NOTES ON THE SILVICULTURE OF MAJOR NSW FOREST TYPES

5. RIVER RED GUM

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Appendices

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NOTES ON THE SILVICULTURE OF MAJOR NSW FOREST TYPES

5. RIVER RED GUM TYPES

1. INTRODUCTION

River Red Gum[1] has the widest natural distribution of all eucalypts, fringing the inland streams of Australia often as a single line of low, spreading trees, but sometimes spreading out over the flood plain to form large blocks of tall forest.

It is with these forest blocks that these Notes are primarily concerned - forests that are among the most unusual in Australia:

- Depending not on the annual rainfall, but on periodic flooding, for their water requirements, and indeed for their very existence;
- Providing one of the world's outstanding examples of a natural forest monoculture;
- Occupying a position of peculiar significance in the history of forestry In NSW;
- Receiving in some areas extremely high levels of recreational use;
- Providing forest cover and habitat in districts that are otherwise largely devoid of trees;
- Supporting some of the best examples of wood utilisation in the State, despite the usually poor stem form and often faulty nature of the trees.

Such forests represent a major part of forest responsibilities in several forestry districts in southwestern NSW and also in neighbouring parts of Victoria, and they support a small sawmilling industry across the border in South Australia. The species itself is found in most districts west of the Divide and off the Tablelands.

River Red Gum is closely related to other eucalypts of the Red Gum group and some of these others species also receive passing mention in these Notes.

2. BOTANY AND FOREST ECOLOGY

2.1 Botany

River Red Gum (***Eucalyptus camaldulensis*,** Pryor & Johnson code SNEFP) is one of about a dozen species of Red Gums that occur in NSW. These form one of the most clearly defined groups of eucalypts, with close similarities in form, foliage, bark pattern, fruits and other characteristics. Pryor & Johnson (1971) place these (and some other species not native to NSW) in the informal Series Tereticornes (SNE), in which they recognise two subseries, Bancroftinae (SNEC) and Tereticorninae (SNEE) (they also include the very localised Pokolbin Mallee, ***E. pumila*,** in this Series, though subsequent study suggests it warrants more individual treatment; Brooker, 1979).

The species within this Series intergrade with each other in a complex manner. Pryor & Johnson discuss this pattern of species variation under the heading "The 'Stringybark' Pattern", and after referring to Stringybarks around Sydney they go on:

> *"This is one of the most complex situations, involving members of two subseries, and is perhaps most closely paralleled by the 'Red Gums', SNEE subseries Tereticorninae, including species such as SNEEA* ***E. amplifolia,*** *SNEEB* ***E. tereticornis,*** *SNEEC* ***E. glaucina,*** *SNEEF,* ***E. blakelyi,*** *SHEEH* ***E. chloroclada,*** *SNEEJ E.* ***dealbata,*** *and SNEEL* ***E. dwyeri*** *. . . SNEEP* ***E. camaldulensis*** *is also involved in this complex in parts of its range, and in turn links with SNEER E.* ***rudis****, giving virtually an Australia-wide coenospecies…*

[1] For botanical names of plants, see Appendix 1.

In all of these cases some botanists have expressed the view (in print or otherwise) that only one very variable species was involved. This can only be supported if one demands lack of interbreeding as a species criterion. Such a view makes nonsense of the actual practical usage of the species category in plants, and has been rejected often enough to require little further discussion. It is certainly not likely to appeal to those who are well-acquainted with any of the above-listed groups in the field." [2]

Pryor & Johnson recognise two subspecies of River Red Gum, in effect a subspecies ***camaldulensis*****,** SNEEPA, and one based on the previously described var. ***obtusa*****,** SNEEPE.

Pryor (1979) has outlined the differences between these subspecies:

*"**E. camaldulensis** is the most widespread of naturally distributed eucalypts: it is found in all States except Tasmania. It can be divided into two subspecies, one occurring in the northern tropical part of Australia, the other in the south. All those in New South Wales are the southern form, although even within the State there is a good deal of variation.*

*The southern form of **E. camaldulensis,** which is so characteristic of the Murray-Darling River systems extends also into western Victoria and South Australia. This southern form is narrow leaved, scarcely glaucous, and without lignotubers: the northern form has broader and quite glaucous, juvenile leaves, and most of the seedlings have lignotubers.*

The northern form is much more frost susceptible than the southern form, but it grows very well indeed as an exotic in the drier tropics such as in parts of Africa. Following extensive provenance trials over the last 10 - 15 years in many countries of the world, the northern form is now being planted much more widely and promises to be one of the most Important species for the rather dry monsoon tropics characteristic of much of Africa and Asia. As it has yet barely reached rotation age, a good deal more remains to be learned of this form of the species under cultivated conditions."

The variation mentioned by Pryor has in the past been recognised by certain varieties described by botanists, e.g. the glaucous var. ***subcinerea*** from the Broken Hill area. This is now recognised as a local variant of the ssp. ***obtusa*****,** and (as Silverton or Bluish-leaved Red Gum) has proved popular for amenity use in some districts. Notwithstanding Pryor's statement, this example of the northern subspecies does of course occur in NSW

As indicated by Pryor, and as would be expected from a species with such a wide natural range, River Red Gum shows distinct provenance differences, and information on the behaviour of different provenances in overseas trials has been summarised by F.A.0. (1979).

Besides its wide natural distribution, River Red Gum is also one of the most widely planted eucalypts overseas, with a world plantation area of about half a million hectares (F.A.O., 1979). It had been planted in Italy in 1803, and may have been introduced even earlier than that, and it received its botanical name from the Abbey of Camalduli, in whose gardens it grew and from which it was collected and described in 1832. This was only the year after Charles Sturt had voyaged down the Murrumbidgee and Murray Rivers and had confronted a large gathering of hostile Aborigines on a sandbank of the Murray: school book representations of this event give probably most Australians some impression of how the Red Gum forests look.

River Red Gum hybridises with various other eucalypts of the sub-genus Symphomyrtus, both in nature and in plantations, where species that do not naturally occur together may be brought into close proximity. One such hybrid with Bangalay has been described as **x *E. trabutii*,** and has some potential as a plantation tree if it could be reliably produced as an F1 hybrid.

[2] This appears to be an admirable interpretation, but one that is unfortunately not always accepted by botanists, eg White Cypress Pine

2.2 Forest Types

The types of primary concern in these Notes are those included in the River Red Gum league in "Forest Types of NSW" (Forestry Commission of NSW 1965), where the league is described:

> *"This league occurs throughout western NSW, forming ribbon-stands along the banks of most inland streams as far east as Tumut and Tamworth. Towards its eastern limits it merges with the River Oak type. The league is distinguished by the presence of River Red Gum, which occurs pure in one of the two types recognised and mixed with other species in the other type. Whilst over most of its range the league is of limited forestry importance, along parts of the Murray and Murrumbidgee River flats it occupies extensive areas ... and forms a tall forest community with trees up to 50m in height. These forests support locally important sawmilling industries. Elsewhere the league appears as a savanna woodland community. It invariably occupies low, riverside sites subject to periodic flooding."*

The two types described are:

199. River Red Gum. Consists essentially only of the Red Gum, with an herbaceous understorey, occurring on sites receiving periodic flooding along inland rivers. Varies from a single line of riverbank trees, through areas of savanna woodland, to tall forest. Occasional associates may include River Oak in the more easterly sites and River Cooba in some westerly areas, including in the vicinity of Hay.

200 River Red Gum-Box. Occurs on slightly more elevated sites that receive less frequent flooding, growing as woodland in which the Red Gum is associated with various Boxes, usually Black Box in the southern parts of the State and Coolabah in the north. Other Boxes may also sometimes occur, including Yellow Box and Western Grey Box, with Carbeen also present in some moister areas of the northwest.

Type 200 in turn usually merges into sometimes extensive open woodlands of Type 202, Black Box/Coolabah type, on flat, poorly drained sites subject to periodic but irregular inundation. Along the Paroo this type is replaced by one dominated by Napunyah.

Other species of Red Gum occur in a large number of types, of which the most widespread include:

- 85. Grey Box - Forest Red Gum
- 92. Forest Red Gum
- 93. Cabbage Gum
- 172. Yellow Box - Blakely's Red Gum
- 192. White Cypress Pine - Red Gum
- 205. Red Gum - Ironbark

Of these, Type 92 may at times show extraordinary similarity to some of the better quality River Red Gum stands, occupying low, poorly drained flats. The Forest Red Gums, however, tend to be of slightly better form and are often associated with scattered smaller stems of Swamp Box and Broadleaved Apple. In parts of Queensland these two types grade into each other, and provide some of the most highly regarded provenances of Red Gum, Forest or River (F.A.O., 1979).

River Red Gum stands occur within a number of regions that have received ecological surveys, and in all cases have been regarded as constituting, in recent terminology, a distinct alliance, usually with but a single, River Red Gum, Association which may vary in form from savanna woodland to tall forest; Beadle (1948), in his broad ranging study of the vegetation of western NSW, also recognised a Napunyah Association within the alliance. Coolabah and Black Box stands have been recognised as separate Alliances. Besides Beadle's study, other relevant surveys are those of Morland (1949) for the Hume Catchment, Moore (1953) for the eastern Riverina, and Biddiscombe (1963) for the Macquarie region.

In a more recent Australia-wide vegetation survey, Beadle (1981) recognises a River Red Gum Alliance, but declines to identify associations within this. Instead he discusses six 'assemblages', separated on a regional basis. Three of these occur in southeastern Australia: the eastern rivers with clay flood-plains, including all significant stands in NSW; south, remote from rivers, covering some

Victorian and South Australian occurrences; and dry, sandy watercourses, which would include some occurrences in northwestern NSW Beadle's other assemblages are from northern Australia and the interior. Associated with this Red Gum Alliance, Beadle also describes Coolabah and Black Box Alliances, the former including a Napunyah Association.

Other accounts of the River Red Gum types have been given by Incoll (1947) for Victoria, where a distinction is made between the river occurrences and the western Victorian stands where River Red Gum occurs away from the river flats, and by Boomsma (1950), ranging over southeastern Australia but concentrating particularly on stands away from rivers in South Australia, where he notes that a number of "forest types" may occur based on the association of the Red Gum with other eucalypts, she-oaks, cypress pines and wattles. Specht et al. (1974) record River Red Gum alliances from all mainland States and from the Northern Territory, usually as woodland formation but sometimes also as low woodland (under 10m tall), open woodland or open forest (in NSW).

So far as NSW is concerned, River Red Gum forms an ecologically distinct community, either by itself or, on less favoured sites, with one or more of several other eucalypts, and confined to areas that receive inundation at varying, and sometimes irregular, intervals.

As noted, these River Red Gum stands can vary in form from open savanna woodland with trees only 12 or so metres high, to forest where individual trees may reach 50m in height, and possibly higher. This range represents marked differences in productive capacity, and in the better quality and more extensive forest areas of both NSW and Victoria the River Red Gum types have been split in to three quality classes. In NSW the classes were initially recognised on the basis of DBH/total height relationships (Forestry Commission of NSW, 1954), though in practice this has tended to be simplified into a dominant height relationship:

Q 1 Over 34m
Q 2 21 - 34m
Q 3 under 21m

The Victorian classes are similar, except that the boundary between qualities I and II in set slightly lower, at about 30m (Dexter, 1967). Quality 3 (or III) stands are essentially savanna woodland, whilst Q1 and Q2 represent true forest.

(Commenting on the early differentiation of quality classes in the forests of the Central Murray, N. Davies has noted that it was not unusual to find areas of regrowth stands where the dominant height of the young trees was greater than that of the scattered remnant old growth trees. He speculates that, whilst this may have been due to the close spacing in many regrowth stands, it may also have resulted from a continually changing and developing forest environment.)

2.3 Environment

2.3.1 General Environmental Factors

The occurrence and growth of Red River Gum types are dominated, to a greater extent than perhaps any other major Australian forest types, by a single factor, that of periodic or irregular flooding. Because of its importance, this factor will be looked at in more detail in Section 2.3.2. In this section, the other factors that influence the River Red Gum types will be examined.

The **climate** of various stations close to sites carrying River Red Gum types is indicated in Appendix 2. Of the eight stations, Mathoura typifies the important forest area of the Central Murray (see Map 2); Euston the down-river forests managed from Mildura; Griffith, though located away from the river itself, the major group of forests along the Murrumbidgee; Hay those further down the river; Menindee the stands along the Darling; and Narrabri, Forbes and Gundagai (where they have been miscoloured in song) River Red Gum stands lying to the east of the main commercial sites. More specific details relating to the Central Murray stands, and taken from Dexter (1978), are given in Table 1.

Table 1

TEMPERATURE, EVAPORATION AND RAINFALL FOR STATIONS IN THE VICINITY OF BARMAH FOREST

Temperature and Rainfall are for Echuca, Evaporation is for Tatura

Information taken from (Victorian) Central Planning Authority Goulburn Region 1948 and data supplied by Tatura Horticultural Research Station

Temperature °C. *(Base 58 yrs.)*						**Evaporation** *(mm) (Base 14yrs)*	**Av. Rainfall** (mm) (Base 30yrs)
Month	Mean Max	Mean Min	Mean	Highest	Lowest		
January	30.72	15.28	23.00	46.11	4.44	234	24
February	30.77	15.38	23.10	45.00	5.56	184	44
March	27.28	13.17	20.22	41.94	2.94	148	26
April	22.00	9.56	15.83	35.00	-0.56	93	48
May	17.50	6.67	12.05	28.33	-2.22	55	49
June	14.06	5.06	9.56	22.50	-3.33	38	46
July	13.33	4.06	8.72	25.56	-5.00	33	44
August	15.11	5.06	10.06	25.89	-4.44	52	42
September	18.22	6.56	12.39	33.89	-2.22	80	40
October	22.28	8.94	15.56	37.78	-2.78	109	42
November	26.44	11.5	18.94	41.11	-1.11	156	27
December	29.22	13.83	21.56	44.44	1.67	209	40
Yearly Mean/Total	**22.22**	**9.61**	**15.94**			**1391**	**426**

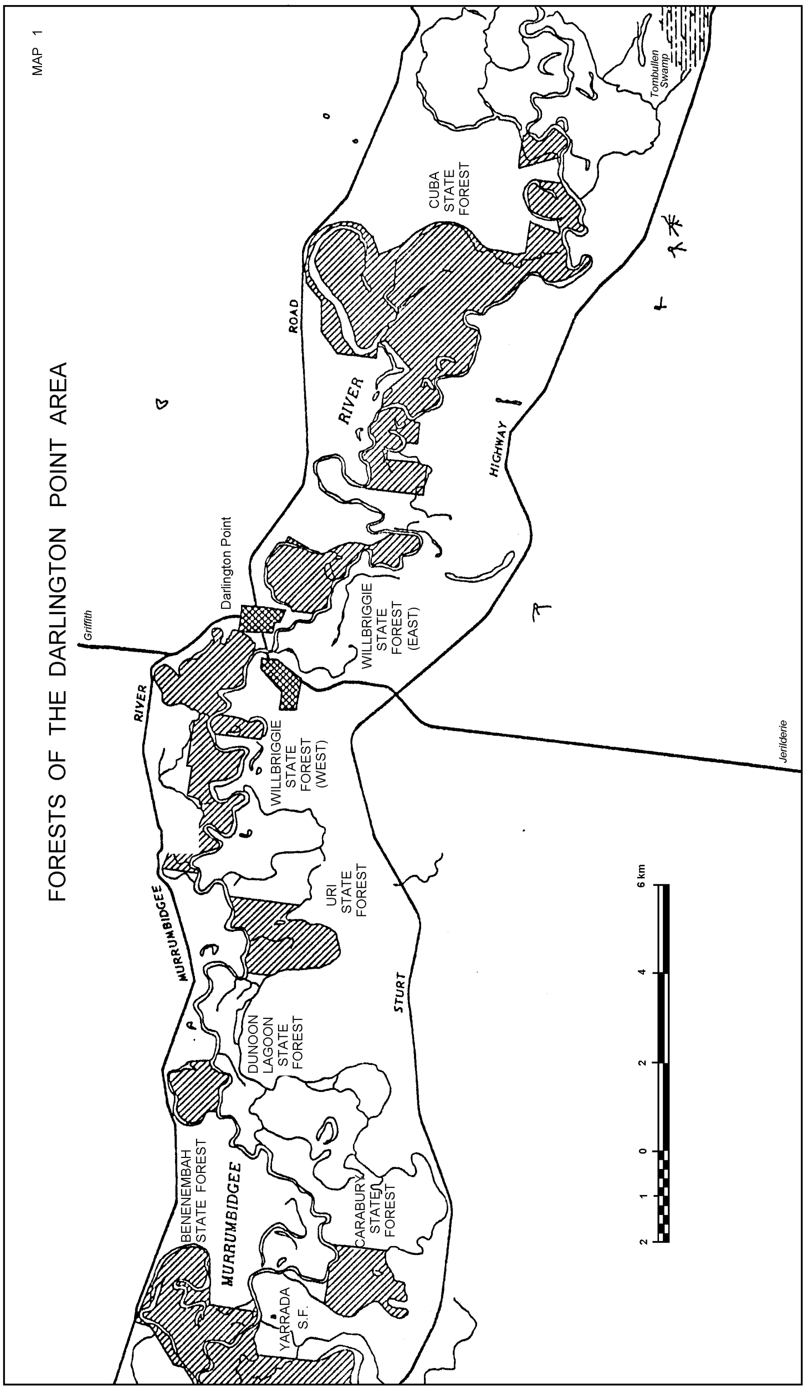
Features of the climate at these stations are:

- Generally low annual rainfall (down to a little over 200 mm at Menindee);
- Except for the more easterly stations, an unreliable rainfall;
- High evaporation rates;
- Very hot summers, with temperatures commonly reaching the high thirties: Dexter (1967), referring to the Victorian stands near Echuca, indicates that maxima above 3 38°C are experienced 5 to 8 times a year between October and March, and usually above 32°, 30 to 40 times a year;
- Cold winters, with frequent frosts: Dexter again records a frost-free period of 7.5 to 8 months, with severe frosts limited to a period of 8 weeks between June and August, and usually with 6 to 8 such frosts a year.

Unlike some of the Victorian and South Australian stands, the River Red Gum types in NSW are confined to riverbank or floodplain situations, and this determines the **topography** of the types, which skirt the main river channel and which occupy the adjacent floodplains to an extent determined by water availability.

- On sites not subject to regular flooding, and to a lesser extent on those that are regularly flooded, the quality class of the Red Gum forest showed a close correlation with the depth to the watertable: Q1 sites occurred where the depth to the watertable was less than 6m, Q2 mostly where it lay between 3 and 9m, and Q3 where it was deeper than 6m.
- The source of water in the watertable appeared to be the main river system.

The floodplains themselves are by no means without relief. They may show distinct terracing or benching close to the river; they may be traversed by complex systems of anabranches, effluents and runners; they may be edged by higher levees along the main channel; they may be clearly defined away from the river by rising slopes, or may merge imperceptibly into neighbouring plains of apparently unrelieved flatness; they may be broken by billabongs or low swamps, or carry higher sand dunes or sand rises that reflect past and different climates and river systems, and that support quite distinct vegetation communities, often dominated by White Cypress Pine.



Within the Murray-Darling basin, which effectively encompasses the occurrence of River Red Gum types in NSW, considerable work has been carried out on the origins and landforms of the various river systems, and much of this information has been summarised for a symposium on the Murray-Darling system, held by the Royal Society of Victoria in 1978, and published in the Society's

Proceedings, vol. 90, part 1 (Gill, 1978, and succeeding papers). Unfortunately the Proceedings are not available from the Commission 's library.

Over most of this occurrence the River Red Gum types occupy only a narrow tract of land within the flood plain proper - in the case of many of the rivers, the belt of land to which the rivers' meanders are confined: see Map 1. However in the Central Murray valley the creation about 15 000 years ago of the Cadell Fault (or Tilt) between Deniliquin and Echuca has considerably altered this pattern by establishing a broad triangular deltaic area extending from the Fault back towards Tocumwal, and splitting the river into two arms, the Murray going south and then northwest and the Edward north and then west to rejoin nearly 200km downstream. This profoundly affects the flood regime of this section of the river, and has produced conditions favouring the extensive development of River Red Gum types both above and below the Fault, where the total area of the Red Gum forests, in both NSW and Victoria, is about 120 000 ha: see Map 2.

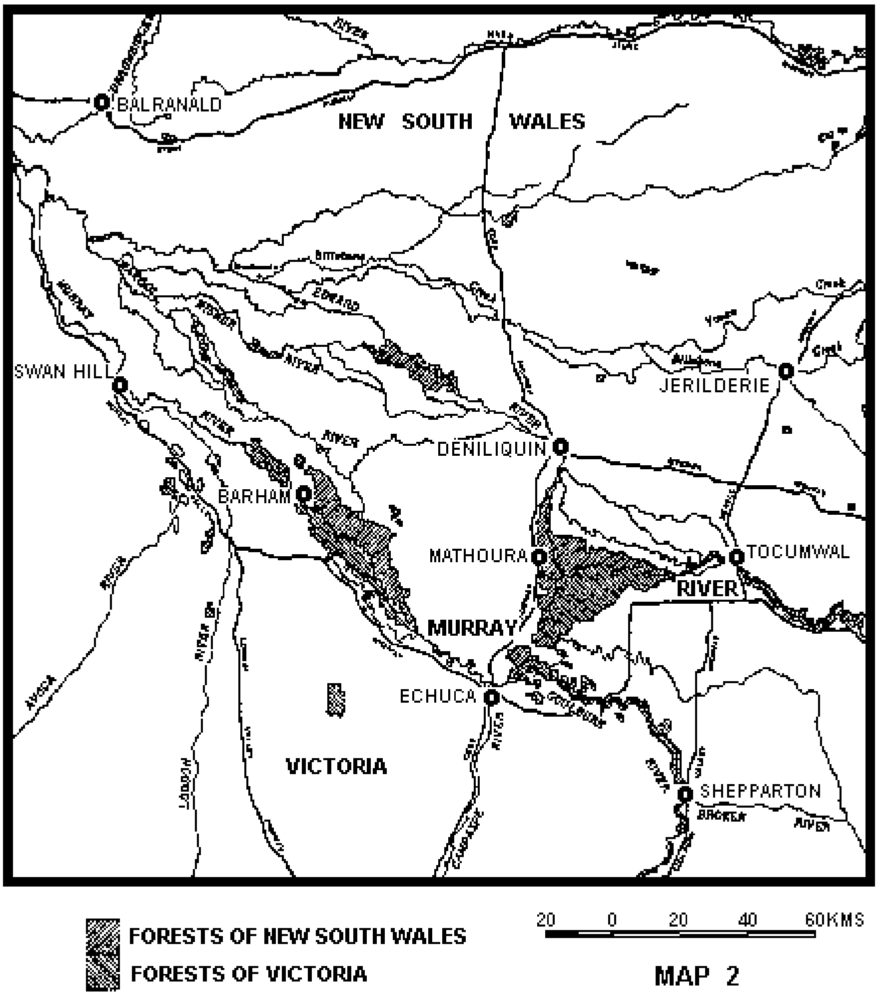
It should be added that, in geological terms, 15 000 years is a very short period, and it appears that the land-forming processes resulting from the Fault have still not reached stability. N. Davies suggests that this may explain the differences in dominant height sometimes shown by differently aged stand components on the some site (see section 2.2).

As would be expected from the topographic conditions, the **soils** carrying River Red Gum types are of alluvial (fluviatile, occasionally lacustrine) origin. Beadle (1948), writing generally about western NSW, observed that River Red Gum had no particular soil preference but, because of its association with watercourses, it was predominantly found on grey soils of heavy texture, although capable of thriving on sandy soils. On such alluvial soils, soil fertility would be rarely, if ever, a limiting factor to growth, though Boomsma (1950) has shown that in its dry land (away from river) occurrences in South Australia, River Red Gum is confined to the soils of higher fertility.

Further studies on the soils of the extensive stands of the Central Murray were carried out during the Murray Management Survey of 1944-53, when bore holes to a depth of 9 metres were established over a large area on a grid of about 1 kilometre. The findings were reported by Feagan (1947) and Davies (1953). Major findings from these studies were:

- Except where a watertable was encountered the profiles were dry, and it appeared that there was only limited vertical seepage of water down the profile. As an indication of the lack of permeability of the clays, Davies reports the presence of red (ferric) colours, indicating an absence of waterlogging, at a depth of only 1.2m below a swampy site that carried water for at least 6 months of the year.
- Roots were commonly encountered for the full depth of the profile. Davies notes that in a deep soil pit it could be seen that the roots arose in layers, travelling outward and down ward from the tree, while Feagan observes that, despite the evidence of deep root penetration, the greater part of the root system seemed to occupy the top half metre of soil.
- Many bore holes showed no presence of a watertable to 9m.
- Where a watertable was encountered, it was essentially always in a layer of sand or sandy gravel, and could appear at almost any depth down to 9m, where boring ceased. Bore holes showing a watertable above 9m tended to occur in broad bands through the forest area, suggesting the occurrence of wide, underground streams. Davies suggests that about 30 per cent of Millewa S.F. overlies such a watertable.
- On sites not subject to regular flooding, and to a lesser extent on those that are regularly flooded, the quality class of the Red Gum forest showed a close correlation with the depth to the watertable: Q1sites occurred where the depth to the watertable was less than 6m, Q2 mostly where it lay between 3 and 9m, and Q3 where it was deeper than 6m.

FORESTS OF THE CENTRAL MURRAY AREA



MAP 2

The source of water in the watertable appeared to be the main river system. Dexter (1978) also has examined soils in the Red Gum forests of this Central Murray area:

> *"Soils of the forest areas are periodically flooded and subjected to water logging, which results in pronounced mottling of sub-soil horizons. Clay is the predominant component of sub-soil horizons and compact layers below the surface hinder penetration of water (Davies 1953). Nodules of calcium carbonate occur at various depths below the surface, indicating the depth of penetration of moisture down the profile. The surface soil on areas that receive regular flooding is often silty and hard when dry.*
>
> *Several profiles were excavated to depths of 1.8 to 2.4m and although the findings may not apply generally to the forest, some significant features were noted. In some cases the sub-soil was stratified both with respect to composition and texture. Between 1.2 and 1.5m there was a coarse sand layer several cm thick, and above and below this layer were predominantly clay fractions with a reddish-yellow mottling typical of Iron compounds. In some instances there was 'ironstone gravel' in the profile, a feature of soils subject to periodic water-logging….*
>
> *There was no lateral percolation in those profiles, which were uniform throughout. Such profiles excavated to about 1.2m below the water level of a semi-permanent swamp and only 7.5m away showed no evidence of lateral percolation after one week.*

However, there are hundreds of hectares of high quality forest located on a relatively narrow strip of river frontage that is not normally flooded. It is probable that these stands receive water via lateral percolation from the main stream. Davies (1953) found evidence of lateral percolation associated with stands adjacent to the Murray River ...

Extensive cracking of the surface soil is typical of most locations in the forest. Cracking commences with the onset of rapid drying conditions, and, by the end of summer, cracks of more than 25 mm in width have been traced to depths of 2m. As little as 7 mm of summer rain may penetrate via these cracks to depths of more than 1.5m. This source of soil moisture aids seedling establishment.

Further studies showed that the first one to two metres of soil profile are readily saturated even by floods of short duration. Penetration of water is facilitated by the deep cracks, and the sub-soil reaches field capacity at least to depths of 1.2 to 1. 5m. Even in the absence of flooding, the sub-soil is usually saturated in the young seedling root zone by winter rains, at least to 38cms depth. However, soil in which moisture is replenished by winter rains commences to dry out again during late winter/early spring. By the time of flood recession in later spring/early summer, soil moisture tension in surface layers on unflooded areas may already be at wilting point and the soil has usually commenced to dry out *in depth. This contrasts with the high moisture content of soils in flooded or very recently flooded areas."*

Jacobs (1955, para. 362) also offered some observations on the Red Gum soils. Referring to some unpublished work carried out by H.D. Waring, of the Forestry and Timber Bureau, he noted that the depth of the heavy clay surface soil varied with the depth of flooding, from 15 to 30cm on the sites receiving little flooding to 1.5m or more on the lower, better quality sites. Below this the soil, even if of clay, is better aerated and roots are more prolific. The surface, heavy clay layer cracks deeply during dry periods, as noted by Dexter, and Jacobs records how "*advancing floods may be observed to pour into these cracks for a considerable time before they fill up*".

The River Red Gum types have a very restricted **flora**, consisting mostly of annual herbs; a list from the Victorian Barmah Forest is given by Dexter (1978). Apart from the Red Gum itself, or in marginal sites the associated Boxes, woody plants are few - occasional wattles, of several species, including the River Cooba along some western streams. Sometimes in the more easterly areas a few River Oaks (which can be found along the Murrumbidgee as far downstream as Darlington Point); mistletoes; and a Native Cherry, which appears to be spreading in some areas, possibly as a result of reduced flooding (like other Native Cherries, it is a root parasite). Grasses and other monocots provide herbage for both domestic stock and some native animals.

The **fauna** of the Red Gum types will be dealt with below (2.4); the vertebrates, though in some cases dependent on the existence of the forests, do not appear themselves to influence the forest occurrence, but some of the Insects can have periodic major effects on the health of the stands.

Like probably all eucalypt forests, fire is an occasional feature of the River Red Gum types; unlike many eucalypt stands, however, it does not appear to be an essential part of the forest life cycle. Nonetheless old trees frequently show butt damage and scarring from fires, while the fires are remarkably effective in removing the otherwise very durable and long-lasting branch and stem debris from the forest floor - a feature possibly of greater importance in stands where logging occurs than in the original unlogged stands.

2.3.2 Flooding

The factors reviewed above all are involved in determining the occurrence and condition of the River Red Gum types. However, their effects in NSW are quite overshadowed by these of flooding, which also have greatly influenced the topography and soils of the Red Gum forests.

Within NSW River Red Gum only occurs on sites that are subject to flooding. In some areas the flooding, in Nature at least, may be essentially annual, elsewhere it may only rarely occur, but occur it does. In broad terms, sites that are regularly flooded for some months each year produce the higher quality forest stands; those that are only rarely flooded produce lower site quality or mixed Gum-Box stands. However, as previously noted, the occurrence of an accessible watertable, presumably fed from the main rivers, will also influence this pattern.

In the Murray -Darling River system, flooding in the northern tributaries that feed the Darling comes primarily from summer monsoonal rains (though, as happened in 1983, it may also occur from winter rains). The southern rivers, particularly the Murrumbidgee, Murray and its southern tributaries from Victoria, receive the bulk of their water from winter and spring rains and spring thaw: flooding here is, or has been, much more regular than in the Darling, and it is along these southern rivers that the main commercial River Red Gum forests occur. As noted above, topographic features associated with the Cadell Fault have resulted in these forests being most extensive in the vicinity of the Fault, but stands of comparable quality occur lower down the Murray and along parts of the Murrumbidgee and lower Lachlan Rivers.

(In passing, and although it is by far the major river system of Australia, the Murray - Darling is not a major stream in the world scene: The Mississippi carries 20 times as much water, the Amazon 75 times (Gill, 1978).)

Over most of the course of the southern rivers, floods are normally confined to a fairly well defined, and relatively narrow, flood plain (Map 1). In a high flood the whole plain may be inundated, in a lesser flood only some of the lower and middle level benches may go under water; trees growing along the raised natural levees may very seldom be flooded.

In the Central Murray the pattern is such more complicated (Map 2). The Cadell Fault has had several side effects, and in particular it has resulted in the creation of much wider flood plains, while at the same time constricting the flow of water down the Murray through the so called "Barmah Choke", at the southern end of the Fault.

Another constriction occurs in the vicinity of Swan Rill. Because of the Choke, only about 11 000 Ml/day can pass down the river between Tocumwal and Echuca, without causing an overflow of the banks (River Murray Commission, 1980). With overflow, water floods into the forests by a system of natural effluents and runners, those on the east and south returning to the river in a relatively short distance, and those to the north and west feeding into the Edward River offtake, to rejoin the Murray several hundred kilometres to the west. In both cases the water spreads out into the forests, which act as a giant reservoir as well as a user of water. Downstream from the Choke several major tributaries (notably the Goulbourn) join the Murray from the south, and again rises in the river lead to flooding of the forests through effluents that head northwesterly and ultimately again join the Wakool-Edward system. The pattern is illustrated diagrammatically in Figure 1, which shows peak discharges at various points during the high May, 1974 flood (from Currey and Dole, 1978); the effect of topography on flooding patterns in this area is also well described by Paunovic (1982).

Based on gauging at Tocumwal, a flow of 6 000Ml/day may cause some unblocked effluents to run, but flow definitely occurs into the forests at discharge rates of over 11 000 Ml/day, and overtops the banks above 18 000 Ml/day (Dexter, 1978). A flow of 18,000 Ml/day, maintained for a month, waters about half the forest area (River Murray Commission, 1980), whilst a flow of 24 500 Ml/day for four weeks is needed for the effective watering of the Victorian Barmah forest (Dexter, 1978; River Murray Commission, 1980), "effective" referring to about 90 per cent of the area being flooded. Paunovic (1982) considers that a somewhat greater discharge is needed for an equivalent flooding of the NSW forests in this Central Murray region. This effective flooding of the forests involves the consumptive use of about 100 000 Ml/year on each side of the river, with the remaining flood flow returning to the river system (River Murray Commission, 1980).

Flooding patterns of course vary from year to year, but the normal sequence in river flow and flooding has been described by the Forestry Commission of NSW (1973):

> *"In the natural state the summer flow was low and confined to the main rivers traversing the flood plain and a few perennial lakes contiguous with the main rivers. The summer flow levels in this unregulated state were of the order of 1.2 to 2m Tocumwal gauge level. Heavy discharges from the catchments of the Murray and its tributaries from winter and spring rain and snow falls caused a rise in flow levels from June to December corresponding to a range of 2.7 to 7.3m Tocumwal gauge. Within the flood plain areas, levels equivalent to approximately 2.7m Tocumwal gauge or higher cannot be contained within the main river and water spreads out over the flood plain. Thus, under natural conditions flooding of the forests areas normally occurred in this winter to spring period."*

The pattern was thus one of low summer flow and regular flooding in the winter-spring period. The River Murray Commission (1980) has calculated that, over 77 years of flow records, under natural conditions (i.e. disregarding effect of river control measures in recent decades), in 70 years daily flow would have exceeded 18 000 Ml for at least a month during the winter-spring season, and in 61 seasons it would have exceeded 24 500 MI. Expressed differently, in only 5 seasons out of 77 would more than one year have elapsed between successive floods of 18 000 Ml/day or more for a period of a month (i.e. 1 year in 15) and never would more than 2 years have elapsed; for the higher floods (24 500 Ml/day for a month), in 13 seasons more than 1 year would have elapsed between such floods (1 year in 6) and on one occasion, 2 years. Occasional summer flooding occurred, with the River Murray Commission calculations showing the following pattern of summer months when the daily flow exceeded 11 000 Ml:

November	December	January	February	March
57	26	8	1	3

Virtually the whole of the River Red Gum ecosystem depended upon this pattern of winter-spring flood and low summer flow that allowed the flood waters to drain away from the forest. Whilst sustained flooding for a period that Includes two summers will kill Red Gum, the trees depend upon the annual winter floods to regenerate, to recharge the soil moisture, and for their seasonal growth; lack of winter flooding weakens the trees and favours the build up of defoliating insects, and probably also of mistletoes and root parasites; the onset of flooding triggers breeding responses in many of the characteristic waterbirds (and again probably in many of the fish); too early an end to flooding may result in breeding failure, the abandonment of nests or fledglings, or the subsequent death of the young birds by starvation or predators. By contrast, the recession of the floods in late spring or summer aids seedling establishment, permits forest growth to occur and provides food and breeding conditions for other groups of birds (Hodgson, 1980).

However ...

The water has many values besides those involved in maintaining healthy riverine forests, and increasingly the rivers have been dammed to hold back the winter-spring floods, and then to release the water during the summer for use in irrigation. The result is that the extent of winter flooding is reduced, both in frequency and in depth of flooding; first call on the water is to replenish the reservoirs, and only when this is achieved does the surplus winter water move down the river and spread out over the floodplains.

At the same time summer flows are increased, as the stored water is released to meet irrigation demands downstream. Obviously it is in the interests of water management authorities to ensure that no more water is released than the river channel can carry - a quantity largely dictated by the capacity of the Barmah Choke and the Edward off-take. Nonetheless on occasions larger volumes will be released - sometimes to meet particular downstream demands, and probably more usually because of “water rejections”.[3]

These effects of river regulation were long foreseen, and were anticipated and warned about by the then Assistant Forester at Deniliquin, W.C. Wentworth, in 1913, when regulation was first being mooted on the Murray. They started to become evident following the completion of Hume Reservoir in 1933, and were accentuated by the enlargement of the reservoir in the 1950s and more particularly as a result of the recent construction of the Dartmouth Dam.

[3] Water sought for irrigation, and in transit, when local rain on the irrigation area makes it no longer required. In such cases, instead of being diverted (e.g. into Mulwala Canal), the water continues down river, sometimes raising discharge rates at Tocumwal above 11,000 Ml/day and thus causing flooding.

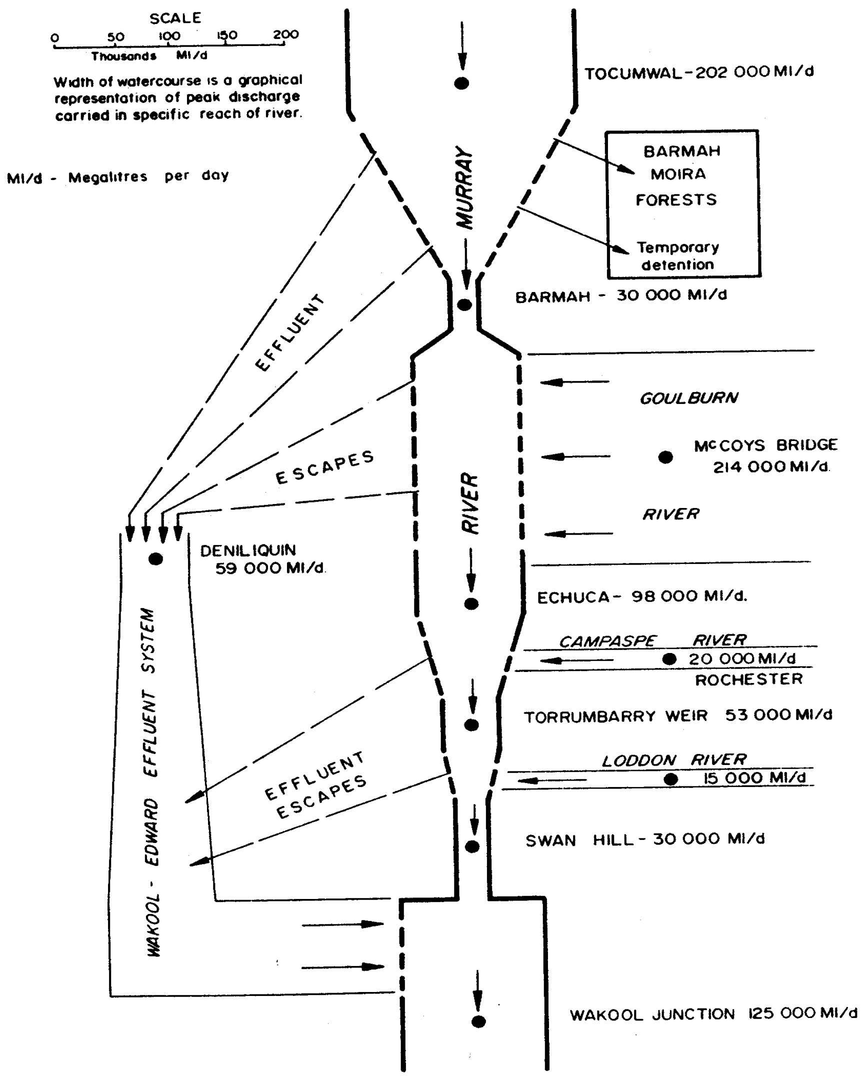


Figure 1: Peak Discharges during May, 1974, Flood.
(from Currey and Dole, 1978)

Simulation studies by the River Murray Commission (1980) show that, over the same 77 seasons referred to above, current regulated flow in the Murray (i.e. post-Dartmouth conditions) would have reduced the seasons when winter flow exceeded 18 000 Ml/day for at least a month at Tocumwal from 70 occasions to 32, and when it exceeded 24 500 Ml/day from 61 to 28 occasions; furthermore the duration of flooding, when it did occur, would have been reduced. Similarly the periods when winter flooding did not occur increased dramatically, as shown in Table 2.

Table 2

EFFECT OF REGULATION ON PERIODS BETWEEN SUCCESSIVE WINTER FOREST FLOODING (MAY TO OCTOBER)

Periods between successive winter/ spring Forest Flooding for Average monthly Tocumwal Flow indicated	Number of times in 77 years when the Period between successive Winter/Spring Forest flooding is as Indicated			
	Tocumwal Flow 18,000 Ml/day		Tocumwal Flow 24,000 Ml/day	
	Natural	Post-Dartmouth	Natural	Post Dartmouth
> 1 year	5	47	13	50
>2 years	0	19	1	22
>3 years	0	9	0	9
>4 years	0	6	0	7
>5 years	0	1	0	4
>6 years	0	1	0	2
>7 years	0	1	0	2
>8 years	0	1	0	2
>9 years	0	1	0	1
>10 years	0	0	0	1

These lengthy periods - of up to 10 years - between successive effective floods represent probably the most worrying aspect of river regulation to the future management of the River Red Gum forests.

The same simulation studies showed that river regulation increased the likelihood of flooding in February and March, but decreased it earlier in the season.

In the forests, the higher general level of summer flow in the river has increased the area of permanent swamps or lakes connected to the Murray or Edward by low off-take creeks, except where the off-takes have been blocked or regulated; in the process some of the higher quality stands have been drowned. This tends to reverse the previous pattern of lakes becoming swamps and of swamps gradually being invaded by forest. It also tends to interfere with access into the forest during the normal season for logging, recreation and various other activities. At the other end, reduced winter flooding has meant less water available to maintain healthy growth over much of the forest. In the long run this can be expected to result in a widespread, and downwards, shift of site qualities; more immediately it has been reflected in poorer growth rates, increased insect attack, probably the spread of parasitic plants, and wide evidence of droughting effects during dry summer periods. As Paunovic (1982) aptly says, "*the forest in general is suffering mostly from a lack of water and in a minor way from too much water for too long".*

On the lower Murray the problem of the reduced winter-spring flow remains, but the lesser problem of summer flooding is rarely experienced - most of the excess water has already been removed for irrigation use, while in any case the river, with its high banks in this section, has a better capacity to cope with increases in summer flow. Forests in the lower sections of the Murrumbidgee and Lachlan Rivers also show ill effects from reduced flooding.

The problem is appreciated by water management authorities (River Murray Commission, 1980; Forestry Commission of NSW and Water Resources Commission of NSW, 1978). There is of course no way that the original flow conditions will be restored, and even the opportunity cost of specifically providing water on a regular basis to flood the forests appears prohibitively expensive - in excess of $7 million per annum. However there are means of alleviating the difficulties, at least as far as Red Gum growth is concerned, largely involving the more effective use of excess flows as and when they occur (River Murray Commission, 1980; Paunovic, 1982). In no small measure the long-term future of the River Red Gum types, as commercial forest stands in the Central Murray, will depend upon the success of these measures.

2.4 Other Ecological Effects

Two other features of the River Red Gum forest environment warrant mention, though neither is directly related to the silviculture of the stands.

The first is the importance of these stands as wildlife habitat, and also, through their constant association with waterways, as aquatic habitat. It Is sometimes difficult to separate these two aspects - trees, collapsing into the rivers, produce the shelter and deep holes favoured by some fish; much of the bird life consists of waterfowl, many of which depend on trees for their nesting; the river provides the water, and the forest the shelter, for much of the terrestrial life.

Bird life tends to be particularly rich, and a list of birds recorded from Gulpa Island S.F., near Mathoura, is attached as Appendix 3 (from Wheeler, 1974). River Red Gum provides the major source of reproductive sites for birds which require tree hollows for nesting, and in the arid and semi-arid zones of Australia a large proportion of the avifauna falls Into this category, including the parrots, kingfishers and owls. The large, overmature Red Gums can be particularly important in providing these sites. One species of bird, not recorded in Appendix 3, but attracting some scientific attention because of its virtual restriction to River Red Gum forests in eastern Australia, is the Regent Parrot, which nests in the riverine forests downstream from Balranald into South Australia. This bird is dependent on the deep hollows provided by veteran River Red Gums, nesting in tree cavities up to 5m in depth.

Besides the larger fauna the forests harbour many insects and other invertebrates, some species of which can become serious pests. The role of the fauna, and their dependence on the Red Gums, is vividly portrayed in a poster produced by the Northern Territory Conservation Commission (undated).

The second feature is the previous importance of these river forests to the **Aboriginal inhabitants,** who maintained relatively high population levels along these rivers. Accounts of Aboriginal life in these areas have been provided by Buchan (1979) and, in passing, by Walker (1983). Buchan also provides further references. Even in those areas that today lack Aboriginal population centres, the activities of their forebears are frequently evident through the presence of middens, sandhill burial sites, canoe trees, stone fish traps and other relics, and in some districts these or other local features have particular significance to present day residents of Aboriginal descent. Prior to the arrival of European settlers the forests were apparently maintained in a more open condition by frequent Aboriginal burning, while many of the place and locality names in use today are those of the earlier Inhabitants.

3. OCCURRENCE

The River Red Gum types occur throughout inland NSW, following the various watercourses of the Murray-Darling system and extending east-ward to elevations of something over 300 - 400m. They cross into the Hunter Valley through the low gap in the Great Divide, being found as for east as Singleton. As noted previously, the main occurrences of commercial interest are in southern districts, along the Murray, Murrumbidgee and Lachlan Rivers, and are portrayed, with some omissions, on the NSW forest type map (Forestry Commission of NSW, 1978). However the types in reality are far more widely distributed than this map suggests, extending as narrow ribbons along most inland streams. The types form the major part of the Murray, Mildura and Darlington Point Forest Management Areas, and are a component of many other western management areas.

The types extend into all other mainland States and the Northern Territory, usually as riverine or creek-side stands, but extending on to dry land sites away from rivers in parts of Victoria and South Australia (Incoll, 1947; Boomsma, 1950; Beadle, 1981).

The 1971-72 survey of the State's forest resources (Hoschke, 1976) showed some 40 000 ha of River Red Gum types in NSW. Of this area, about 100 000 ha were on State Forest, and the remainder was shown as being more or less evenly split between leasehold and freehold tenures.

Whilst the sampling grid for the survey was large in western NSW, thus increasing the possible error in the results, these figures appear to give a realistic estimate of the extent of the types in NSW.

4. UTILISATION

To people used to the coastal and tableland forests, the River Red Gum stands usually appear as a fairly unpromising site for a high level of timber utilisation. The trees tend to be of poor form, they often show visible signs of defect, and many are relatively short-boled and heavily branched. Nonetheless these stands along the Murray and Murrumbidgee Rivers have been utilised for timber from the early years of European settlement, they have been subjected to various management practices for a longer period than virtually any other forest communities in NSW, and they today demonstrate some of the best levels of wood utilisation to be encountered in NSW. The generally excellent utilisation has several causes, of which one is undoubtedly the proximity of the main forest areas to large population centres (particularly Melbourne) which lack other ready sources of durable timber.

Properties of River Red Gum timber and two of the associated Boxes are given in Appendix 4, together with those of Forest Red Gum for comparison: details from Bootle (1971). The appendix, however, hardly does justice to the variety of uses to which River Red Gum timber is put. Small stems along the Murrumbidgee have been sold for mining timber. Much of the poorer material can be used as landscape sleepers, which sometimes appear as little more than rings of wood held together by kino or termite frass. Old wood may be converted to charcoal. Logging waste has been chipped for garden use. Sawn timber is frequently marketed in short lengths, and logs down to about 2.5m can be sold. Much of the original demand for Red Gum timber developed around the production of house blocks used in Melbourne. This use has greatly diminished. The wood has always been sought as fuel. In recent years Red Gum has represented about 2 per cent of the total Crown cut in NSW (Forestry Commission of NSW 1981).

The sometimes associated Boxes are rarely if ever milled but may be used for such purposes as fencing timber and sleepers. Black Box in particular is highly regarded for use as round and split fence posts.

Besides their value for timber production the Red Gum types serve a wide range of other purposes (Hamilton, 1977).

The forests receive considerable use for **grazing** during the summer and autumn, much of the stock usually being removed prior to the winter floods. The grazing is largely based on Moira Couch, which has the ability to recover quickly after flooding (Hamilton, 1977).

River Red Gum and the western Boxes (including Napunyah in the northwest) are all highly esteemed as **honey** trees. The Gum is a fairly reliable heavy flowerer, particularly during the summer, producing both nectar and pollen in copious quantities. The honey from the nectar is valued in its own right, whilst the pollen is important in allowing colonies to breed up. In a good season up to 55 kg of honey can be obtained by a colony in Red Gum stands (Blake and Roff, 1958), together with large quantities of pollen.

The forests receive high levels of **recreational use**, with over 100 000 visitor days a year in the Central Murray stands of NSW, and similar levels along the Murrumbidgee, which possesses more sandy beach areas. Whilst the forests themselves undoubtedly contribute to the pleasantness of the recreational environment, they are usually not the major attraction - that role is played by the water, which is used for swimming, boating and fishing, while the forest provides access and sites for camping and picnicking. Facilities to improve the level of recreational enjoyment have been provided in a number of areas, and include serviced picnic and camping sites, marked forest drives, and descriptive leaflets.

Duck hunting also appears to be commonly practised in parts of the Central Murray, although strictly illegal on State Forests in recent years.

Along the Murray most of the recreation usage comes from Victoria, while on the Murrumbidgee it comes from the nearby irrigation centres. On the lower Murray much of the recreational usage involves boating, with a large number of houseboats and five resident paddle steamers based at Mildura.

Additional, and to some people the major, values of the River Red Gum types come from their **landscaping** function - providing some vertical dimension to what is often an otherwise entirely featureless, horizontal landscape, and in supplying visual relief from the monotony of the adjacent plains; from their important role as **wildlife habitat**, and the ancillary benefits that this may have to neighbouring Cropland (eg. through sheltering insect-eating birds); and from their past, and often still evident, association with the earlier **Aboriginal inhabitants.**

The trans - Murray Victorian Red Gum forests provide a similar range of benefits and uses to those on the NSW side of the river, and Hodgson (1980) has made an estimate of the annual gross value of products from Barmah and Gunbower Forests - analogues of the NSW Mathoura and Barham groups, with a total area of about 48 000ha. This estimate is reproduced in Table 3, and shows annual production of about $6.7 million, or close to $140 per hectare. Values from NSW would presumably be of a comparable order.

Table 3

ESTIMATED ANNUAL GROSS VALUE * (1980 PRICES) OF PRODUCTS FROM BARMAH AND GUNBOWER FORESTS, VIC.

(from Hodgson, 1980)

Product	**Unit Value ($)**		**Total ($' 000)**
4 308m³ of sawn timber	250		1 077
105 000 sleepers	22	(1)	2 310
5 506m of piles	20		110
2 100m of poles	10		21
37 000 posts	5		185
17 837 t of firewood	40		714
19 125 bags of charcoal	9		172
4 050 head of cattle	50	(2)	203
83 bee sites	2 400	(3)	199
10 horses per year	300		3
Insect control by ibis on 100 000 ha	6.75	(4)	675
54 000 visitor days	19	(5)	1 026
			6 695

* Gross value in this context means the value of product sold to consumers.

Note: 1: Sleeper value at sawn timber prices for equivalent volume.
2: Four years to finish an animal worth $200.
3: For sites to support a colony of 125 hives.
4: Five per cent of average wheat crop value to represent protection of a mixture of lands, the most productive and best protected of which are irrigated pastures.
5: Not included are visitors to duck shooting sites elsewhere to use birds bred and partly grown on the forests, nor the scientific and cultural value of community ownership of the ecosystem.

5. HISTORY OF USE AND MANAGEMENT

The western riverine forests of NSW were inhabited by Aboriginal tribes for perhaps 40 000 years; certainly the far-reaching event of the Cadell faulting would have been witnessed by the tribes.

Writing of this prehistoric period, Walker (1983) states:

"The riverside land was a corridor through an inhospitable landscape. Despite an ultimate dependence on the river, the floodplain communities evolved to meet the vagaries of flow. The plants and animals could withstand difficult periods by exercising their powers of tolerance, by lying dormant or perhaps migrating elsewhere. When good conditions returned, as with drought-breaking rains, they were prepared to utilise them quickly and efficiently. Opportunism was the key to survival - the river had a nomad's rhythm.

Aboriginal people lived in the region forty thousand years ago. For man, as other animals, the Millewa [4] was comparative security and comfort in a forbidding environment. It yielded water, wood for shelter, cooking fires and weaponry, bark and reeds for canoes, baskets and other utilities, plants, fish, waterfowl, mussels and yabbies as food, and a host of other resources. Surplus could be traded, extending the river's influence to remote inland areas. Above all, the Millewa figures in spiritual traditions. It was the Provider, past, present and future - totems, rituals and ceremonies were celebrations of the river community...

The impact of Aboriginal man on his environment was not insignificant. His widespread, persistent use of fire greatly affected the riverland forests and grasslands. Plants of many kinds were harvested. The size and contents of still-intact riverbank middens attest to an active, productive existence as hunters and gatherers. If Aboriginals lived in harmony with nature it was not without effect, and less by choice than necessity. They were subjects of the Millewa, without the pretensions of masters."

European explorers came into the western districts in the 1820s and '30s, and were rapidly followed by the settlers; within a generation the destruction of the Aboriginal culture was almost complete.

To the settlers in the mid-19th century:

"Red Gum from both sides of the river was the universal timber, used for slab huts, bridges, carts and joinery. It was the available species, it was more easily worked than the more scattered Box away from the river, and yet it was relatively durable. Later it played an important role in the river traffic, in mining, and later still, in the development of the railways. Gradually it became important on the Melbourne timber market which did not have a local durable hardwood for road paving, house stumps, bridges and other exposed woodwork." (Hamilton, 1977).

The forest areas were initially occupied by the settlers as grazing runs and leases from about the 1840s (Forestry Commission of NSW, 1973; Dexter, 1978), and it was probably not until the forest districts were linked by rail to the more populous areas, in the 1860s and 1870s, that the forests were used for other than local timber production. However at this stage, and extending into the early part of this century, the Red Gum forests along the Murray, at least, became some of the most important forest areas in NSW. The flat terrain was ideal for the operation of bullock teams, hauling the logs to the banks of the rivers, whence they were carried in barges to the various sawmills and converted to lumber which was then railed to meet Melbourne's ever-present needs. They had access and market advantages available to few other forests at that time.

One result of these advantages was that these were probably the first eucalypt forests in Australia to receive silvicultural treatment.

Aboriginal management appears to have maintained the forests in an open, savanna-like condition by frequent burning. The disappearance of tribal Aboriginal life, a sequence of good years for regeneration in the 1870s, and the fact that at this stage domestic stock and rabbits were not yet ubiquitous resulted during the 1870s in widespread regeneration, which was being hampered by large trees that were quite useless to the demanding standards of the time, and from the 1890 a work started on ringbarking these culls and in thinning out the regrowth (Jacobs, paras. 332 & 367, Baur, 1982). (Similar, but smaller sized, regeneration widespread in the forests along the Murrumbidgee River apparently dates from a felicitous combination of high flooding and good rains about 1911). An early report on this work is reproduced as Appendix 5.

Selective harvesting and periodic silvicultural treatment continued in the stands through the first half of this century, with water remaining the main transport medium until probably the 1940s.

In 1944 the Forestry Commission, in one of its more innovative and interesting moves, established the Murray Management Survey (M.M.S). This came from a proposal by the then Commissioner, E.R.P. Swain, and followed the completion of the Alpine Ash survey on Bago S.F. The M.M.S. was to examine various aspects of the growth and management of River Red Gum (Muir, 1950), and it continued until 1953. The survey played an important role not just in relation to the riverine forests, but more broadly within the State: it provided training for a number of officers; it pioneered the

[4] Millewa was an Aboriginal name for the Murray River

use of aerial photography in NSW; it examined the hydrology of the forests; it typed and assessed stands over a large area; and it introduced a new marketing system ("Improved Utilisation", or I.U.) which considerably extended the availability of logs in the forests and which almost certainly provided the inspiration for the gross Hoppus system of log sales, introduced on a broader canvas some years later.

The survey culminated in the preparation of a management plan that was introduced in 1953. The plan has been revised and rewritten at 10 yearly intervals, giving the forests of the Central Murray probably the longest continuous period under management plan control of any forest area in the State.

The effects of river regulation were already evident at the time of the M.M.S. (Davies, 1953), and became more apparent in subsequent years as the Hume Reservoir was enlarged and the Dartmouth Dam built. Since the 1960s this has been the major factor in the management of the Murray Red Gum forests, and its effects have already been discussed (Section 2.3.2.) - the drowning and extension of swamps in some of the lower lying, and usually high site quality, stands; less frequent flooding in the forests as a whole, with consequent reduced growth rates and a long-term downward drift of site quality and productivity. Hamilton (1977) notes that in 1950 the M.M.S. arrived at an average diameter increment for crop trees of 0.3 inches per annum (7.6 mm), based on a number of plots measured in some cases for lengthy periods; subsequent measurements suggest that the current rate of increment is about 0.1 inches (2.5 mm), with the drop, and its obvious management implications, attributed to the altered pattern of flooding.

Harvesting has continued to the present, but since about the 1940s based on road transport to the mills. Stands are tree-marked prior to logging, with stems judged capable of making further useful growth, and those considered necessary for wildlife habitat or aesthetic purposes (especially near beaches or along forest drives), being retained. Because of the long history of culling and the generally favourable market conditions, little if any ringbarking or other cull tree removal is now carried out.

6. Regeneration Requirements

6.1 Regeneration Establishment

In the NSW forests, natural regeneration from seed is almost invariably relied upon for the establishment of new stands in the River Red Gum types.

River Red Gum in the main commercial forest areas does not produce lignotubers, though these are shown by northern provenances of the species. The tree is regarded as a ready coppicer, but no regular use is made of this feature in the management of stands in NSW, though stems of coppice origin following earlier logging are not uncommon.

Artificial regeneration is not used in Red Gum forest management in NSW. However for the Victorian forests Dexter (1967, 1978) has recommended direct seeding as the "*cheapest and most flexible technique*" for regenerating River Red Gum, employing aerial seeding following clear felling and slash burning.

As previously noted (Section 2.1), River Red Gum is one of the most widely planted eucalypts outside Australia, with the major concentration of older plantations in the Mediterranean basin, though recent interest in the northern provenances is likely to increase the species' popularity in more tropical areas. Planting is usually as container stock, and in most cases the plantations are managed as coppice stands on short rotations, usually in the range of 7 to 14 years, for such purposes as fuel, charcoal, posts, poles and pulpwood for fibreboard production: F.A.0. (1979) notes that in Israel five successive 10-year coppice rotations of River Red Gum have been established. The species is also one that is regarded as being quite readily propagated vegetatively from young trees, though, like eucalypts generally, not from old trees. It has also been the subject of tissue culture propagation trials, particularly for the more salt-tolerant strains.

Little attention has been paid to the regeneration of the associates of River Red Gum on more marginal sites, but observation suggests that regeneration sufficient to maintain the presence of these species is usually present. Jacobs (par. 356; fig 127) refers to one stand of primarily Yellow and western Grey Box: this stand regenerated profusely with Red Gum following unusually high floods in

1931; a small proportion of the Boxes also regenerated, and with the passage of time these are becoming dominant in the regrowth stand. Similarly A.L. Yates has reported regeneration of Yellow Gum, in one of its rare NSW occurrences, dating from the 1956 flood and appearing with Red Gum on Tammit Station, downstream from Euston.

6.2 Seeding Habits

Dexter (1967) has studied the flowering and seedfall of River Red Gum in the Victorian forests of the Central Murray, and his results appear perfectly applicable to the main commercial forests in NSW.

Inflorescence buds are produced about November, and their protective bracts are shed during December and January. The flower buds develop for about a year, with flowering occurring in the following late spring to summer. Flowering occurs most years, but the crops are variable in size, and a heavy flowering one year is likely to be followed by a light or negligible crop the following year. Defoliating insects may sometimes have the effect of reducing or even completely preventing flowering.

The seed matures rapidly in the capsule, and viable seed is produced four to six months after flowering, though normally seedfall in the field does not commence until about 9 months after flowering, with peak fall occurring in spring and summer. Some fall may occur throughout the year, but it is least in the winter. Dexter records that following one heavy flowering, about three quarters of the seed crop was shed the following season, but about a quarter was held on the tree and not shed until the winter and spring 1.5 to 2 years after flowering. Some of this seed was shed in the capsules.

Boland et al. (1980) record a larger number of seed tests carried out on River Red Gum than on any other eucalypt. The seed averaged 670 000 viable seeds per kilogram, with over 3 million/kg in the most prolific batch tested. They recommend collection over the period March to August, and note that the species can produce “*large quantities of seed per tree”.*

A graph (Fig. 3) given by Dexter (1967), certainly confirms this: it suggests the production of over 300 million viable seeds per hectare over one 12 month period following heavy flowering. In reality the seed traps used were placed beneath the crown of a heavy yielding tree, and the figures should not be converted to a per hectare basis (Dexter himself does not do this), but they clearly indicate the very high rates of seed production that individual Red Gum trees can exhibit.

6.3 Seedling Germination and Establishment

Concern over the poor regeneration of River Red Gum in Victoria during the 1950’s led to some detailed studies on the problem by the Forests Commission, including the comprehensive field studies of Dexter (1967) and some detailed studies on germination by Grose and Zimmer (1958).

Grose and Zimmer examined batches from various sources in Victoria. They were unable to find any relationship between germination requirements and the environments of particular seed sources, but they did demonstrate a number of general features concerning the germination of River Red Gum seed:

- Germination was best at a constant temperature of 35°C, with both percentage germination and germinative energy increasing with temperatures above 21°C, and then decreasing to nil at 43°C.
- Exposure to light was required for satisfactory germination, with the need for light increasing as temperatures departed from the optimum of 35°C .
- Stratification (moist cold storage at 8°C for 25 days) removed the need for light.
- After-ripened seed, and imbibed seed exposed to light for a short period at near-optimal temperature, would germinate fairly readily through the temperature range 15 to 38°C.

Some of these features (eg the benefits of stratification and the high optimal temperatures for germination) tie in with natural germination following the recession of spring floods.

Dexter's work followed from this, and looked at the problems of germination and establishment in the field. His findings (Dexter, 1967; 1978) included:

- On non-flooded sites, most germination occurs at times of consistently wet conditions, particularly during the winter and early spring. Because of row temperatures at these times, germination tends to be slow.
- Under these conditions, germination is best in sites protected from desiccation. Highest germination rates occur on grassy sites, but these are poor for subsequent establishment; other suitable sites are those where the seed has been covered.
- Seeds can overwinter beneath floodwaters, and then germinate as the floods recede. Little, if any, germination occurs under water.
- A seedling from winter germination can survive at least 6 weeks subsequent immersion in spring floods.
- Bare, cultivated soil and burnt sites are most satisfactory for seedling establishment. (A.L. Yates has confirmed that, in the Mildura district, post-logging burning gives the best regeneration establishment response.)
- Germinates on exposed sites may suffer mortality from frost damage: over 2 seasons, between 15 and 25 per cent of young seedlings in frosty sites were killed in this way; survival was better where surface litter protected the seedlings. Nine to 12 months old seedlings are rarely killed by frost.
- Germinates are also very liable to mortality by stem girdling due to temperatures at the soil surface exceeding 65°C: such temperatures can be experienced in exposed situations from September through to March. More advanced seedlings are better able to withstand and survive these conditions than young germinates.
- Availability of soil moisture is the main determinant of survival and growth over the first 8 months, and a summer drought will kill most younger seedlings on all but the most favourable sites, which include deep ash-bed and cultivated sites free from competing vegetation; soil moisture is also a major factor in the behaviour of older seedlings.
- Soil drought is common in spring, summer and autumn on non-flooded sites carrying grass or other surface vegetation; the survival of seedlings in dense grass is only satisfactory in occasional summers of well above average rainfall.
- Mature trees also severely deplete soil moisture and hence prevent seedling establishment.
- The seedlings have certain adaptations to assist in their surviving the spring and summer droughts. These include an unusually high root:shoot ratio of about 4:5 , which allows the roots to pass speedily through the heavy surface soils into more amenable subsoil layers (see also Jacobs, paras. 255, 361-2). Another adaptation is the ability of even small seedlings to lose their leaves during periods of prolonged moisture stress, and then to recover from axillary or basal shoots when conditions improve.
- Prolonged flooding is another major cause of seedling deaths. Late summer flood recession occurs at a time of hot temperatures that will destroy seed and young germinates; complete immersion for several months is usually lethal to seedlings under about 25cm in height. However, up to 95 per cent of seedlings 50-60cm high may survive from 4 to 6 months inundation, depending on period of total and partial immersion.
- Seedlings can survive up to 14 weeks flooding, including several weeks of total immersion, with little ill effect other than the shedding of the lower leaves of small seedlings.

Jacobs (1955) has also offered some observations on the establishment of River Red Gum in the forests of the Murray. Some of these were subsequently developed further by Dexter, and are summarised above, but others of importance were:

- The problem with Red Gum is establishment, not germination; there in usually plenty of seed available, and germinates occur most years (para. 357).
- Successful regeneration is often associated with litter heaps, which appear to provide suitable conditions for foraging by surface roots while the tap-root grows through the heavy soil; the litter probably also offers better protection to the seedlings from frost, insolation and droughting. Jacobs suggested that there might be benefit in endeavouring to trap the litter as it moved with the rising flood waters (para. 358, fig. 136).
- The level of the annual flood each year is an important factor in regeneration establishment; sites above the flood level are more likely to suffer droughting, those below may have young seedlings drowned. Because of the flatness of the terrain, a few centimetres difference in flood height may represent tens of metres difference in the lateral occurrence of the flood waters (para. 359).
- For the same reason the mounds usually found at the base of large trees are important when the old tree is destroyed or dies: they provide repeated conditions for regeneration to establish (fig.131).
- Grazing destroys many seedlings, and consequently successful clumps of regeneration are often found within the physical protection offered by the heads of fallen trees or other obstruction (pars. 360; fig. 134).

Dexter (1967) noted that seedling growth was retarded and survival adversely affected within about a 20m radius of mature trees, and he observed also that the effect of large trees, as indicated by the browning off of grass and other plants in the vicinity, varies considerably with site quality - from about 20m in Quality 1 to about 40m in Q3.

Incoll (1979) reports some work on this carried out by J. Opie, who found that the zone of influence of large, mature River Red Gums increased with both stem diameter and with decreasing site quality. For all site qualities pooled, the zone of influence around an overwood tree of 100cm DBH was estimated to be 32m in diameter, or roughly twice the crown diameter.

Incoll comments that, had Opie assessed the effect of overwood on regeneration more precisely (it was done by ocular estimate only), it is likely that the zone of influence would have been found to be substantially increased.

A summary of these various findings and comments on River Red Gum regeneration might be to the effect that, on any particular site, the establishment of regeneration will be largely a matter of chance related particularly to features of the season's flooding and the summer rainfall pattern. Nonetheless, there are things that can be done to improve the odds - removal of large trees, disturbance of soil surface, trapping or spreading litter, on occasions supplementing seed source. On this basis Dexter favoured clearfelling, poisoning any non -merchantable trees and aerial seeding as the "*cheapest and most flexible technique*"; alternatively either a single-stage or two-stage clearfelling with natural regeneration could be used.

Although Dexter (1978) reports that the absence of regeneration was a problem in the Victorian forests, few NSW foresters would consider that they had a real regeneration problem on the north side of the Murray, certainly in the Q1 and 2 sites, while the Q3 sites would naturally tend to be open, woodland stands.

6.4 Regeneration Damage

As already noted, various agencies can damage or destroy regeneration of River Red Gum, and of these the most serious are **climatic** - particularly dry periods producing water stress, and aggravated by competition from nearby trees, grasses and other plants, but also frosting and high soil surface temperatures affecting germinates. Flooding also can destroy young regeneration, even though the regeneration depends, to a large extent, on flooding for its establishment.

Dexter (1967) also lists insects as an important cause of damage to seedlings under 8 months, leading to the loss of up to 14 per cent of germinates. Dexter does not identify types of insects involved in this damage. Old regeneration is commonly attacked by defoliating insects, including Cup moths and the Gum Leaf Skeletoniser Moth, and by gall-forming insects (Dexter, 1967).

Grazing, by domestic, native and feral animals, is another cause of damage and loss to regeneration. Dexter has reviewed the effects of these.

During prolonged droughts, when Moira Couch fails to regenerate, repeated grazing by kangaroos and rabbits may destroy the majority of young Red Gum seedlings. Wild horses will graze grass and seedlings alike over extensive areas. Cattle may trample large numbers of recent germinates on local loose soil patches that are used as dust baths; otherwise cattle appear to be selective grazers that avoid the Red Gum seedlings. Indeed Dexter notes that seedling stocking, where cattle grazing occurred, remained adequate as the growth of grass and weed species, which competed for soil moisture, was suppressed; by contrast, where cattle grazing was excluded the stocking of Red Gum seedlings fell to unacceptable levels due to mortality from soil drought in summer.

The Forestry Commission of NSW (1973) generally concurs with this assessment of the effects of cattle, but notes that they have at times caused mechanical damage to large regeneration. Sheep are considered more destructive because of their tendency to congregate in flocks and to browse close to the ground. In general, however, grazing with controlled numbers of stock does not cause critical destruction of regeneration in the major forest areas of the Central Murray and Murrumbidgee.

Further downstream there may be problems, and A.L. Yates has noted that sheep (and rabbits) have been shown to reduce regeneration stocking significantly in the Mildura district. He observes that isolated river bends are particularly vulnerable to damage by sheep; fencing off the bends has often resulted in good stocking, usually as a result of reshooting by previously established seedlings which had been regularly browsed back by the sheep.

River Red Gum regeneration can be destroyed by **fire**. The seedlings lack lignotubers, and fires, which tend to burn fiercely close to, and sometimes just below, the soil surface, can kill well-established regeneration. This provides an added reason (besides preparing an improved seed bed) for post-logging burning, even though the logging debris gives some protection from browsing by sheep and can also act as a litter trap.

6.5 Early Growth and Development

Dexter (1967) has given a table showing the early development of Red Gum regeneration on various sites. This table, converted to metric measure, is reproduced as Table 4.

The importance of the seed bed type to the growth of the young seedlings can be readily seen, with plants on the more favourable beds (ash bed or cultivated) averaging up to 10 times the height of those on the less favourable beds. Note that, over the range of sizes represented in the table, root depths can be expected to be from 4 to 5 times the seedling height; obviously on the more favoured beds the roots are well down into the subsoil, giving the plants a much stronger chance of survival than those on the poor beds.

Table 4

SEEDLING SURVIVAL AND DEVELOPMENT IN RELATION TO SEED BED

Seed Bed Type	Seedling Heights – (cm)		Survival %
	Age 3 - 5 months	Age 8 - 10 months	8 - 10 months
Deep ash bed	5 (range 1.3 -25)	61 (range 7.5 - 140)	53
Heavily cultivated bare soil	10 (6 - 15)	38 (6 - 76)	80
Hard bare earth	1.3 (0.6 - 1.8)	10 (5 - 25)	64
Light grass	1.3 (0.6 - 1.8)	6 (1.3 - 15)	2 .5

As indicated by the seedlings on the ash bed, where the best seedling was 1.4 metres high at age 10 months, Red Gum seedlings have the ability to make very rapid growth under favourable growing conditions.

Foresters from coastal districts sometimes tend to regard River Red Gum as a slow growing species, but this can be far from the case. Overseas, River Red Gum on suitable sites can maintain MAI's of 2m in height and 2cm in DBH for their first 10 years (F.A.0. 1979).

River Red gum is a species with generally rather weak apical dominance - indeed this is a feature of the Red Gum group as a whole. As a result, stems are frequently of rather poor form and inclined to forking and heavy branches, all defects that are accentuated when the seedlings have been damaged at a young stage and then produced new shoots from axillary or basal buds. Because of this feature there are benefits in endeavouring to grow the regeneration in reasonably dense clumps, restricting branch development and forcing vertical growth. Where water availability is not limiting, dominants form fairly quickly in these clumps (which, as with the 1870's regeneration on the Murray and the 1911 regeneration on the Murrumbidgee, may at times cover vast areas), though the suppressed trees show remarkable persistence.

Jacobs (para. 353) notes that coppice resulting from thinning regrowth clumps is often of much better form than the original stem. The desirability of having the regeneration in dense clumps led the Victorian Forests Commission to adopt a higher stocking standard (50% of 4 m^2 plots stocked) than applied generally in that State (Dexter, 1978).

7. Growth And Yield

7.1 Growth Rates

Any discussion on growth of River Red Gum in the forests of the Central Murray has to be of mainly academic interest. As Hamilton (1977) has pointed out, the Murray Management Survey, based on the growth shown by many plots, some of which were of long standing, arrived at an average DBH increment of 0.75cm a year for crop trees of Red Gum, for both Q1 and Q2 sites; subsequent measurement has seen this figure reduced to about 0.25cm a year, the drop being attributed to the drier growing conditions of the regulated river, possibly associated also with increased outbreaks of the Gum Leaf Skeletoniser Moth.

There are strong reasons for attributing the reduced growth to reduced flooding of the stands. H.C. McDonald has recently closely examined the growth shown by one increment plot established in the Barham area in 1914 and maintained with periodic measurements till 1936. Mr. McDonald has shown an astonishingly high correlation between the BA growth of the plot and the number of days that the river gauge at Barham exceeded a height of 3.12m (10 feet 3 inches). This height apparently resulted in recharging an aquifer that provided water to the plot (flooding of the plot site occurs at a somewhat higher gauge level). The analysis of growth in this plot is capable of unusually precise interpretation, and is reinforced by several other plots, of similar venerability, examined by Mr McDonald; hopefully these results will be made more widely available in due course.

Over the 22 years of measurement the BA of this plot increased from about 37 to 68 m^2/ha. The best fit regression obtained by Mr McDonald for this plot has the form:

$$\log_e BA = 0.397842 + 1.493009 \times 10^{-4} d,$$

where d = cumulative days that the gauge height was at, or exceeded, 10 ft 3 in, counted to 15 days prior to plot measurement;

BA = basal area growth on 0.1 acre (0.04 ha) plot.

This regression has a coefficient of determination (r^2) of 0.9985.

The significance of this work is that it demonstrates that the growth of the River Red Gum stands is almost solely dependent upon periodic flooding. No flood, no growth; short flood, little growth.

Some of the information derived by the M.M.S. and used in the determination of Red Gum growth rates was reproduced in the original management plan for these forests (Forestry Commission of NSW, 1954), including graphs of DBH increment against DBH for various stand components. Features of these relationships include:

- Very similar increments for both Q1 and Q2 sites (if anything, Q1 growth tended to be slightly below that of Q2), but with Q3 significantly less.
- DBH increment maintained close to 0.75cm a year (0.3 inches) for crop trees on the Q1 and Q 2 sites over a wide range of diameters.

- A consistent drop in increment for trees in the 20 to 50cm DBH range. (In the case of suppressed trees, this drop occurred in the 10 to 30cm range). This would appear to correspond to the regrowth stands originating from the 1870's, and to be brought about by the denser stocking of these stands.
- Disregarding this drop, even suppressed stems showed a steady growth rate (averaging about 0.5cm a year), indicating the persistence of these stems.

Table 5

PROVISIONAL YIELD TABLE - EVEN-AGED STANDS OF RIVER RED GUM

(from Forestry Commission of NSW, 1954)

Age (years)	**DBH** (cms)	**Q1 Stands**		**Q2 Stands**	
		Stocking (/ha)	**Tot. Volume** (m^3/ha)	**Stocking** (/ha)	**Tot. Volume** (m^3 /ha)
8	5.3	3 600	17	3 000	13
18	12.1	1 050	44	900	36
28	19.4	730	84	480	68
38	26.7	370	135	320	105
48	34.0	275	190	235	140
68	50.0	165	300	140	220
88	65.0	120	410	95	280
108	78.8	90	520	70	310

Based on the growth rates determined during the M.M.S., a provisional yield table for even-aged stands of River Red Gum was developed, and an abridged version of this is reproduced in Table 5. The table shows no difference in diameter growth between Q1 and Q2 sites, but the Q2 stands produce less volume because of lower stocking and poorer height development. Volume MAI's rise to nearly 5 m^3/ha/an for Q1 sites at 110 years, but only to about 3.2 m^3/ha/an between 70 and 90 years for Q2. Well, that's what might have been; the reality under conditions of river regulation appears to be something substantially less over the broad areas of these forests.

Table 6

CROWN:STEM DIAMETER RATIOS

(from Davies, 1950)

DBH (m)	**River Red Gum**		**Western Grey Box**	
	Crown Diameter (m)	**K:d Ratio**	**Crown Diameter** (m)	**K:d Ratio**
0.5	6.5	13	10.6	21.2
1.0	14.0	14	15.8	15.8
1.5	18.2	12.1	18.5	12.3
2.0	21.4	10.7	-	-

Logging in the Murrumbidgee forests commonly yields about 50 m^3/ha, and leaves about a similar volume standing. However, some sites yield much larger volumes, with the recent best logging area providing 220 m^3/ha of all products - sawlogs, sleepers and other material.

7.2 Thinning

As noted in Appendix 5, regrowth thinning has been carried out in stands of Red Gum regeneration since last century. This treatment has generally been of a non-commercial nature, aimed at reducing the stocking, and improving the growth of selected trees, in the more extensive areas of regrowth, and particularly in the 1870 regeneration along the Murray and the 1911 regeneration along the Murrumbidgee.

Early treatments tended to be fairly conservative, apparently in part due to the silvicultural beliefs of the time, and certainly at a later stage in an effort to minimise the effects of coppicing (Jacobs, para. 353, suggests that in the 1890 treatment, stumps were sometimes grubbed out to avoid coppicing). By the 1950's the guideline used in the Murrumbidgee forests was for a spacing of "D + 6", i.e. the spacing (in feet) should be equivalent to the diameter of the selected stem in inches plus 6; a 10 inch (25cm) stem would be spaced roughly 16 ft (4.9 m) from its neighbours. A stand of such trees would in theory be thinned to a stocking of about 170 stems/acre (420/ha), and carry a BA of about 90 sq ft/ac (20 m^2/ha); in practice the stocking and BA always tend to be higher.

In 1961 a series of thinning plots, covering a range of treatments, were established in 50 year old regrowth on the M.I.A. Forest; the stand at the time was fairly even in development with a mean dominant height of 22 m, an average stocking of nearly 3 000 stems/ha, and an average B.A. of 39m^2/ha. Following treatment plots varied in stocking from about 200 to over 3 000 stems/ha, and in BA from about 11 to 32 m^2/ha.

Describing the establishment of these plots, Hills (1964) noted that in the plot thinned to the "D + 6" guideline, only 15 per cent of the total BA was removed, and the BA after thinning was 31 m^2 /ha. He considered such a light thinning to be uneconomic and also unrealistic if the aim was to carry the stand through to the stage where it could produce a commercial thinning of poles or sleepers without further treatment. He observed that coppice had developed strongly in most plots, and to minimise the effects of this he considered that thinning should aim at the removal of competing co-dominants around selected crop trees, retaining the dominated and suppressed trees in the interests of both economy and coppice control. He suggested, on early results, that thinning should be concentrated on stands in the 20 - 30cm range, and should aim to release from about 170 - 220 potential crop stems per hectare (equivalent to a BA of about 10 m^2/ha).

These plots were reviewed again by Hamilton (1971, 1972), who drew the following conclusions:

- At the wider spacings, crop trees had maintained a DBH increment of about 0.7cm a year over 10 years.
- Although the coppice from thinned stems looked weak, it still survived on 75 per cent of stumps, and appeared to be having a retarding effect on growth; retention of suppressed stems is therefore favoured.
- There was some indication that spacing of crop trees should be more or less regular; where this was not the case (one plot only) growth was lower than expected.
- There was a steady decline in stand growth from a maximum at BA's of 11 - 14 m^2/ha down to nil at 37 m^2 or over.
- The widest spacing (about 7.3m, or about 190 stems/ha) did not appear too severe.

Hamilton noted that these results generally supported the preliminary recommendations of Hills, and subsequently (Hamilton, 1977) he has summarised these findings:

> *"The work of Hills has shown that the productivity of better stems is increased by co-dominant thinning to a spacing of about 7m by 7m in sapling pole stands. Earlier thinning is not recommended as apical dominance is weak, and a wide selection of stems for later thinning is desirable."*

Red Gum thinning has also been studied in Victoria, and Incoll (1979-80) has summarised the results of some trials in 26-28 years old stands, commenced in one case in 1953. Incoll's conclusions largely support those of Hills and Hamilton:

> *"The results showed that a maximum net basal area increment of 1m^2/ha/yr was obtained when the stands were thinned to basal areas between 15-25 m^2/ha, but that the maximum diameter growth of 0.4-0.9 cm/yr for the largest 123 trees per hectare was obtained after the heaviest thinnings, where 7-10 m^2/ha of basal area was retained after thinning. The heaviest thinnings did not cause visible deterioration of stem quality."*

During the late 1960s and up until 1982, poison thinning using Tordon (picloram) was quite widely used in the Murrumbidgee regrowth stands, and was effective in preventing coppicing though producing stands that lack a bit in visual appeal (eg. Cuba S.F.). Occasional instances of Tordon causing the death of neighbouring untreated trees, presumably by transfer via fused roots, were reported, but not in sufficient numbers to cause serious doubt as to the efficacy of the treatment.

Since 1982 non-commercial thinning has been dropped, as markets for small products developed. For similar reasons, little in the way of cull tree removal by ringbarking now takes place, as in most cases some products can be obtained from the trees.

7.3 Size and Longevity

River Red Gum can reach fairly massive proportions, and records of some of the larger known trees (mostly still standing) are shown in Table 7.

Table 7
RECORDS OF LARGE RED GUMS

Location	DBH (m)	Height (m)	Notes
River Red Gum			
Manie S.F.	3.63	45	Stem burnt out
Mallee Cliffs S.F	2.23	48	
Adj. Mallee Cliffs S.F. (P.P.)	2.85	-	vol. 68.8 m^3, felled 1976
Koondrook S.F.	1.09	47	vol. 11.1 m^3
Manie S.F.	4.27	c .30	Hollow; very swollen butt
TR 23438 (W. of Hay)	2.63	40	Vol. 35m^3 - Rod Squire Tree
Cumbijowa S.F.	2 54	34**)**	Close to each other,
Cumbijowa S.F.	3.32	31**)**	last two hollow at butt.
Cumbijowa S.F.	1.60	38**)**	
Forest Red Gum			
Wallaby Ck., Urbenville Dist	1.62	48	
Busbys Flat Reserve	2.18	48	

Larger trees have almost certainly existed in the past, and some of considerable height are known, but not yet formally reported: one on Millewa S.F. has been measured at 51m by hand instrument; Jacobs (para. 352) refers to trees of 170 feet (52m) being known; and Beadle (1981), possibly on scanty evidence, describes the species as forming forests up to "c .60m" in height.

The large trees are of appreciable age. The M.M.S. growth relationships infer that trees with a DBH of about 1.80m are in the order of 350 - 400 years old, and Jacobs (para. 111) makes the comment, about River Red Gum, of *"numerous individuals having a maximum age of around 1 000 years".* He also notes that the largest trees are often not the oldest.

As far as is known core wood from Red Gum has not been dated by the C14 technique - indeed the innate faultiness of the larger trees means that few, if any, possess core wood to be tested.

8. DAMAGE TO OLDER STANDS

Like any forest, the River Red Gum types are subject to damage from a wide range of sources. Some of these are of greater significance than others, but the end result is that Red Gum is a species notorious for its defective logs - hence the importance of the work of the M.M.S. in introducing "improved utilisation" logging.

Red Gum has considerable ability to withstand **drought,** though some of the interior provenances are undoubtedly hardier in this respect than those from the forests along the inland rivers of NSW. Extended dry periods, without either flooding or effective rains, will affect Red Gum, particularly on the more raised sites, but sometimes also in the lower and usually higher quality, sites, possibly because of locally rapid subsoil drainage.

Initially affected trees develop dull, lustreless foliage that in very apparent to anyone travelling through the forests, and that contrasts strongly with the brighter green of trees where water is available. Subsequently heavy leaf fall occurs. While most trees normally recover following rain or flood, the droughting would greatly reduce growth, may well promote gum vein production, leads to the death of some stems and renders others more prone to Insect attack. Related to droughting are of course the effects brought about by river regulation reducing the incidence of winter-spring flooding, as has already been discussed (see especially Section 2.3.2).

Other climatic effects appear to have little role in causing damage to mature forests, though occasionally heavy crown damage may result from local **windstorms**, such as one that damaged part of the M.I.A. Forest in November, 1981, and another that occurred in Millewa S.F. about 1977. These may warrant subsequent salvage logging.

Whilst **flooding** is normally vital to the existence of the Red Gum forests, prolonged inundation will ultimately kill trees. This is one of the effects of river regulation which maintains higher than natural summer flow levels, leading to the prolonged, or even permanent, flooding of some of the lower lying, and usually highest site quality, stands. In the Deniliquin district it has been estimated that about 2 000 ha of forest, mostly of Q1, have been already lost in this way.

Although **fire** is a natural feature of the Red Gum forests, the trees are more susceptible than many eucalypts to damage by fire. In Aboriginal times it seems that fire was used regularly in the forests, maintaining them In a fairly open condition, and undoubtedly also contributing to the butt damage of many of the stems; it also would have kept the forest floor in a fairly clean condition. Fire of only moderate intensity will kill the cambium near the base of the tree, leading to dry sides. Such wounds are often quite rapidly occluded, but enclose pockets of dead sapwood; the fires also promote the formation of gum veins, and are thus a major cause of the ringiness that is often a feature of Red Gum logs. Intense fire round the base of a tree may kill the tree or, if more localised, lead ultimately to the hollow, burnt out butts that are encountered in many of the larger Red Gums.

Fire in River Red Gum forests can be difficult to control as it tends to go underground and burn in old stumps and roots for long periods. At the same time fire needs to be used in the management of these forests to remove the heavy accumulations of debris that can occur and to reduce grass mats and other undergrowth so as to favour regeneration establishment.

Fungal or similar diseases do not appear to be a major problem with Red Gum, except for the ubiquitous presence of wood-rot: “punk”, in part fungally induced, is a major defect of Red Gum logs.

Red Gum is subject to attack by a number of groups of **insects,** of which the most widespread and important seem to he those that attack the foliage. Carne and Taylor (1978) refer to several groups that have been recorded as damaging Red Gums, including psyllids (*Cardiaspina spp*.) and the Gum Tree Scale (*Eriococcus coriaceus*). Cup moths may also cause considerable damage, particularly on smaller stems or In the lower canopy levels of the forest. However, the major defoliator of these stands appears to be the Gum Leaf Skeletoniser Moth (*Uraba lugens*, syn. *Roselia lugens*), whose biology was studied and reported in some detail by Campbell (1962). Between 1900 and 1962 this insect had occurred in plague numbers on the Murray River forests on at least 11 occasions, defoliating areas of up to 40 000 ha in an outbreak. Campbell showed a clone association between severe outbreaks of *Uraba* and the occurrence of winters when flooding the forests did not occur, and he suggested that flooding was necessary for the “mortality factors”, such as fungal infections, that regulate the increase of the insect.

Other factors leading to a build up of insect numbers appeared to be the presence of stands of trees growing close together, abundant fresh, undamaged leaves, and a continuous canopy of foliage. The effects of these plagues on the forests appear to be similar to those of droughting - particularly reduced growth and some increased mortality.

Besides the leaf-attacking insects, stem borer and termite damage can occur in these stands. However ground-foraging termites are absent, and this probably contributes to the long-lasting build up of woody debris on the forest floor, unless it happens to be removed by fire.

Hollows in trees are sometimes used as colony sites by feral bees, which can then represent a hazard to log fallers.

Mistletoes are fairly common in the Red Gum stands, and there is some suggestion that they may be increasing in frequency: this could be expected as a consequence of the reduced health of much of the forest following river regulation. Similarly the apparent spread of **Native Cherry** may well be related to reduced flooding; its effects on the growth of the Red Gums have not been recorded, but as a root parasite it can be expected to have some adverse effects on growth and vigour, and some tree mortality appears to have been caused by Cherry infestations.

Salinity is a problem of increasing severity in various parts of western NSW, and particularly in some of the irrigation areas. It has not developed as a significant problem in the forest areas, though some effects on Red Gum have been noted along the Murray and in the creek reserves close to Broken Hill. The strain of Red Gum growing in the latter reserves, the so-called Silverton Red Gum, is regarded as remarkably salt-tolerant, and has been used in reclamation trials in areas affected by saline irrigation damage.

9. PRESERVATION

Specht et al. (1974), referring to the River Red Gum alliance in NSW, state that the conservation status of the alliance where it appears as open forest is poor, as woodland, excellent, and as low woodland, moderate. This appears to portray a rather brighter picture of the preservation of River Red Gum types than reality suggests. The major occurrence controlled by the National Parks and Wildlife Service (and then hardly in a pristine condition) is Kinchega N.P. (44 000 ha), which includes some stands along the Darling River near Menindee. Some of the other western parks would include occurrences of Red Gum along normally dry creek beds.

Only five preserved areas of the Forestry Commission, with a total area of less than 400 ha, carry River Red Gum types. These are identified in Appendix 6 and, despite the limited area coverage, show a reasonable spread of geographic location and types covered.

Other Red Gums are included in some 18 preserved areas, also listed in Appendix 6, and these areas show a fairly, though not completely, comprehensive coverage of the various species and communities of Red Gums occurring in NSW.

In addition to these preserved areas, the specimens shown in Table 7 and growing on State Forests are also preserved for their natural lives.

10. MANAGEMENT ASPECTS

10. 1 Objectives of Management

From the period when the River Red Gum forests were among the most important timber-producing forests in NSW, the emphasis in management has changed considerably. The NSW Indigenous Forest Policy (Forestry Commission of NSW, 1976) expresses current objectives as follows:

> ***"5.4.5 River Red Gum***
>
> *Management of these forests should continue on a multiple use basis. Their fundamental role is to provide flood buffer areas, but their importance as wildlife habitat, as fish feeding and breeding grounds, and as recreational areas should be given increasing emphasis in management. Although their timber production capacity will diminish, as river regulation reduces growth rates, commitments to industry should continue to be fulfilled through selective logging.*
>
> *Yields in the immediate future should be regulated to current sawlog commitments, with sleepers and other products coming from residual timber in sawmill operations and from thinning sub-sawlog size stands. Any drop in sawlog demand should be used to reduce yields to a lower level which could be sustained indefinitely. No regeneration expenses should be incurred to establish future timber. The forest type should be maintained through natural regeneration, in response to periodic flooding. Ringbarking of large cull trees during logging operations should be continued to help promote increment on established growing stock harvestable within the next 30 years. Extensive grazing should be continued, but regulated so that continuation of the forest type is not endangered by excessive destruction of regeneration."*

Note that the policy objectives emphasise the multiple use management of these stands, acknowledge the effects of river regulation in reducing wood production, prohibit specific expenses to obtain regeneration, but favour the ringbarking of cull trees to help promote increment on adjacent trees.

10.2 Management Problems

Management of the River Red Gum forests, certainly along the Murray, and probably little less in the other areas of commercial stands, is overshadowed by the problems caused by river regulation, as has been effectively discussed in various recent reports. Since it seems that little in the way of major improvements in river flow, so far as the forests are concerned, can be expected in the future, management has to make the best use it can of existing circumstances, including the less frequent winter-spring floods and irregular low flooding caused by water rejections. Useful proposals in this regard have been provided by River Murray Commission (1980) and Paunovic (1982).

At the same time the Forestry Commission should take every opportunity to oppose any proposed developments likely to reduce further the incidence of winter-spring flooding or to raise further the summer flow through the main forest areas. The opposition should not be primarily on the basis of maintaining the local timber industry, but rather so as to maintain the existence of what must surely be some of the world's most unusual and interesting forests and its associated fauna which, to a large extent, is dependent upon the continued well-being of the forest stands.

Because river regulation will continue, forest managers must face continued lose in productivity and a long-term drift in forest site qualities. However there is no reason to believe that the forests will not themselves survive, and a positive attitude should continue to be taken in the management of these stands.

After all, they have a lot going for them.

10.3 Guidance Points

Most writers on the silviculture of River Red Gum ultimately, and usually at an early stage, list the various silvical characteristics of the species. These have already been covered elsewhere in these Notes, but they do serve to tie together most of the important aspects in the silvicultural care and treatment of the River Red Gum types. So...

- River Red Gum is a fairly prolific seeder, and can be expected to carry seed at most times.
- The seedlings in the commercial forest stands of NSW are non-lignotuberous.
- Germination is favoured by warm to hot conditions.
- Survival of seedlings is primarily determined by the availability of moisture during the summer; in this connection the presence of grass or nearby trees can reduce soil moisture and cause heavy mortality.
- Establishment tends to be best on cultivated soil or ash beds, and the presence of surface litter can be beneficial.
- Seedlings have a very high root: shoot ratio, allowing them rapid access to subsoil moisture sources.
- Both as seedlings and as trees they have a remarkable ability to withstand long periods of flooding, though protracted complete inundation is fatal to seedlings.
- Given adequate moisture, normally provided by flooding, seedling growth can be rapid.
- The young trees have poor apical dominance, and benefit from being grown through the sapling stage in fairly dense clumps.
- Provided moisture conditions are favourable, dominants are usually produced at an early stage.

- However the suppressed stems can be very persistent, and survive for long periods with poor, and largely epicormic crowns.
- The trees coppice readily.
- Regrowth stands benefit from being thinned out, but coppice from the stumps can reduce response in the crop trees.
- Roots on mature trees can extend at least 9m vertically through mostly heavy clay soil.
- Trees growing in sites that are regularly flooded will often produce aerial roots on the section of their trunk that is sub-merged each year.
- Growth and site quality is primarily dependent upon the frequency of flooding or access to subsoil moisture sources.
- The species in rather susceptible to fire damage, seedlings and young regeneration being killed and older stems likely to develop dry sides and other defects.
- It is subject to a fair level of Insect attack on the foliage, with the level of attack often highest during seasons of poor moisture availability.
- Large trees, with their frequent stem and branch hollows, pro-vide important wildlife habitat.
- The trees tend to show obvious signs of water stress during extended dry periods.
- Nonetheless the trees must be regarded as very hardy, and they survive in an environment where no other native tree occurs.

Following from these features, various points can be developed to assist in the silvicultural treatment of the stands. These have been mentioned previously, and essentially all are applied in the field to the extent possible:

1. Do everything reasonable to encourage winter-spring flooding: this will promote growth and regeneration, reduce Gum Leaf Skeletoniser attack, and maintain healthy stands that are less likely to be troubled by droughting, mistletoe, Native Cherry and other insect damage.

2. In logging, endeavour to keep heads of felled trees away from growing trees, and after operations are complete carry out a top disposal or more general hazard reduction burn. This will reduce fire hazard, tidy up the forest, and create suitable beds for regeneration establishment.
3. Unless specifically wanted for environmental purposes (den trees, canoe trees, etc), large old trees that are incapable of making positive increment should be removed. Very frequently such trees contain useable timber; if this is not so, and seems unlikely to become the case, they can be ringbarked. Their removal will both assist in the establishment of regeneration and eliminate an inhibiting influence on neighbouring trees. However, because of limited response, no specific expense should be incurred on the removal of such trees from Q3 sites, and on all sites efforts should be made to retain some of the veteran stems in the stand for habitat purposes.
4. Do not be impatient over the establishment of regeneration, and appreciate that one of the effects of river regulation is that the circumstances favouring regeneration will occur less frequently than in the past. It has probably always been unusual for regeneration to become established over wide areas, the circumstance requiring high winter-spring floods and then a rainy summer to allow seedlings to survive and get their roots down. In the more usual season the occurrence of regeneration will be more limited. Post-logging burning and the removal of cull trees will assist in the establishment of regeneration.
5. Regrowth stands should be maintained in reasonably dense conditions until dominants are well established, and then thinned to favour dominants or other

selected crop trees at a fairly wide spacing. The recommendations made by Hills (1964; see Section 7.2) still seem valid in this respects:

6.

- Favour crop trees in stands with an average crop tree DBH in the 20-30cm range.
- Select crop trees at a spacing of about 7 x 7m.
- Remove competing co-dominants; do not worry about suppressed stems, as these will help deter active coppice growth.
- Alternatively, poison-thinning will largely eliminate the coppice problem.

Under recent conditions thinning for mining timber and other products has sometimes removed the need for non-commercial thinning.

7. Remember that the value of the Red Gum forests for other purposes is on a par with, and in the eyes of many people may be much greater than, their value for wood production. Occurring as they do in regions otherwise largely devoid of trees this statement tends to have much more validity than is the case in most other forest areas of NSW.

Nothing new here to foresters familiar with Red Gum management, but the items may be of value to new foresters to the riverine forests.

Management of the River Red Gum forests in NSW has generally tended towards selective harvesting, though there are extensive areas of even-aged young stands (eg from 1870's and 1911 floods). It is suspected that in the long run these even-aged stands will also be managed by selective logging, resulting in something akin to a group selection system. This seems to be quite well suited to the silvical requirements of River Red Gum.

10.4 Further Research

In the fairly extensive management that is likely to be the lot of the Red Gum forests in the foreseeable future, there is little justification for a research programme of any intensity or scale. However there is one field where research is needed. This relates to the continuing effects of river regulation on the forests generally - on the growth shown by inventory plots, on the changes in site quality, on related ecological changes, and so on. It need not be an intensive programme, but it does need planning to ensure that records and observations are maintained, effects monitored, photographic records (including appropriate aerial photographs) kept.

It is research that may never contribute much to the better understanding of the silviculture of River Red Gum and its forests, but it will contribute a great deal to man's understanding of the long term effects brought about by major changes to the environment - in this case, by river regulation.

11. ACKNOWLEDGEMENTS

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Appendix 1

PLANT SPECIES MENTIONED IN TEXT

Common Name		Botanical Name
Apple, Broadleaved	AAABA*	Angophora subvelutina
Roughbarked	AAABB	A. floribunda
Bangalay	SECAD	Eucalyptus botryoides
Belah		Casuarina cristata
Bloodwood, Brown	CAFUJ	Eucalyptus trachyphloia
Box, Black	SUDEC	E. largiflorens
Grey	SUL:B	E. moluccana
Swamp		Lophostemon suaveolens
Western Grey	SUL:DB	Eucalyptus woollsiana ssp. microcarpa
White	SUL:G	E. albens
Yellow	SUX:A	E. melliodora
Carbeen	BAA:A	E. tessellaris
Cherry, Native		Exocarpos strictus
Cooba, River		Acacia stenophylla
Coolabah	SUADF	Eucalyptus microtheca
Couch, Moira		Pseudoraphis spinescens
Cypress Pine		Callitris spp
, Black		C. endlicheri
White		C. columellaris, 'inland form'.
Gum, Cabbage	SNEEA	Eucalyptus amplifolia
Grey	SECE	E. propinqua or punctata
Red		General name for members of Pryor & Johnson series Tereticornes, SNE.
, Blakely's	SNEEF	E. blakelyi
Bluish-leaved	SNEEPE	E. camaldulensis ssp. obtusa (local form)
Forest	SNEEB	E. tereticornis
Narrowleaved	SNECA	E. seeana
River	SNEEP	E. camaldulensis
Silverton	SNEEPE	E. camaldulensis ssp. obtusa (local form)
Slaty	SNEEC	E. glaucina
Tumbledown	SNEFJ	E. dealbata
Yellow	SUX:C	E. leucoxylon
Ironbark, Red	SUX:I	E. sideroxylon
Lignum		Muehlenbeckia cunninghamii
Mallee, Pokolbin	SNECH	Eucalyptus pumila
Mistletoe		Amyema & related spp.

Napunyah	SUJ:B	Eucalyptus ochrophloia
Oak (or She-Oak)		Casuarina or Allocasuarina spp .
Bull		Allocasuarina luehmannii
River		Casuarina cunninghamiana
Wattle		Acacia spp.

*Coding from Pryor and Johnson (1971).

Appendix 2

CLIMATIC DETAILS - RIVER RED GUM STATIONS

NARRABRI WEST

Latitude 30°20'S **Longitude** 149°45'E **Elevation** 212m

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Daily Max Temp. (c) Mean	34.0	33.8	30.7	27.0	21.3	18.6	17.8	19.3	22.8	26.9	29.7	32.1	26.1
Daily Min Temp. (c) Mean	18.6	18.4	16.2	11.4	7.1	4.7	2.9	4.7	7.3	11.4	13.9	16.9	11.1
Rainfall (mm) Mean	79	71	61	39	48	54	45	42	41	53	63	66	662
Raindays (No) Mean	6	5	4	4	5	6	5	5	5	5	5	6	61

MENINDEE

Latitude 32°24'S **Longitude** 142°25'E **Elevation** 61m

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Daily Max Temp. (c) Mean	34.0	33.2	30.2	25.8	20.4	17.4	17.0	18.5	21.6	26.9	28.7	31.8	25.5
Daily Min Temp. (c) Mean	19.5	19.5	15.6	8.7	12.1	8.2	5.2	6.1	8.6	12.5	14.5	16.9	12.0
Rainfall (mm) Mean	18	21	18	15	22	22	16	18	17	21	20	21	229
Raindays (No) Mean	2	3	2	3	4	5	4	5	4	4	3	3	42

FORBES

Latitude 33°23'S **Longitude** 148°1'E **Elevation** 245m

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Daily Max Temp. (c) Mean	31.9	31.1	28.6	24.0	18.2	15.3	13.8	15.6	19.2	23.4	27.4	30.0	23.2
Daily Min Temp. (c) Mean	16.4	16.1	13.4	9.1	5.2	3.3	2.3	3.8	5.2	8.9	11.7	14.3	9.1
Rainfall (mm) Mean	47	45	44	40	42	46	41	44	41	49	40	47	526
Raindays (No) Mean	5	5	5	5	7	9	9	8	7	7	5	5	77

GRIFFITH

Latitude 34°17'S **Longitude** 146°2'E **Elevation** 126m

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Daily Max Temp. (c) Mean	31.1	30.9	27.9	23.4	17.8	15.2	14.3	16.1	19.3	23.2	26.4	29.3	22.9
Daily Min Temp. (c) Mean	16.1	16.2	13.4	9.2	6.1	3.6	2.4	3.9	5.6	9.1	11.3	14.1	9.3
Rainfall (mm) Mean	28	30	35	34	36	40	32	40	31	42	31	32	411
Raindays (No) Mean	4	4	5	6	8	9	10	10	8	7	5	5	81

HAY **Latitude** 34°30'S **Longitude** 144°51'E **Elevation** 94m

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Daily Max Temp. (c) Mean	33.1	32.1	29.0	24.4	18.8	16.4	15.0	16.9	20.3	24.3	28.0	30.7	24.1
Daily Min Temp. (c) Mean	17.2	16.9	14.3	10.6	6.9	4.6	3.7	4.9	6.7	10.1	12.7	15.1	10.3
Rainfall (mm) Mean	26	30	30	29	34	37	29	32	30	34	25	24	360

EUSTON **Latitude** 34°35'S **Longitude** 142°44'E **Elevation** 61m

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Daily Max Temp. (c) Mean	33.1	32.8	29.0	24.0	18.2	15.9	15.3	17.1	19.5	25.3	27.4	30.4	24.0
Daily Min Temp. (c) Mean	15.6	16.1	12.7	8.5	5.3	2.9	2.2	3.4	5.8	9.1	11.0	13.7	8.9
Rainfall (mm) Mean	20	22	22	22	30	34	26	30	29	30	24	22	311
Raindays (No) Mean	3	3	3	4	6	8	7	8	7	6	4	3	62

GUNDAGAI **Latitude** 35°4'S **Longitude** 148°6'E **Elevation** 216m

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Daily Max Temp. (c) Mean	31.3	31.6	27.1	22.5	14.7	12.7	12.0	14.1	16.2	21.4	24.3	28.6	21.4
Daily Min Temp. (c) Mean	19.5	19.5	15.6	8.7	12.1	8.2	5.2	6.1	8.6	12.5	14.5	16.9	12.0
Rainfall (mm) Mean	58	35	64	78	77	58	46	83	67	61	94	77	798

MATHOURA **Latitude** 35°49'S **Longitude** 144°54'E **Elevation** 76m

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Daily Max Temp. (c) Mean	31.7	30.6	27.7	22.6	17.0	14.5	12.8	15.1	17.9	22.2	26.2	28.7	22.3
Daily Min Temp. (c) Mean	15.5	15.3	12.9	9.2	6.0	4.4	3.3	4.4	5.8	8.7	11.0	13.2	9.1
Rainfall (mm) Mean	33	29	47	38	47	38	40	47	44	47	37	34	476
Raindays (No) Mean	5	6	6	7	6	9	8	11	8	9	7	2	84

Appendix 3

LIST OF BIRDS RECORDED FROM GULPA ISLAND STATE FOREST
(from Wheeler, 1974)

Emu
Little Grebe
Pelican
Black Cormorant
Little Black Cormorant
Little Pied Cormorant
Darter
White-necked Heron
White-faced Heron
White Egret
Nankeen Night Heron
White Ibis
Straw-necked Ibis
Royal Spoonbill
Yellow-billed Spoonbill
Black Swan
Wood Duck
Black Duck
Chestnut Teal
Grey Teal
Blue-winged Shoveler
White-eyed Duck
Musk Duck
Swamp Harrier
Brown Goshawk
Collared Sparrow-hawk
Little Eagle
Wedge-tailed Eagle
White-breasted Sea eagle
Whistling Eagle
Fork-tailed Kite
Peregrine Falcon
Brown Hawk
Nankeen Kestrel
Painted Quail
Little Quail
Dusky Moorhen
Coot
Spur-winged Plover
Black-fronted Dotterel
Southern Stone-curlew
Peaceful Dove
Diamond Dove
Common Bronzewing
Crested Pigeon

Purple-crowned Lorikeet
Little Lorikeet
White Cockatoo
Long-billed Corella
Galah
Cockatiel
Yellow Rosella
Eastern Rosella
Red-backed Parrot
Swift Parrot
Fantailed Cuckoo
Black-eared Cuckoo
Horsfield Bronze-cuckoo
Barn Owl
Boobook Owl
Tawny Frogmouth
Owlet-nightjar
Spine-tailed Swift
Azure Kingfisher
Laughing Kookaburra
Sacred Kingfisher
Rainbow-bird
Horsfield Bushlark
Welcome Swallow
Tree Martin
Fairy Martin
Ground Cuckoo-shrike
Black-faced Cuckoo-shrike
Little Cuckoo-shrike
White-winged Triller
Grey Fantail
Willie Wagtail
Leaden Flycatcher
Scissors Grinder
Jacky Winter
Scarlet Robin
Red-capped Robin
Hooded Robin
Golden Whistler
Rufous Whistler
Gilbert Whistler
Grey Shrike-thrush
Eastern Shrike-tit
Grey-crowned Babbler
White -browed Babbler

Blackbird
Western Warbler
Brown Weebill
Eastern Whiteface
Little Thorn hill
Chestnut-tailed Thornbill
Buff-tailed Thornbill
Yellow-tailed Thornbill
White-browed Scrub-wren
Superb Blue Wren
Rufous Songlark
Reed Warbler
Pipit
White-breasted Wood-swallow
Masked Wood-swallow
White-browed Wood-swallow
Dusky Wood-swallow
Brown Treecreeper
White-throated Treecreeper
Orange-winged Sittella
Mistletoe-bird
Spotted Pardalote
Striated Pardalote
Eastern Striated Pardalote
Brown-headed Honeyeater
Black-chinned Honeyeater
White-plumed Honeyeater
Noisy Miner
Red Wattle-bird
Blue-faced Honeyeater
Noisy Friar-bird
Little Friar-bird
Eastern Silvereye
Goldfinch
House Sparrow
Diamond Firetail
Starling
Olive-backed Oriole
Raven
Pied Butcherbird
Black-backed Magpie
White-backed Magpie
White-winged Chough
Magpie-lark

Appendix 4

PROPERTIES OF MAJOR TIMBER SPECIES: RED GUM TYPE

(Derived from K. R. Bootle: "Commercial Timbers of NSW and Their Use")
Abbreviations: L-S, Lyctid susceptible; G, green; S, seasoned; B, basic (re density)

Common Name	**Gum, River Red**	**Gum, Forest Red**	**Box, Western Grey**	**Box, Yellow**
Botanical Name	*Eucalyptus camaldulensis*	*E. tereticornis*	*E. woollsiana* ssp. *microcarpa*	*E. melliodora*
General Properties	Red heartwood, distinct sapwood. Moderately fine texture, interlocked and sometimes wavy grain, giving decorative figure. Not difficult to work. Takes high finish. Selected stock bends well.	Red heartwood, distinct sapwood. Moderately fine uniform texture. Interlocked grain. Hard. Resembles River Red Gum.	Light brown heartwood, fine texture, usually interlocked grain. Very hard. Bends well.	Light pinkish or yellowish-brown heartwood. Fine texture. Grain frequently interlocked. Very hard.
Density kg/m^3	G: 1125 S: 850 B: 660	G: 1170 S: 1105 B: 950	G: 1155 S: 1105 B: 880	G: 1315 S: 1105 B: 900
Durability	2, Sapwood L-S.	2 L-S	1 Rarely L-S	1 Rarely L-S
Strength	B for many properties, but because of frequent wavy grain usually classed as D/S5	B/S2	A/S2	B/S3
Sawlog Group	Separate treatment (roughly equivalent B)	B	A	B
Uses	Heavy construction, sleepers, flooring, turnery.	Heavy construction, sleepers, piles, poles, bearings	Heavy construction, sleepers, poles, crossarms.	Heavy construction, poles, sleepers, fencing.
Other Notes	Slow drying, Some checking, warping, collapse may occur but variable.		Dries slowly, not prone to checking.	Dries slowly

Appendix 5

REPORT ON THE TREATMENT OF RIVER RED GUM FORESTS

(from Annual Report of Forestry Dept., N .S .W . , 1910 -11)

The Red Gum forests of the Murray occur principally on the frontages and low lying inundated areas adjoining that river, and yield a valuable timber which is greatly in demand for building, constructive, and other purposes.

While the species is found to a greater or less extent throughout, the whole course of the river, the principal forest areas extend up and down stream from the vicinity of Moama, and comprise the Millewa, Gulpa Island, Moira, Bama, Pericoota, Koondrook, and Campbell's Island reserves, embracing a total area of about 186 500 acres of forest country.

The importance and value of these forests to the State lies in their wonderful productivity, the fact that the land, owing to inundation is unsuitable for residential settlement, and that they are in the vicinity of the comparatively treeless but extensive Riverina country, which is famed for its pastoral value, and is eventually destined to carry a large agricultural and timber-using population.

During the past thirty years, under natural unaided conditions, these forests have yielded an average of about 10 000 000 super feet [30 000m^3] of timber per annum, the revenue from which in timber royalties has for the past ten years amounted to about £80 000, but under reafforestative treatment their future possibility in timber yield will be very much greater.

These forests have been under systematic treatment for reafforestation during the past fifteen years. In 1895 the work was commenced at public cost, and provided employment for a large number of persons, principally in cleaning up and burning off debris. During later years it was continued partly at State cost, but mainly under improvement lease conditions subject to State supervision.

The general scheme of improvement was in the direction of reafforestation, but in carrying it out the grazing facilities were also improved. Owing to the peculiar characteristics of the species, the varied conditions of the forest, and the need for exercising sound judgment in the different processes, these works demanded expert direction and close supervision, and on the whole have been carried out under the management of Mr. District Forester 0. Wilshire with excellent results.

Briefly, the treatment comprised, first cleaning up and burning off fallen timber and debris so as to prepare the land for reafforestation, and prevent depredation of growths by running fires; next, the judicious destruction of over-matured or useless growths by ringbarking, a process which vitalised the soil and enabled reproduction from seed; and lastly, the thinning out of super-abundant regrowth when it had arrived at the proper stage. These processes are of little value unless applied continuously, and, in the ringbarking and thinning, bad judgement or inexperienced treatment results in injury rather than benefit to the forest.

Experience has shown that the most practical and economical method of improvement is by way of improvement leases in large areas under State supervision; but as the work is costly (averaging about 9 shillings per acre) it is difficult to secure lessees willing to undertake this expenditure, unless inducement in the way of long tenures and reasonable rentals is offered. Leasing small areas in this class of country is found to be of little benefit to the forest, experience being that it requires capital to carry out the work; moreover, an impecunious lessee, unable to complete the conditions, may in the end defeat them by the illegitimate use of fire.

The total area of reserves in the series is 186 510 acres, of which 101 290 acres have been so far improved in the interests of reafforestation.

Appendix 6

PRESERVED AREAS ON STATE FORESTS
RED GUM TYPES

River Red Gum Types

Sanddune Pine Flora Reserve No. 79997. Millewa S.F. 56 ha. Includes sanddune with White Cypress Pine, surrounded by flood plain carrying River Red Gum and Red Gum - Box (Yellow and Western Grey) types.

Wilbertroy Flora Reserve No. 80003. Wilbertroy S.F. 134 ha. Flat flood plain of Lachlan River, carrying River Red Gum, with broad sandrises supporting fine stands of Yellow Box; also Western Grey Box, Belah and Bull Oak present, and some areas of Lignum.

Paiko Creek Forest Preserve No. 47. Manie S.F. 97 ha. Apparently unlogged stand of River Red Gum close to Murray River; Q2 and 3. Given way to Black Box types on higher sites.

Gin Gin Forest Preserve No 71. Gin Gin S. F. 30 ha. Flood plain of Macquarie River with River Red Gum type (much 1920 regeneration); also some Yellow Box with Black Box, White Box and some River Red Gum.

Toupna Creek Forest Preserve No. 128. Millewa S.F. 48 ha. Covers range of local types except for sandhills - River Red Gum type, from Q1 to Q3; Red Gum-Yellow Box; Yellow Box - Western Grey Box; pure Yellow Box; and small grassland plain.

Other Red Gum Types

Tooloom Scrub Flora Reserve No. 62253. Beaury S.F. 705 ha. Includes a topographic vegetation sequence in the upper Clarence valley, with Forest Red Gum woodland in the valley bottom and also Forest Red Gum - Grey Gum - Roughbarked Apple type.

Glenugie Peak Flora Reserve No. 79972. Glenugie S.F. 105 ha. Includes Forest Red Gum - Grey Gum - Roughbarked Apple and Forest Red Gum types.

Tulipwood Flora Reserve No. 79988. Kangaroo River S.F. 60 ha. Takes in some valley-bottom Forest Red Gum type with Broadleaved Apple.

Lanes Mill Flora Reserve No. 79994. Pilliga East S. F. 690 ha. Includes stands of Cypress Pines with Tumbledown Gum.

Gilgai Flora Reserve No 79995. Pilliga East S.F. 2 460 ha. Various White Cypress Pine stands, including those with Blakely's Red Gum and Tumbledown Gum.

Sandgate Flora Reserve No 79996. Sandgate S.F. 16 ha. Typical "sand monkey" with White Cypress Pine - Blakely's Red Gum type.

Diggers Hill Flora Reserve No. 80000. Queens Lake S.F. 40 ha. Coastal communities, including poorly drained sites with Narrowleaved Red Gum near southern limit.

Wittenbra Forest Preserve No. 32. Wittenbra S.F. 40 ha. Black Cypress Pine types, with Blakely's Red Gum near creek.

Ginee Belah Forest Preserve No. 33. Pilliga West S. F. 16 ha. Some White Cypress Pine Blakely's Red Gum type on lighter soils.

Tinpot Forest Preserve No 69. Bodalla S.F. 47 ha. Unusually good example of Grey Box - Forest Red Gum type with little disturbance.

Yarindury Forest Preserve No. 72. Yarindury S.F. 20 ha. Black Cypress Pine communities , with Blakely's Red Gum as one associate.

Sepoy Forest Preserve No 87. Sepoy S.F. 35 ha. Representative White Cypress Pine Blakely's Red Gum stands.

Yearinan Bloodwood Forest Preserve No. 96. Yearinan S.F. 40 ha. Brown Bloodwood types, including some Tumbledown Gum.

Sand Monkey Forest Preserve No 97. Pilliga West S.F. 65 ha. Another “sand monkey” site with White Cypress Pine - Blakely’s Red Gum type.

Bunbury Forest Preserve No 97. Bunbury S.F. 283 ha. Rugged area including Red Ironbark - Tumbledown Gum type.

Bunal Forest Preserve No 112. Bunal S.F. 182 ha. Botanically a most interesting area with some Blakely’s Red Gum types

Pokolbin Forest Preserve No 172. Pokolbin S.F. 90 ha. Includes the very rare Red Gum-relative, Pokolbin Mallee.

Selection Flat Forest Preserve No. 198. Myrtle S.F. 141 ha. Contains very good example of Forest Red Gum flat, with Swamp Turpentine. Also contains specimens of the rather limited Slaty Red Gum.