration and larger trees. For example, the 1982 fire on Pilliga East S F. burnt over some 106 000 ha, about a third of it Pine types, and killed an estimated 50 000 m^3 of merchantable Pine. In addition, Hawkins (1966) has shown that the seed production of Pine is disrupted for 5 or more years in moderately burnt stands, while the damaged trees are predisposed to Jewel Beetle attack (Hadlington and Gardner, 1959).

8.3 Insects

A number of insects can damage Cypress Pine, with the most important being the Cypress Pine Jewel Beetle (*Diadoxus erythrurus*). The Beetle larvae burrow in the conductive tissue of the stem causing the often serious "grub-hole" degrade of both White and Black Pine. Attack is usually confined to trees which have already been debilitated by other damage - drought, fire, mechanical injury or insect defoliation (Hadlington and Gardner, 1959). Trees may be killed when the larval tunnels ring the tree.

The Cypress Pine Sawfly (*Zenarge turneri rabus*) can cause the complete defoliation of Pine, with young trees preferred to old. A single defoliation will rarely kill a tree, but may predispose it to Jewel Beetle attack. However trees growing in unfavourable sites, especially low-lying areas, may be repeatedly attacked with some mortality. Attack often appears greatest in periods of above average rainfall. The insect is widely distributed through southern and central districts, but apparently does not extend into the Pilliga area. The life history of the insect has been studied by Moore (1963).

Among other insects of Cypress Pine, the Cypress Pine Aphid (*Cinara tujafilina*) may cause the death of foliage tips and also reduce seed crops (Hawkins, 1966). It is of limited significance, but is sometimes associated with visually disfiguring sooty mould. Longicorn beetles and a subterranean termite have been found in the stems of dead or dying Pines, but are believed to be secondary infestations. Although Cypress Pine timber is largely immune to the ravages of termites, termites are not uncommonly found in living trees and frequently cause severe damage to eucalypts growing in the same stands.

Froggatt (1923), besides describing the three main species mentioned above, refers to several other minor insects found on Pine, and Lacey (1973) refers to some gall-forming insects and also to the more significant destroyers of seed (see Section 6.4), while Thomas et al. (1980) mention the presence of coccids and weevils on dieback-affected trees.

8.4 Fungi

The most serious fungal damage to Cypress Pine is Yellow Rot, caused by *Phellinus* (syn. *Fomes*) *robustus*. It produces a yellow (occasionally chocolate coloured) stringy or lamellate rot (Lacey, 1973). Whilst commonly spread by root contact and appearing as a butt rot, it can apparently also infect stems through branch stubs, and can appear in the heads of logs or even in the centre of logs that appear free of damage at both ends. Marketing studies carried out in 1968 suggested that Yellow Rot was responsible for a volume recovery loss of up to 14 per cent in the sale of Pine logs, and this would have been an underestimate since logs totally unsuitable for milling because of Rot were not included. Damage tends to be greater in the larger sizes, but can affect all sizes: C.J. Lacey recorded the incidence of Yellow Rot in the butts of trees removed in the course of plot establishment on Killarney SF, in a site regarded as "average" for Rot, and his results are shown in Table 8 (from letter dated 22-4-69 on H.0. 45872).

Some sites are known to be more prone to Yellow Rot than others, with deep sands often showing a high incidence. In particularly bad sites the extent of Rot may make harvesting uneconomic. No measures to control or reduce this timber degrade are known. Besides its attack on Cypress Pine, the fungus is also a common cause of rot in associated eucalypts and particularly in Bull Oak.

Table 8
INCIDENCE OF YELLOW ROT BY STEM DIAMETER: KILLARNEY SF

DBH Class (cm)	Total No. Stems	Stems showing Rot	% with Rot
5-10	155	1	0.6
10-12.5	137	4	2.9
12.5-15	135	14	10.4
15-17.5	77	12	15.6
Over 17.5	47	10	21.3
Total	**551**	**41**	**7.4**

Less common, but still widespread in Pine stands, is Brown Rot that causes a brown cubical rot, usually confined to the butt of the tree. The causative organism is not known, though *Gloeophyllum abietinum* (*Lenzites abietina*) has been suggested. Other fungi attack the sapwood of dead standing timber (Lacey, 1973).

8.5 Other Causes of Damage

The mistletoe, *Muellerina bidwillii*, is not uncommon as a parasite on Cypress Pine trees with heavy infestation usually appearing in poor health.

In some areas (eg. Courallie SF) the Silkpod (*Parsonsia eucalyptophylla*) is widespread, with vines growing on almost all the larger trees. It does not appear to inconvenience the trees. Devils-Twine (*Cassytha* spp.) sometimes covers smaller stems: see Silvicultural Notes No. 8, (Dry Coastal Hardwoods) Section 6.6.

Dense stands of Bull Oak occur in many areas and can effectively prevent the development of Pine. Treatment of the Oak is costly and of doubtful value in the denser sites, with the oak coppicing. The dynamics of such stands (eg. Trinkey SF) warrant further study, as there is some evidence of a cycle of stand development, with some possible opportunities for Pine or Ironbark establishment at certain stages.

Lacey (1973) notes that Galahs and White Cockatoos may attack seed crops, but the significance of the damage is slight.

Dieback in Queensland Cypress Pine forests has been related to occasional waterlogging of sites after periods of above average rain, with thinned and culled sites showing a tendency to greater incidence (Thomas et al., 1980). Initially salinity was also implicated, but later studies (Lamb and Walsh, 1982) suggest that waterlogging alone explains the dieback. This appears to be related to the post-drought deaths recorded from Narrandera and elsewhere, and mentioned in Section 8.1.

Deaths of Cypress Pine from waterlogging on Bimbi and Wilbertroy SFs have been attributed to changed drainage patterns resulting from earthworks (eg. levees) constructed on adjoining properties. However occasional inundation is not necessarily lethal to Pine: a particularly good stand of Pine, associated with Bimble Box, occurs on a floodway adjacent to a watercourse on Grahway SF. In this case the floods are probably of short duration and the stand appears to be on a free-draining sandy soil.

9 PRESERVATION

Hoschke (1976) showed no White Cypress Pine types reserved on national park in NSW, and 31 000 ha of Black Pine types. This information would have been incorrect at the time and has been overtaken by events since the 1971-72 inventory, when large areas of forested lands have been added to the national park estate in NSW

Parks or equivalent areas with significant areas of Cypress Pine types include Cocoparra (8 400 ha), Mount Kaputar (36 800 ha), Warrumbungle (19 600 ha) and Weddin Mountains (8 300 ha) National Parks and Yathong (207 000 ha) and Pilliga (69 600 ha) Nature Reserves. In addition, most of the isolated occurrence of White Pine in the Snowy River valley is within Kosiuszko NP. The recent (1986) update of Hoschke's inventory estimates some 58 000 ha of Cypress Pine types on national parks or equivalent reserves, and large areas of Pine are included in the proposed nature reserve in the Mt. Hope-Euabalong area.

Areas of White and Black Cypress Pine types that have been specifically reserved on State Forests as Flora Reserves or Forest Preserves are listed in Appendix 6. There are 22 such sites listed, occupying over 6 400 ha and sampling much of the range of site conditions of these types in NSW.

Appendix 6 also separately lists other Commission-controlled preserved areas that support other species of Cypress Pine. Eight sites, with an area of about 2 400 ha, are listed, carrying 4 other species of *Callitris*.

When not already occurring in reserved areas, the outstanding trees listed in Table 7 and growing on State Forest are individually reserved to live their natural lives.

10. MANAGEMENT ASPECTS

10.1 Objectives

The Indigenous Forest Policy for NSW (Forestry Commission of NSW, (1976) states with respect to Cypress Pine:

> *"The first requirement is the examination of long term supply zone possibilities. A long term supply zone is defined broadly as a forest or group of forests capable of sustaining a sawlog yield of 6 000m³ or more per annum, to an economically located industry centre. Where existing management areas do not meet this criterion, the possibility of amalgamation with other management areas should be considered.*
>
> *In those forests which can be included in a long term supply zone, management should aim at maximising merchantable increment over the next 30 years. Apart from the expected Statewide shortage of sawlogs, this period will be critical for cypress pine management in bridging the gap between the late 19th century growing stock and the post 1950 regeneration.*
>
> *The aim of maximising merchantable increment will be met in logging operations by thinning well stocked merchantable stands to a residual basal area of about 10m² /ha where stand conditions permit. Alternatively, logging of "increment" stands should be as light as economically feasible. Overmature stands with increasing defect and mortality should be logged as frequently an practicable to minimise loss of sawlog volume.*
>
> *Silvicultural treatment will aim primarily at increasing increment in those stands which will provide merchantable volume over the next 30 years. In practice, this will mean the non-commercial thinning of sub-merchantable cypress pine stands, and removal of hardwood stems actively competing with merchantable or sub-merchantable pine. The thinning of post 1950 regeneration way also be carried out, but will be a lower priority. In general, forests closer to the industry centre will be treated before the more remote forests. Treatment specifications should provide for retention of some stocking of species other than pine for ecological reasons.*
>
> *Provision and control of forest grazing will be an integral part of forest management, particularly for reduction of fire hazard, control of unwanted regeneration, and for revenue. Direct capital expenditure for grazing purposes should be avoided where possible, but in some situations will be justified.*

The general aim in long-term supply zones will be to fix sawlog yields at a level, which can be sustained. Where existing commitments are above this level, appropriate opportunities should be taken to reduce the commitment to the sustained yield level.

Those cypress pine forests which cannot be included reasonably in long-term supply zones will be managed on an extensive basic. Although many of these forests would be suitable for agriculture or grazing, a primary management aim will be to retain the forest cover for environmental reasons, as reservation of forests in the cypress pine zone is considered to be deficient.

The yield of cypress pine sawlogs from these forests should be regulated to minimise loss of volume by death or defect, and could be act on a periodic basis rather than annually. Yield of agricultural timber and other minor products should aim to fill local requirements, subject to the objective of maintaining a forest cover.

Grazing should be used in these forests to reduce fire hazard and obtain revenue. Where an urgent regeneration need exists, the grazing regime should be modified accordingly.

Direct investment in silvicultural treatment or capital works should be avoided, but on occasions minor investment may be justified, - eg. to improve grazing values sufficient to attract a lessee or permittee."

This policy in general covers well existing attitudes to the management of the Cypress Pine types, except that it predates the analysis of the Pine thinning plots (Section 7.2.3) and in consequence tends to set a residual BA rather higher than is now considered desirable and indeed than is retained in practice. It is a safe policy that avoids rocking the boat of established practice.

10.2 Management Problems

Much is known about the silviculture of Cypress Pine, and management regimes providing for the sustained production of mill logs have been developed: the cycle outlined in Table 6 is fairly typical. It is also uneconomic.

Under present conditions the dense regeneration of Pine has to be thinned to a wide spacing if selected stems are to reach merchantable size. Without thinning, stands could feasibly go through a rotation without any stems becoming large enough to sell; alternatively some may grow to such a size, but over so long a period that they would almost certainly be diseased and faulty. Yet the cost of thinning imposes an early debt that it seems impossible to repay from subsequent sales.

What can be done?

Still under present conditions the possibilities include:

- A changed accounting technique, wiping the slate clean and debiting the pre - commercial thinning cost against the proceeds of the earlier regeneration and final fellings, so that the cycle does not start with a heavy debt - psychologically beneficial, but anathema to those of economic bent.

- Reducing quantity of regeneration, so that thinning costs are much less. BA control and grazing offer some scope for improvement, but the uncontrollable factors - notably weather - exercise an almost overwhelming effect that would seem to make significant planned improvement unlikely.

- Cheaper thinning technique. Unlikely, though in an era of chronic unemployment much work may be done under social schemes.

- Increased grazing revenue. Suggested by Edwards (1987), and with undoubted scope in some areas, though often not until additional capital expenditure has been incurred (fencing, watering points, etc.).

- Market for small Pine thinnings. Where this exists, pre-commercial thinning can be less intensive and hence cheaper. However, short of new technological developments involving small Pine logs, it is hard to see any major improvements occurring.

- Higher stumpage rates. Cypress Pine seems to represent the one segment of the NSW timber resource where supply broadly exceeds demand, a feature that does not augur well for price rises. Nonetheless, a modernisation of the current Pine milling industry should result in economies helping to make Cypress Pine timber more competitive. However major improvements of significance would seem to depend on technological developments or inspired marketing (for example convincing South-east Asia that Pine is a better timber for joss sticks than Sandalwood - but it burns too fast).

In all, while some scope for improvements exists, the overall view remains pessimistic.

This leaves more revolutionary approaches, involving more extensive management, greater involvement with grazing, the use of fire, and ultimately reduced yields but more economic production of them. The use of fire has already been suggested by Johnston (1987) for Queensland, and appears to warrant closer examination and study in NSW. It is an approach that would seem to need to be introduced gradually - in part because of difficulties in burning under most current stand conditions, but also to enable skills in the use of fire in these western stands to be developed and to allow the neighbouring community to adjust to the idea. Some moves in this direction are already in hand, eg. provisions in Gunnedah Management Plan.

Another alternative, in many respects related to the previous one, is the adoption of a minimum treatment regime, such as already is applied in the Western Division stands, with a periodic scavenging of the logs of merchantable size, and allowing the regeneration to take its chances of stagnation, fire and grazing. It would ultimately tend to result in uneven-aged stands managed on an extensive selection system with a long cutting cycle, and again with decreased yields.

An intensification of grazing, with perhaps a wider tree spacing to promote pasture growth and with greater direct control over stocking rates and species - a form of multiple use management where the balance is tipped more strongly towards grazing than is normally the present case - is another possibility.

Or, of course, governments could agree to subsidise management in its current form, as at present, in order to maintain local employment levels and to sustain the existing timber industries supported by those forests: remember that unemployment relief schemes represent one such form of subsidy.

Cypress Pine management has undoubted problems, but there are alternative approaches available, though some of these need more research and practice. The alternatives do, however, need to be considered.

10.3 Guidance Points

These Notes have proved unusually - and in many respects undesirably - long, but they contain within them much that should help the forester newly faced with management of Cypress Pine stands. A few only of these matters are repeated here:

1. Most present day forests containing White Cypress Pine appear to differ greatly in structure and appearance from those of pre -European times (see Sections 2.2, 2.3, 5).

2. Seed supply is rarely a limiting factor in Pine regeneration (Section 6.1).

3. Optimum germination of Pine occurs at about 20°C, and most field germination appears in autumn and early winter (Section 6.3.2).

4. Successful regeneration depends upon a combination of factors occurring together - adequate seed; suitable seed bed conditions; good moisture conditions persisting through one, and in more westerly areas two, summers; protection from insolation; freedom from grazing. It is like playing a poker machine, with all the aces needed at the same time. Grazing is the only one of these factors over which much control can be exercised. When all conditions are favourable, stockings in excess of a million seedling/ha can result (Section 6.3.7).

5. Grass cover is beneficial in protecting seedlings from insolation (Section 6.3.5).

6. Waves of regeneration can be expected at BAs below 6m²/ha, and it has been suggested that BAs of 7-9m²/ha will allow establishment of more moderate stocking levels (Section 6.3.4).

7. Limited information suggests that the deliberate regeneration of eucalypts in the Pine stands is more difficult to obtain, though the eucalypt component usually seems able to be maintained (Section 6.3.8).

8. Regeneration can be destroyed by fire, though dense stands of regeneration are largely immune to fire damage because of the paucity of litter (Section 6.4).

9. Grazing, by both rabbits and domestic stock, can effectively destroy young established regeneration (Section 6.4).

10. Dense regeneration stands can lock, with little development of dominant stems, low mortality and negligible growth. Thinning of such stands is necessary if individual stems are to reach merchantable size (Section 6.5.2).

11. A spacing of 6 x 6m (about 280 stems/ha) seems necessary in most districts for all remaining stems to reach merchantable size, though a closer spacing can be adopted where markets for small thinnings exist (eg. 4 x 4m - 625/ha - in parts of Riverina, where vine posts can be sold), while in Forbes a spacing of 5 x 5m (400/ha) is considered satisfactory on most sites, even though development to merchantable size is somewhat delayed (Section 6.5.3).

12. Stands of or approaching merchantable size may show either a “plateau" response to thinning, with BA increment maintained over a range of BAs, or a peaking of BA increment, indicating a tendency to lock at higher BAs. In either case NSW plots tend to show about 8m²/ha as the level where BA increment reaches its maximum, and 6-10m²/ha as the optimum range to maintain BA (Section 7.2.3).

13. Increment tends to decline with age, though the rate of decline is not rapid over the age range 30-80 years (Section 7.2.3).

14. Locking, in plot studies, occurred on deep sands, while the plateau response occurred on solodized solonetz soils, with production levels (i.e. site quality) also tending to be higher on the deep sands (Sections 7.2.3, 7.2.4).

15. A suitable means of determining SQ in Cypress Pine stands has still to be found (Section 7.2.4).

16. There is some evidence that, in the higher SQ stands, DBH increment is maintained through a wide range of diameter classes, whereas in lower SQ stands it diminishes in the larger classes (Section 7.2.5).

17. There is also some evidence that, in the larger DBH stems, high increments can be maintained at higher BAs than would otherwise be expected (Section 7.2.5).

18. In multiple aged stands, the understorey trees seem better able to utilise the site than do the larger trees (Section 7.2.5).

19. Culling of unwanted, overtopping eucalypt stems has been widely practised in Pine stands. There is little experimental evidence, but much practical experience, to support this practice; though for environmental reasons a eucalypt component should be maintained in all stands (Section 7.2.6).

20. The commercial eucalypts tend to be faster growing than the Pines, and in mixed stands it is probably desirable to space the Pine regrowth without regard to the eucalypts, allowing the full response of the Pine to occur after the eucalypts have been harvested (Sections 7.2.6, 7.2.7).

21. Large White Cypress Pines can attain heights up to about 30m, DBH of 1m, and ages of about 300 years.

22. Drought is a major cause of mortality and malformation in Pine, even though the species is well adapted to withstand drought. In stands where older trees are growing above dense regrowth, mortality is most likely among the overstorey trees. Mortality can also be experienced in wet periods (particularly following drought), apparently as a result of waterlogging (Sections 8.1, 8.5).

23. Old trees can usually tolerate ground fires, though scattered regrowth may be killed. Dense stands provide limited fuel, though they may be killed or damaged by fire during extreme conditions (Section 8.2).

24. The major insect pest of Pine is the Jewel Beetle, which commonly attacks stressed trees and can kill them as well as cause timber loss (Section 8.3).

25. The main fungal disease is Yellow Rot, which causes significant timber loss. It is often most prevalent on deep sands (Section 8.4).

26. Current approaches to Pine silviculture are not economic (Sections 7.3, 10.2).

Current management practices in Cypress Pine are largely based upon the guidance points outlined above.

10.4 Further Research

Whilst there is a need to maintain and to analyse further the various growth plots established in Cypress Pines, it is suggested that the major research need at this stage should involve alternative approaches to Pine management, in particular involving more extensive management practices, more grazing and the possible use of fire in stands modified to allow periodic ground fires. The development of further markets for small stems could also revolutionise Pine management, but more extensive management practices seem more likely to produce commercial accounts that are in the black.

11. ACKNOWLEDGMENTS

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Appendix 1

LIST OF SPECIES MENTIONED IN TEXT

Common Name	Botanical Name
Apple, Rough barked	Angophora floribunda
Smooth barked	Angophora costata spp. leiocarpa
Belah	Casuarina cristata
Bloodwood, Brown Pale	Eucalyptus trachyphloia Eucalyptus polycarpa
Box, Bimble Fuzzy Pilliga Red Western Grey Western Red White Yellow	Eucalyptus populnea Eucalyptus conica Eucalyptus pilligaensis Eucalyptus polyanthemos Eucalyptus woollsiana (incl. spp. microcarpa Eucalyptus intertexta Eucalyptus albens Eucalyptus melliodora
Brigalow	Acacia harpophylla
Broombush	Melaleuca uncinata
Budda	Eremophila mitchellii
Curracabah	Acacia cunninghammii or aff.
Cypress Pine, Black Brush Coastal Mallee Mueller's Northern Port Jackson Rottnest Island Slender White	Callitris endlicheri Callitris macleayana Callitris columellaris Callitris verrucosa Callitris muelleri Callitris intratropica Callitris rhomboidea Callitris preissii Callitris preissii Callitris glaucophylla
Grass, Corkscrew Red-leg Spear Wire	Stipa spp Bothriochloa ambigua Stipa spp Aristida spp
Gum, Baradine Red Blakely's Red Mallee River Red Scribbly Snow Spotted Tumbledown	Eucalyptus chloroclada Eucalyptus blakelyi Eucalyptus dwyeri Eucalyptus camaldulensis Eucalyptus rossii Eucalyptus pauciflora Eucalyptus maculata Eucalyptus dealbata
Ironbark, Blueleaved Caley's Narrowleaved Red Silverleaved	Eucalyptus fibrosa spp. nubila Eucalyptus caleyi Eucalyptus crebra (in Qld. may be E. drepanophylla) Eucalyptus sideroxylon Eucalyptus melanophloia
Kurrajong	Brachychiton populneum

Common Name	**Botanical Name**
Mallee, Green Grey Red	Eucalyptus viridis Eucalyptus morrisii Eucalyptus socialis
White	Eucalyptus dumosa
Mistletoe	Muellerina bidwillii
Mulga	Acacia aneura
Myall, Coastal	Acacia pendula Acacia binervia (syn A. glaucescens)
Myrtle, Common Fringe	Calytrix tetragona
Oak, Bull	Allocasuarina luehmannii
Pine, Cypress - See Cypress Pine	
Rosewood , Western	Heterodendrum oleifolium
Sallee , Black	Eucalyptus stellulata
Sandalwood	Santalum spicatum
Silkpod	Parsonsia eucalyptophylla
Steelhead	Callitris monticola
Stringybark , Red	Eucalyptus macrorrhyncha
Wattle, Western Black	Acacia hakeoides
Waxflower	Eriostemon trachyphyllus

Appendix 2 (A)

FOREST TYPES IN CYPRESS PINE ZONE
(after Lindsay, 1967)

LIST OF SPECIES SYMBOLS USED IN REPORT[4]

Botanical Name	Common Name	Symbol
Callitris hugelii (syn. C. glauca)	Cypress Pine	P
endlicheri (syn. C. calcarata)	Black Pine	Bp
preissii	Desert Pine	Dp
Eucalyptus albens	White Box	H
blakelyi	Red Gum	B
camaldulensis	River Red Gum	R
conica	Fussy Box	Cn
crebra	Narrowleaf Ironbark	C
dealbata	Red Gum	D
dwyeri	Mallee Gum	Dw
intertexta	Western Red Box	I
melanophloia	Silverleaf Ironbark	Me
melliodora	Yellow Box	M
nubila	Broadleaf Ironbark	N
pilligaensis	Pilliga Box	Pg
populnea	Bimble Box	Pf
sideroxylon	Mugga Ironbark	Sd
trachyphloia	Bloodwood	T
woollsiana	Grey Box	W
various	Mallee	Mall.
Angophora floribunda (syn. A. intermedia)	Roughbark Apple	A
Angophora costata (syn. A. lanceolata)	Smoothbark Apple	L
Casuarina cristata (syn C. Lepidophloia)	Belah	Be
luehmannii	Forest Oak	O
Acacia harpophylla	Brigalow	Brig.
Hakea leucoptera	Needlewood	Nd
Melaleuca uncinata	Broom	Br.

[4] **Note**: The common names and symbols used for species in this report do not necessarily coincide with those now adopted by the Forestry Commission (See "Forest Species of N.S.W.", Form F.C. 88, 1963).

Appendix 2 (B)

SPECIES TYPES IN CYPRESS PINE ZONE
(after Lindsay, 1967)

Group I.	**Pure pine**
Type 1	PP Distinguished only in Terry Hie Hie Group. See text for explanation re non-separation in other areas
Group II	**Pine-Ironbark**
Type 2	PCO Cypress Pine-Narrowleaf Ironbark-Forest Oak. 219 000 ac., 19.5% of total area. By far the most widespread type - Baradine, Dubbo and Glen Innes regions, forest Oak normally present but may be absent. Usually found on sandy loams with underlying hardpan. Both Pine and Ironbark are commercial.
Type 3	PCB Cypress Pine-Narrowleaf Ironbark-Red Gum. 28 000 ac. 2.5% of total area. Found in Baradine, Dubbo and Glen Innes regions. Intermediate between 2 and 8 but usually a clearly defined type. Usually found on deep sands. Both Pine and ironbark are commercial.
Type 4	PTCB Cypress Pine-Bloodwood-Narrowleaf Ironbark- Reg Gum 7 000 ac., 0.6% of total area. Feature is presence of Bloodwood. Characteristic of upland sandy areas in eastern Pilliga.
Type 5	PN Cypress Pine-Broadleaf Ironbark PCN Cypress Pine-Narrowleaf Ironbark-Broadleaf Ironbark 59 ac. A very small type distinguished in Baradine and Dubbo. Transition to PNO and not an important type. PNO Cypress Pine-Broadleaf Ironbark-Forest Oak 33 ac. Distinguished only in Dubbo. More usual type is BpN. Poor country type. PNB Cypress Pine-Broadleaf Ironbark-Reg Gum
Type 6	PMe Cypress Pine-Silverleaf Ironbark 21 000 ac., 1.8% of area. A distinct and valuable type confined mainly to Narrabri and Inverell districts. Found on both gentle and steep slopes. Pine is commercial.
Type 7	PSd Cypress Pine-Mugga Ironbark 1 326 ac. A distinct but not commercially important type on hilly areas in Dubbo and Forbes regions. Pine is commercial. Ironbark is used to limited extent for sleepers, poles and posts.

Group III	**Cypress Pine-Red Gum**
Type 8	PBA Cypress Pine-Red Gum-Roughbark Apple 42 000 ac., 3.7% of total area. A very distinct type on sand ridges and deep sandy soils Baradine region and Dubbo and Gilgandra districts. Roughbark Apple is not invariably present. Pine reaches large proportions but yellow rot is rather frequent.
Type 9	PTB Cypress Pine-Bloodwood-Red Gum 1 700 ac., 0.1%. Confined to upland sandy soils in Baradine and Narrabri districts. Absence of C differentiates from Type 4.
	PD Cypress Pine-Red Gum (dealbata) 1 700 ac., 0.1%. Distinguished in Forbes region, but species of Gum requires checking. Not given type number.
Type 10	PBL Cypress Pine-Red Gum-Smoothbark Apple 1 400 ac., 0.1%. A distinct type on raw sandy soils in Narrabri and Inverell districts.
Group IV	**Cypress Pine-Box**
Type 11	PPg Cypress Pine-Pilliga Box 33 000 ac., 2.9%. A distinct type confined to Baradine, Narrabri and Gilgandra districts. Pine is commercial, Box used to limited extent for fencing material. Fair grazing country.
Type 12	PPf Cypress Pine-Bimble Box 101 000 ac., 9.0%. A large and distinct type that is found in all districts and extends to the western division. Found on both light and heavy soils. Pine is commercial. Box used to limited extent for sleepers and posts. Fair grazing country.
Type 13	PH Cypress Pine-White Box 16 000 ac., 1.5%. A distinct type generally confined to gravelly loam upland areas in Baradine, Dubbo and Forbes regions. Pine is commercial, Box used to limited extent for fencing material. Fair grazing country.
Type 14	PW Cypress Pine-Grey Box 111 000 ac., 9.9%. A large and important type found on loam and clay loam soils in south of Dubbo to the Riverina. Botanical identification of Box not certain in all cases, but subdivision not desirable. Forest Oak is frequently present. Pine is commercial. Box used to certain extent for sleepers and fencing. Good grazing and wheat country.
Type 15	PM Cypress Pine-Yellow Box 12 000 ac., 1.1%. Not a very large type, but is valuable forest on loam and sandy loam soils in Dubbo district (south of Dubbo), Forbes region and Riverina region. Pine is commercial. Box is mainly of honey value. Good grazing and wheat country.

Type 16	PCn Cypress Pine-Fussy Box 1 097 ac., 0.1%. A small type occurring in Pilliga West State Forest and in Forbes, Grenfell and West Wyalong districts. Occurrence of Cn is restricted but the type is quite distinct on loams and sandy loam soils.
Type 17	PI Cypress Pine-western Red Box 11 787 ac., 1,1%. Confined to Condobolin district on sandy loam soils in low rainfall area.
Group V	**Black Pine-Ironbark**
Type 18	BpCO Black pine-Narrowleaf Ironbark-Forest Oak 3 602 ac., 0.3%. Definite type found in Dubbo district, Terry Hie Hie Group and Yetman area. Black Pine is rarely commercial. Ironbark used for sleepers.
Type 19	BpN Black Pine-Broadleaf Ironbark 671 ac. A very small type described in Gilgandra district. Occurs more widely on the non-assessed Breelong and Goonoo State Forests. Main commercial value is for Ironbark sleepers.
Type 20	BpSd Black Pine-Mugga Ironbark 56 ac. Described in Terry Hie Hie group. Occurs more extensively in non-State Forest hilly areas in Forbes and Grenfell. Black Pine used to limited extent. Mugga used for poles and fencing material.
Group VI	**Black Pine-Red Gum**
Type 21	BpB Black Pine-Red Gum 394 ac. Confined to upland areas in Grenfell district. BpTB Black Pine-Bloodwood-Red Gum 199ac. Terry Hie Hie Group. BpLB Black Pine-Smoothbark Apple-Red Gum 22ac. Described in Terry Hie Hie and Yetman. All the above small types can be included on BpB.
Group VII	**Ironbark-Cypress Pine.**
Type 22	COP Narrowleaf Ironbark-Forest Oak-Cypress Pine. 198 625 ac., 17.7%. A very large and significant type found in all Baradine districts, Dubbo and Gilgandra districts and Yetman area. Occurs on sands and sandy loams, frequently with hard pan. Pine occurs in varying percentages. In the extreme type Pine is very limited and Pine regeneration is difficult to obtain. Valuable Ironbark type. Oak frequently forms very dense stands.

Type 23	BCP Red Gum-Narrowleaf Ironbark-Cypress Pine 4 176 ac., 0,4%. Related to Type 22 but generally on sandier soils. Occur in Baradine region, Gilgandra districts and Yetman area.
Type 24	TBCP Bloodwood, Red Gum-Narrowleaf Ironbark-Cypress Pine 21 486 ac., 1.9%. Confined to Baradine region (all districts). Feature is occurrence of Bloodwood with Ironbark and Pine. With PTCB (Type 4), CTB and TB includes the main occurrence of Bloodwood. Occurs on sandy upland soils, in eastern Pilliga. Main value is for sleepers.
Type 25	NP Broadleaf Ironbark-Cypress Pine NOP Broadleaf Ironbark-Forest Oak-Cypress Pine 22 ac. Gilgandra District NTP Broadleaf Ironbark-Bloodwood-Cypress Pine 387 ac. Baradine region. Two types above included in generalised NP. Poor Cypress Pine country. Main value is for sleepers.
Type 26	MeP Silverleaf Ironbark-Cypress Pine 4 963 ac., 0.5%. A distinct type confined to Narrabri district and Yetman. Upland sandy to sandy loam areas. In Bingara found on steep slopes. Pine development good. Ironbark used to limited extent for fencing material. Fair grazing country.
Type 27	SdP Mugga Ironbark-Cypress Pine 1 286 ac., 0.1%. Found in Narrabri district, Dubbo district and all Forbes districts. Shallow soils on hilly areas.
Group VIII	**Red Gum-Cypress Pine**
Type 28	BAP Red Gum-Roughbark Apple-Cypress Pine. 19 768 ac., 1.8%. Mainly found in Baradine (all districts) and Dubbo regions, but also in Forbes region except for Condobolin district. typical on sand ridges and very sandy soils. In many cases can be converted to PBA, Roughbark Apple is not invariably present.
Type 29	BTP Red Gum-Bloodwood-Cypress Pine 3 055 ac., 0.3%. Narrabri and Gunnedah districts. Sandy upland soils. Poor Pine type.
Type 30	BLP Red Gum-Smoothbark Apple-Cypress Pine 4 807 ac., 0.5%. Narrabri district and Yetman area. Upland sandy soils. Pine regenerates readily. DP Red Gum (*E. dealbata*)-Cypress Pine 2 879 ac., 0.3%. Forbes region – all districts. Botanical identification of D still to be checked.

	RP River Red Gum-Cypress Pine 288 ac. Only one area and of doubtful character.
Type 31	DwP Mallee Gum-Cypress Pine 660 ac. Distinct type on hill tops in Mt Biny State Forest, Griffith district. No management value.
Group IX	**Box-Cypress Pine**
Type 32	PgP Pilliga Box-Cypress Pine 39 526 ac., 3.6%. Baradine (all districts), Gilgandra district and Yetman areas. Generally on heavy soils. Pine does not regenerate readily.
Type 33	PfP Bimble Box-Cypress Pine 36 460 ac., 3.2%. Baradine, Dubbo and Forbes regions. PfP is show for Griffith district. Generally but not invariably on heavy soils. Pine regeneration readily obtained on lighter soil areas. Fair grazing value.
Type 34	HP White Box-Cypress Pine 9 920 ac., 0.9%. Baradine, Dubbo, Forbes and Glen Innes regions. Generally on upland areas with gravelly soils. Regenerates with Pine to some extent. Fair grazing value.
Type 35	WP Grey Box-Cypress 22 290 ac., 2.0%. Dubbo district, Forbes (all districts) and Riverina. Generally on heavy soils in basins. Pine regenerates on lighter soil areas. Good grazing and wheat country.
Type 36	MP Yellow Box-Cypress Pine 2 495 ac., 0.2%. Dubbo district and Forbes region (except Condobolin district). Not shown in Riverina but PM is common. Generally on loams and sandy loams. Regenerates fairly readily with Cypress Pine. Good grazing and wheat country.
Type 37	CnP Conica Box-Cypress Pine 396 ac. Dubbo district and Forbes region (except Condobolin district). Very local occurrences on loam soils.
Type 38	IP Western Red Box-Cypress Pine 484 ac. Confined to Condobolin district - low rainfall areas.

Group X	**Ironbark-Black Pine**
Type 39	COBp Narrowleaf Ironbark-Forest Oak-Black Pine 2 078 ac., 0.2%. Found in Gilgandra district and Yetman area. Also occurs on non-assessed Goonoo State Forest. Related to COP, but White Cypress Pine completely absent.
Type 40	NTBp Broadleaf Ironbark-Bloodwood-Black Pine 5 266 ac., 0.5%. Found in Gunnedah, Gilgandra and Dubbo districts. Upland sandy areas with little forest value.
Type 41	SdBp Mugga Ironbark-Black Pine 1 926 ac., 0.1%. Found at Terry Hie Hie and in Gilgandra, Grenfell and West Wyalong districts. Shallow soils on hilly areas. More extensively found in Forbes region outside State Forests.
Group XI	**Red Gum-Black Pine**
Type 42	BBp Red Gum-Black Pine 36 ac. Very small area in Gilgandra district
	DBp Red Gum (*E. dealbata*)-Black Pine 2 607 ac., 0.2%. Found in Forbes, Grenfell and West Wyalong districts on hilly areas with shallow soils. Botanical identification of D requires check.
	BLBp Red Gum-Smoothbark Apple-Black Pine 45 ac. Very small area in Terry Hie Hie, not given type number
Type 43	TBBp Bloodwood-Red Gum-Black Pine 365 ac. Terry Hie Hie and Yetman areas. Upland sandy areas - poor forest country.
Group XII	**Pure Eucalypt Forest-Ironbark Present**
Type 44	C Narrowleaf Ironbark 5 765 ac., 0.6%. Baradine region (all districts) and Gilgandra district. Also found on non-assessed Goonoo State Forest. Sandy loam soils, possibly with hardpan. Reason for absence of Pine not evident.
	CAB Narrowleaf Ironbark-Red Gum-Roughbark Apple 134 ac. Baradine region district. A small transition type to B. Not given number.
Type 45	CTB Narrowleaf Ironbark-Bloodwood-Red Gum 17 644 ac., 1.6%. Found in Baradine and Narrabri districts on upland areas with sandy soils. C gives main forest value, but poor forest country.

Type 46	N Broadleaf Ironbark 195 ac. Baradine and Gilgandra districts, also found on non-assessed Goonoo State Forest. BCN Red Gum-Narrowleaf Ironbark-Broadleaf Ironbark 210 ac. Baradine district. Transition type grouped with above.
Type 47	NT Broadleaf Ironbark-Bloodwood 7 190 ac., 0.7%. Baradine district. Upland sandy soils. Main occurrence of Broadleaf Ironbark in Baradine region. Poor forest country. TN Bloodwood-Broadleaf Ironbark 646 ac. Closely related to above.
Type 48	Me Silverleaf Ironbark 92 ac. Described in Baradine district only. Occurs extensively on non-State Forest in Bingara area. Fair grazing country.
Type 49	SdW Mugga Ironbark-Grey Box This curious mixture of Ironbark and Box occurs quite extensively in West Wyalong district both on ridges and on gently undulating country.
Group XIII	**Red Gum**
Type 50	B Red Gum (*E. blakelyi*) 2 603 ac., 0.3%. Occurs in Baradine and Narrabri districts, usually on sandy soils near creeks. Roughbark Apple frequently present. No forest value. D Red Gum (*E. dealbata*) 143 ac. Described in Rankin's Springs area, but botanical identification uncertain.
Type 51	TB Bloodwood-Red Gum 3 821 ac., 0.4%. Occurs in Baradine and Narrabri districts, also Yetman. Upland areas with sandy soils. Very poor forest type.
Type 52	LB Smoothbark Apple-Red Gum 164 ac. Described only in Yetman area. Deep sandy soils.
Group XIV	**Box**
Type 53	Pg Pilliga Box 880 ac., 0.1%. Baradine region (all districts). Low lying areas with heavy soils. Fair grazing country.

Type 54	Pf Bimble Box 1 308 ac., 0.1%. Described in Baradine, Dubbo and Forbes regions. Much more extensive on non-State Forest areas. Usually on heavy soils. Fair grazing country.
Type 55	H White Box 98 ac. Described only in West Wyalong district. Occurs on uplands usually with gravely soils. Extensive occurrence east of Cypress Pine zone. Fair grazing country.
Type 56	M Yellow Box 585 ac. Described only in Terry Hie Hie and Gunnedah forests, but occurs quiet extensively east of Cypress Pine Zone. Good grazing country.
Group XV	**Non Eucalypt Types**
Type 57	Be Belah 2 291 ac., 0.2%. Described only in Baradine region (Baradine and Narrabri districts), but small areas not mapped occur in other regions. Typical of gilgai soils. Belah not commercial. Fair grazing country.
Type 58	Mall Mallee 3 299 ac., 0.3%. Described in Gilgandra and Condobolin districts. Also occurs outside State Forests in West Wyalong and Griffith districts. Occurs on mallee soils. Scattered Pine occasionally present. Low grazing value.
Type 59	Brig Brigalow 148 ac. Confined to small occurrence in Baradine region (Baradine and Narrabri districts), but there is also a small occurrence in Gilgandra district. Occurs on sandy soils said toe be of lateritic origin.
Group XVI	**Open and Cleared**
Type 60	Open 1 691 ac., 0.1%. Large open treeless areas without evidence of clearing by man. Distinguished in Baradine, Dubbo and Forbes regions, but not in Riverina.
Type 61	Cleared and Cultivated 1 039 ac., 0.1%. Treeless areas with evidence of clearing by man. Distinguished only in Baradine region.

The distinction between Types 60 and 61 has not been strict. There are many medium sized areas that have been grouped with sparsely stocked areas of definite forest type.

Appendix 3

TREATMENT OF CYPRESS PINE TYPES IN ECOLOGICAL LITERATURE

(**Note**: Although the published reports invariably use botanical names, these have mostly been transformed to common names below for the sake of consistency.)

A. Beadle (1948)

1. Dry Sclerophyll Forest
   - 1.1 Tumbledown Gum-Red Iron bark Association. Lists Black and White Cypress Pines as common associates.

2. Tall Woodland
   - 2.1 Western Grey Box Association. Includes a Western Grey Box-White Cypress Pine type.

3. Savannah Woodland
   - 3.1 Silverleaved Iron bark Association. White Cypress Pine present in small quantities.

4. Shrub Woodland (Can vary to tall woodland)
   - 4.1 Bimble Box-White Cypress Pine Association. Includes Bimble Box-Pine and Western Red Box-Pine types.

5. Scrub
   - 5.1 Acacia -Eremophila Association. Includes White Pine type.
   - 5.2 Belah -Western Rosewood Association. As for 5.1
   - 5.3 Mulga Association. As for 5.1.

(Note: Beadle's Associations and Types correspond to Alliances and Associations of most later workers.)

B. Moore (1953)

1. Dry Sclerophyll Forest
   - 1.1 Tumbledown Gum-Red Iron bark Alliance. Includes Tumbledown Gum-White Cypress Pine association.

2. Tall Woodland
   - 2.1 Western Grey Box Alliance. With Western Grey Box-White Pine and Yellow Box-White Pine associations.
   - 2.2 White Box Alliance. White Box-White Pine association.

(Note: Both White and Black Pine are mentioned as constituents of some other associations.)

C. Costin (1954)

1. Dry Sclerophyll Forest
   - 1.1 Red Stringybark-Scribbly Gum Alliance. Includes Black Cypress Pine in 3 associations - alone, and with Red Box and Scribbly Gum.

2. Tall Woodland
   - 2.1 White Box-White Cypress Pine Alliance. Includes White Pine, White Box-White Pine and White Box-Black Pine associations.

3. Savannah Woodland
   - 3.1 Snow Gum-Black Sallee Alliance. Black Pine a co-dominant in several associations.
   - 3.2 Yellow Box -Blakely's Red Gum Alliance. Includes several associations containing Black Pine.

4. Dry Scrub
   - 4.1 Coastal Myall-Waxflower Alliance. Includes Coastal Myall-White Pine and pure White Pine associations, and similar associations with Black Pine.

D. Specht et al (1974).

(Note: Most of the alliances listed by Specht et al. occur in more than one structural formation, eg. the Tumbledown Gum-Red Ironbark Alliance can appear as dry sclerophyll forest (open-forest and low open-forest) or tall woodland (woodland and low woodland). Only the most typical form is listed below.

1. Dry Sclerophyll Forest
   - 1.1 Red Stringybark-Scribbly Gum Alliance. Includes Black Cypress Pine.
   - 1.2 Tumbledown Gum-Red Ironbark Alliance. With White and Black Pine.
   - 1.3 "Northern Tableland Complex". With Black Pine.
   - 1.4 "Warialda Sandstone Forest". With White and Black Pine.
   - 1.5 Blueleaved Ironbark Alliance. White and Black Pine.
   - 1.6 Narrowleaved Ironbark Alliance. White and Black Pine.

2. Tall Woodland
   - 2.1 Western Grey Box Alliance. White Pine.
   - 2.2 Pilliga Box Alliance. White Pine.

3. Savannah Woodland
   - 3.1 Snow Gum-Black Sallee Alliance. Black Pine.
   - 3.2 Yellow Box-Blakely's Red Gum Alliance. Black Pine.
   - 3.3 White Box Alliance. White and Black Pine.
   - 3.4 Silverleaved Ironbark Alliance. White Pine.

4. Shrub Woodland
   - 4.1 Bimble Box Alliance. White Pine.
   - 4.2 Bimble Box-White Cypress Pine Alliance. White Pine.
   - 4.3 Brigalow Alliance. White Pine.

E. Beadle, 1981.

1. Eucalypt Communities of the Cooler Climates.
   - 1.1 Red Stringybark-Scribbly Gum Alliance. With Black, occasionally White Cypress Pines.

2. Ironbark Forests and Woodlands of the East
   - 2.1 Narrowleaved Ironbark Alliance.
     - 2.1.1 Narrowleaved Ironbark Suballiance. White and Black Pines commonly present, the former often codominant .
     - 2.1.2 Smoothbarked Apple-Eucalyptus Suballiance. White and Black Pines often present.
   - 2.2 Silverleaved Ironbark Alliance.
     - 2.2.1 Silverleaved Ironbark Suballiance. White Pine most common associate.
   - 2.3 Red Ironbark Alliance.
     - 2.3.1 Red Ironbark-Tumbledown Gum Suballiance. Black or White Pine usually present, sometimes codominants.

2.3.2 Blueleaved Ironbark Suballiance. Black Pine common associate, sometimes codominant.

3 . Box Woodlands of the East and Southeast.

3.1 Western Red Box Alliance.

3.1.1 Western Red Box-White Cypress Pine Suballiance .

3.2 Bimble Box Alliance

3.2.1 Bimble Box-White Cypress Pine Suballiance. Pine sometimes forms pure stands on deep sands.

3.2.2 Bimble Box-Acacia Suballiance. Occasional dense stands of White Pine on deep sands.

3.3 Yellow Box-Blakely's Red Gum Alliance. White or Black Pines may be present as smaller trees.

3.4 Western Grey Box Alliance. White Pine usually associated.

3.5 Pilliga Box Alliance. Usually associated with smaller trees of White Cypress Pine.

Appendix 4

CLIMATIC DETAILS - CYPRESS PINE TYPES

WARIALDA : **Latitude** 29°32'S **Longitude** 150°35'E **Altitude** 320m

Rainfall (mm)

Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Total
85	76	65	40	42	48	44	42	45	58	65	70	680

Lowest Annual: 304mm Highest Annual: 1204mm

Temperature

Hottest Month: Mean Min : 16.2° (Feb) Mean Max: 33.6° (Dec)
Coldest Month: Mean Min: 0° Mean Max: 17.4°
Highest recorded: 43.9° Lowest recorded: -8.9°
No. over 32^{0}C: 69 days Over 38^{0}C: 8 days
Av. No. Frosts/ year: 48.8 Ave frost free period: 185 days

BARADINE : **Latitude** 30° 57'S **Longitude** 149°04'E **Altitude** 365m

Rainfall (mm)

Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Total
97	82	51	37	43	42	31	47	43	62	48	61	644

Lowest Annual: 285 mm Highest Annual: 1146 mm

Temperature

Hottest Month: Mean Min : 18.6°C Mean Max: 33.2°C
Coldest Month: Mean Min: 1.9°C Mean Max: 16.8°C
Highest recorded: 45°C Lowest recorded: -6.1°C
No. over 32^{0}C: 65 days Over 38^{0}C: 8 days
Av. No. Frosts/ year: N/A Ave frost free period: N/A

GUNNEDAH : **Latitude** 30°58'S **Longitude** 150°15'E **Altitude** 267m

Rainfall (mm)

Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Total
66	65	48	37	40	43	39	45	38	56	58	64	599

Lowest Annual: 248 mm Highest Annual: 1134 mm

Temperature

Hottest Month: Mean Min : 17.9° (Feb) Mean Max: 34.5° (Dec)
Coldest Month: Mean Min: 2.3° Mean Max: 16.9°
Highest recorded: 47.2° Lowest recorded: -7.2°
No. over 32^{0}C: 88 days Over 38^{0}C: 17 days
Av. No. Frosts/ year: 24.2 Ave frost free period: 216 days

WAGGA WAGGA : **Latitude** 35°10'S **Longitude** 147° 28'E **Altitude** 215m

Rainfall (mm)

Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Total
43	39	45	41	52	50	53	52	47	58	47	44	571

Lowest Annual: 225 mm Highest Annual: 988 mm

Temperature

Hottest Month: Mean Min : 16.5° Mean Max: 32.3°
Coldest Month: Mean Min: 3.2° Mean Max: 13.7°
Highest recorded: 47.2° Lowest recorded: -5.6°
No. over 32^{0}C: 32 days Over 38^{0}C: 3 days
Av. No. Frosts/ year: 13.1 Ave frost free period: 226 days

PARKES: **Latitude** 33.5°8'S **Longitude** 148°11'E **Altitude** 340 m

Rainfall (mm)

Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Total
57	**46**	**47**	**40**	**45**	**52**	**47**	**49**	**39**	**50**	**45**	**52**	**569**

Lowest Annual: 227 mm Highest Annual: 1207 mm

Temperature

Hottest Month: Mean Min : 17.6° (Feb) Mean Max: 32.2° (Dec)
Coldest Month: Mean Min: 3.9° Mean Max: 13.8°
Highest recorded: 45.6° Lowest recorded: -6.1°
No. over 32^{0}C: N/A Over 38^{0}C: N/A
Av. No. Frosts/ year: 9.2 Ave frost free period: 232 days

CONDOBOLIN : **Latitude** 33° 5'S **Longitude** 147° 9'E **Altitude** 190m

Rainfall (mm)

Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Total
41	39	39	33	35	38	32	36	29	41	35	41	439

Lowest Annual: 221 mm Highest Annual: 903 mm

Temperature

Hottest Month: Mean Min : 18.4° Mean Max: 34.3°
Coldest Month: Mean Min: 36° Mean Max: 15.4°
Highest recorded: 48.9° Lowest recorded: -6.7°
No. over 32^{0}C: 73 days Over 38^{0}C: 19 days
Av. No. Frosts/ year: 11.7 Ave frost free period: 240 days

DENILIQUIN : **Latitude** 35° 31'S **Longitude** 144°56'E **Altitude** 90m

Rainfall (mm)

Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Total
28	29	33	32	40	43	34	37	37	40	29	28	410

Lowest Annual: 141 mm Highest Annual: 730 mm

Temperature

Hottest Month: Mean Min : 15.5° Mean Max: 31.9°
Coldest Month: Mean Min: 3.4° Mean Max: 13.7°
Highest recorded: 46.9° Lowest recorded: -3.3°
No. over 32^{0}C: 48 days Over 38^{0}C: 10 days
Av. No. Frosts/ year: 3.8 Ave frost free period: 252 days

COBAR : **Latitude** 31° 30'S **Longitude** 145° 48'E **Altitude** 250m

Rainfall (mm)

Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Total
33	35	31	26	28	32	23	29	23	30	30	36	356

Lowest Annual: 116 mm Highest Annual: 800 mm

Temperature

Hottest Month: Mean Min : 19.7° Mean Max: 34.6°
Coldest Month: Mean Min: 4.3° Mean Max: 15.5°
Highest recorded: 48.2° Lowest recorded: -4.2°
No. over 32^{0}C: 92 days Over 38^{0}C: 29 days
Av. No. Frosts/ year: 12.4 Ave frost free period: 240 days

BROKEN HILL : **Latitude** 31°58'S **Longitude** 141°27'E **Altitude** 304m

Rainfall (mm)

Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Total
23	23	19	17	22	23	17	19	17	23	19	19	241

Lowest Annual: 57 mm Highest Annual: 368 mm

Temperature

Hottest Month: Mean Min : 18.2° Mean Max: 32.8°
Coldest Month: Mean Min: 5.1° Mean Max: 15.1°
Highest recorded: 46.6° Lowest recorded: -2.8°
No. over 32^{0}C: 67 days Over 38^{0}C: 17 days
Av. No. Frosts/ year: 2.3 Ave frost free period 298 days

TAMWORTH : **Latitude** 31°5'S **Longitude** 150°51'E **Altitude** 403m

Rainfall (mm)

Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Total
81	67	50	42	42	51	44	48	49	60	66	73	673

Lowest Annual: 358 mm Highest Annual: 1105 mm

Temperature

Hottest Month: Mean Min : 17.3° Mean Max: 32.3°
Coldest Month: Mean Min: 2.7° Mean Max: 15.6°
Highest recorded: 45.0° Lowest recorded: -6.7°
No. over 32^{0}C: 73 days Over 38^{0}C19 days
Av. No. Frosts/ year: 19.6 Ave frost free period: 217 days

MUDGEE : **Latitude** 32°36'S **Longitude** 149°35'E **Altitude** 454m

Rainfall (mm)

Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Total
66	64	48	44	49	58	50	54	51	59	59	65	667

Lowest Annual: 310 mm Highest Annual: 1442 mm

Temperature

Hottest Month: Mean Min : 15.3° Mean Max: 31.2°
Coldest Month: Mean Min: 1.3° Mean Max: 14.4°
Highest recorded: 45.1° Lowest recorded: -9.4°
No. over 32^0C: 41 days Over 38^0C: 5 days
Av. No. Frosts/ year: 30.4 Ave frost free period: 210 days

COOMA : **Latitude** 36°13'S **Longitude** 149°8'E **Altitude** 840m

Rainfall (mm)

Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Total
54	42	67	35	35	30	34	30	40	51	67	73	558

Lowest Annual: 267 mm Highest Annual: 949 mm

Temperature

Hottest Month: Mean Min : 10.9° Mean Max: 27.6°
Coldest Month: Mean Min: -1.8° Mean Max: 10.8°
Highest recorded: 40.7° Lowest recorded: -11.7°
No. over 32^0C: 41 days Over 38^0C: 1 days
Av. No. Frosts/ year: 81.6 Ave frost free period: 108 days

Appendix 5

PROPERTIES OF MAJOR TIMBER SPECIES: CYPRESS PINE TYPE

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

Common Name	Cypress Pine, White	Cypress Pine, Black	Box, Western Grey (Box Grey)	Box, Yellow
Botanical Name	Callitris glaucophylla	Callitris endlicheri	Eucalyptus woollsiana	Eucalyptus melliodora
General Properties	Heartwood variegated browns, sapwood pale yellow Texture very fine & even. Grain straight. Distinctive & persistent colour. Many knots	Similar to White Cypress Pine but odour not as strong.	Heartwood pale yellowish brown, sapwood paler. Texture fine, even.	Heartwood pale yellow brown, sapwood paler. Moderately fine texture, even. Grain usually interlocking.
Density kg/m³	G: 880 AD: 680	G: 780 AD: 710	G: 1170 AD: 1120	G: 1300 AD: 1100
Durability	Heartwood durable; good resistance to termites.	Heartwood durable (class 2)	Heartwood very durable (class 1). Sapwood occasionally attacked by lyctids	Heartwood very durable (class 1). Sapwood resistant to lyctids
Strength	S5 SD6	S5 SD6	S2 SD2	S3 SD4
Sawlog Group	-	-	A	B
Uses	Flooring, panelling, building framework, small poles.	Flooring, panelling, posts, poles, general construction	Heavy construction, sleepers, bridges, posts, poles. Excellent fuel.	Heavy construction, sleepers, bridges, posts, poles.
Other Notes	Brittle. Prone to surface checking. Sanding dust can be an irritant. Splinter burns to white ash.	Prone to surface checking. Splinter burns to dark or black ash.	Difficult to work.	Difficult to work

Appendix 5

PROPERTIES OF MAJOR TIMBER SPECIES: CYPRESS PINE TYPE

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

Common Name	**Ironbark, Narrowleaved**	**Ironbark, Red**	**Bloodwood, Brown**	**Oak, Bull**
Botanical Name	Eucalyptus crebra	Eucalyptus sideroxylon	Eucalyptus trachypholia	Allocasuarina luehmannii
General Properties	Dark red heartwood, sapwood paler. Moderate, fine texture, even. Grain usually interlocking.	Dark red heartwood, sapwood paler. Moderately fine texture, even. Grain usually interlocking	Heartwood pale yellowish brown.	Heartwood dark red, pale sapwood. Prominent rays. Medium texture, straight grain.
Density kg/m³	G: 1160 AD: 1090	G: 1220 AD: 1130	G: 1250 AD: 1050	AD: 1050
Durability	Heartwood very durable (class 1); Sapwood usually resistant to lyctids .	Heartwood very durable (class 1); Sapwood usually resistant to lyctids	Heartwood very durable (class 1) Sapwood L-5	Heartwood very durable. Sapwood resistant to lyctids
Strength	S1 SD3	S1 SD3	S3 SD3	S2
Sawlog Group	A	A	D	D
Uses	Heavy construction, sleepers, posts, wharfage.	Heavy construction, sleepers, posts, wharfage.	Fencing	Flooring. Suitable for roofing shingles & shakes, fancy turnery, fencing, fuel
Other Notes	Hard to work, slow to dry.	Hard to work, slow to dry.		Very hard

Appendix 6

CYPRESS PINE TYPES: PRESERVED AREAS ON STATE FORESTS

A. Areas carrying White or Black Cypress Pine Types

Boshes Creek Flora Reserve No. 23 Mullions Range S.F. (Orange district). 165 ha. Mostly Red Stringybark-Scribbly Gum and related types, with Black Cypress Pine on N. slopes.

Sandgate Flora Reserve. No. 34 Sandgate S.F. (Gilgandra district). 16 ha. White Cypress Pine-Blakely's Red Gum type on sandmonkey. Much 1950 regeneration.

Sanddune Pine Flora Reserve. No. 35 Millewa S.F. (Deniliquin district). 56 ha. Ancient sand hill in Murray River flood plain carrying White Cypress Pine on the dune, with Yellow Box and Western Grey Box on flanks and River Red Gum on the flood plain.

Lanes Mill Flora Reserve. No. 40 Pilliga East S.F. (Baradine district). 690 ha. Broom plain, surrounded by stands of both White and Black Pine, with Ironbarks, Brown Bloodwood, Tumbledown Gum and Bull Oak.

Gilgai Flora Reserve No. 41 Pilliga East S.F. (Baradine district). 2 460 ha. Some of district's best examples of unlogged White Pine occur in Reserve, with a range of eucalypts.

Wilbertroy Flora Reserve. No. 44 Wilbertroy S.F. (Forbes district). 134 ha. Lachlan River flood plain with sand rises carrying Yellow Box and White Pine. River Red Gum on flood plain.

Pokolbin Flora Reserve. No. 59 Pokolbin S.F. (Cessnock district). 90 ha. Area of poor sandstone soils supporting interesting flora, with Black Pine unusually close to coast.

Yarindury Flora Reserve. No. 61 Yarindury S.F. (Gilgandra district). 49 ha. Black Pine, both in pure stands and associated with Ironbarks, Boxes and Blakely's Red Gum.

Sepoy Flora Reserve. No. 69 Sepoy S.F. (Inverell district). 34 ha. White Pine on hilly to steep land, associated with Silverleaved and Caley's Ironbarks.

Bunal Flora Reserve. No. 93 Bunal S.F. (Inverell district). 182 ha. Sandstone area with particularly interesting flora, including both Black and White Cypress Pine types.

Mehi Flora Reserve. No. 94 Mehi S.F. (Inverell district). 54 ha. Steep area in Gwydir valley carrying White Pine with Silverleaved Ironbark and White Box.

Blue Mallee Flora Reserve No. 95 Blue Mallee S.F. (Forbes district). 65 ha. Mallee stands giving way to Red Iron bark with Black Pine, here close to western limits.

Bumberry Flora Reserve No. 104 Bumberry S.F. (Forbes district). 270 ha. Elevated area of Red Stringybark, Scribbly Gum and Red Ironbark with Black Pine.

Strahorn Flora Reserve No. 117 Strahorn S.F. (Forbes district). 68 ha. White Pine types carrying a range of age and condition classes.

Sand-Monkey Flora Reserve No. 129 Pilliga West S.F. (Baradine district). 75 ha. Sand monkey with typical White Cypress Pine-Blakely's Red Gum type, adjoining Pine-Narrowleaved Ironbark type.

Yerrinan Flora Reserve No. 130 Yerrinan S.F. (Baradine district). 40 ha. Brown Bloodwood with both White and Black Pine.

Wittenbra Flora Reserve No. 131 Wittenbra S.F. (Baradine district). 75 ha. Black Pine with Brown Bloodwood, Narrowleaved Ironbark and Blakely's Red Gum.

Ginee Belah Flora Reserve No. 133 Pilliga West S.F. (Baradine district). 50 ha. Belah flat adjoining various White Pine types.

Wambadule South Forest Preserve No. 108. Pilliga West S.F. (Baradine district). 56 ha. Good example of White Pine-Bimble Box type.

Curryall F.P. Forest Preserve No. 200. Curryall S.F. (Mudgee district). 37 ha. Spotted Gum at western limits, with Black Pine associated.

Scrubby Mountain Forest Preserve No. 252. Balowra S.F. (Condobolin district). 1 700 ha. White Pine with various associates including Bimble and Western Red Boxes and Mallees.

Buckinqbong Forest Preserve No. 257. Buckingbong S.F. (Narrandera district). 155 ha. White Pine with Western Grey and Yellow Box.

B Areas carrying Other Cypress Pines

Bruxner Park Flora Reserve No. 3 Orara East S.F. (Coffs Harbour district). 407 ha. Rainforest and wet sclerophyll forest, with some Brush Cypress Pine.

Mt. Dromedary Flora Reserve No. 7 Bodalla S.F. (Narooma district). 1 255 ha. Coastal mountain with rainforest and eucalypt forest, with both Port Jackson and Mueller's Cypress Pines present.

Norman Jolly Flora Reserve No. 37 Moonpar S.F. (Dorrigo district). 52 ha. Rainforest and wet sclerophyll forest with Brush Cypress Pine.

Wongawanga Flora Reserve No. 41 Orara West S.F. (Coffs Harbour district). 25 ha. Rainforest and wet sclerophyll forest with Brush Cypress Pine.

Dorrigo White Gum Flora Reserve No. 87 Moonpar S.F. (Dorrigo district). 21 ha. Slope above Nymboida River, with some Port Jackson Pine.

Jerusalem Creek Flora Reserve No. 88 Chichester S.F. (Dungog district). 60 ha. Mostly rainforest, with Brush Cypress Pine near southernmost limits.

Twelve Sixty Flora Reserve No. 111 Bagawa S.F. (Coffs Harbour district). 300 ha. Rainforest and mixed eucalypt forest stands, with Brush Cypress Pine.

Crown Mountain Forest Preserve No.125. Warra S.F. (Glen Innes district). 270 ha. Granite mountain with interesting flora, including rare occurrence of *Callitris oblonga* outside of Tasmania.