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FORESTRY COMMISSION OF N.S.W.

TECHNICAL PAPER

No. 11

MAJOR PLANTATION SPECIES

OF

NEW SOUTH WALES

Information on Major Forest Plantation Species used by the Forestry Commission of N.S.W., based on a Statement prepared for the F.A.O. World Symposium on Man-Made Forests, to be held in 1967.

1966
MAJOR PLANTATION SPECIES OF NEW SOUTH WALES.

Information on the Major Forest Plantation Species used by the Forestry Commission of New South Wales, based on a statement prepared for the FAO World Symposium on Man-Made Forests, 1967.

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SYDNEY.
OCTOBER, 1966.
MAJOR PLANTATION SPECIES OF NEW SOUTH WALES.

INTRODUCTION.

In preparation for the World Symposium on Man-Made Forests, to be held in Australia during the autumn of 1967, the Forestry Commission was asked to prepare fairly detailed statements on the major species used by the Commission in the creation of the State's man-made forests.

A man-made forest in this context was defined as:

"All forest crops raised artificially by sowing or planting on land which has not carried a forest cover within living memory, or otherwise involving species conversion; including row plantations (roadside trees, windbreaks, shelterbelts, etc.); excluding artificial regeneration of natural forest."

A major species was regarded as one being planted on a scale of about 250 acres a year or more.

Statements were prepared for seven species in N.S.W. Although several of these may not strictly meet the requirements set out above, they were included either because of their expected wider use in the expanding plantation programme planned for the next decade or, in the case of the eucalypts, because these artificially created stands will feature in the inspection and study tours associated with the Symposium.

The N.S.W. statements are to be incorporated into a consolidated statement for the whole of Australia. However it was felt that the specific details of these species in N.S.W. would be of interest and value to many Commission officers, and consequently this Technical Paper, reproducing the original statements, has been prepared.

It is pointed out that, in the interests of brevity, some generalisations have been included in the statements. As a result, certain details have been simplified and some techniques, which may not completely apply in all districts, are described. As far as practicable operations described are those receiving the widest application in the field.
PINUS RADIATA.

1. Scientific Name: Pinus radiata D. Don.


3. Origin: Seed originally from California, probably from the Monterey occurrence. Early seed supplies used by the Commission were obtained from New Zealand and occasionally from South Australia, but seed is now entirely supplied from established plantations.

4. Historical: The early history of P. radiata in N.S.W. is somewhat obscure. The species was probably introduced by miners coming from the Californian to the Bathurst gold fields during the 1850's, and by the end of the 19th century it was being widely used as an ornamental tree.

It was first used as a plantation tree by the Forest Service in 1914, when it was established on coastal sands on the North Coast (Tunourry Plantation). Experience from coastal plantings in South Australia led to the belief that sites such as Tunourry would be suitable for the growth of this species, but insufficient regard was given to the difference in climatic conditions between northern N.S.W. and South Australia, or to the very low fertility of these coastal sands. The extremely poor growth of P. radiata at Tunourry and in other North Coast areas subsequently indicated that this species was not suitable for use in this part of the State, though plantings with P. radiata continued at Tunourry until 1927. In 1915 planting was commenced at Armidale, on the Northern Tablelands, and in 1919 a further plantation was started at Belanglo, on the Hawkesbury Sandstone plateau of the Central Tablelands, near Moss Vale.

From 1920 to 1931 some 34 further plantations were begun, all using P. radiata as the main species, at least during the initial years. Most of these were in the Southern and Central Tablelands of the State, but they included also some areas on the Northern Tablelands and on the North and South Coast. One (Mannus, on the Southern Tablelands) was established in an endeavour to control the spread of the weed St. John's Wort (Hypericum perforatum), and several were established in conjunction with the Prison's Department as a means of gainfully employing convict labour, thus maintaining a tradition dating back to the first days of European settlement in N.S.W.

Plantings continued in these areas until 1935, by which time 26,100 acres of P. radiata had been established. By then it was apparent that, although, in many of the sites, the species had shown excellent growth, in other areas its development had been unsatisfactory. All plantings were then terminated while a comprehensive review of the existing plantations were undertaken.

Extension of the plantations (except for some of the Prison's Plantations) was further delayed by the 1939-1945 war, but was recommenced in 1945, with subsequent plantings
of *P. radiata* confined to sites known to be suitable for its healthy development. These are mostly in the Southern and Central Tablelands. The total area planted with *P. radiata* at the end of 1965 on Forestry Commission plantations in N.S.W. was 91,800 acres.

5. Extent of plantings:

(a) At the end of 1965 the Forestry Commission had 91,800 acres of established plantations of *P. radiata*. Annual plantings have gradually increased to the current rate of about 8,000 acres, and it is expected that, in line with the Commission's planned accelerated planting programme, the rate should reach about 20,000 acres a year of *P. radiata* by 1974, and should then stabilise at about that figure.

(b) The age distribution of the existing *P. radiata* plantations is as follows:

<table>
<thead>
<tr>
<th>Period Planted</th>
<th>Area Established (acres)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1915-20</td>
<td>41</td>
</tr>
<tr>
<td>1921-25</td>
<td>1,489</td>
</tr>
<tr>
<td>1926-30</td>
<td>4,282</td>
</tr>
<tr>
<td>1931-35</td>
<td>10,136</td>
</tr>
<tr>
<td>1936-40</td>
<td>1,019</td>
</tr>
<tr>
<td>1941-45</td>
<td>903</td>
</tr>
<tr>
<td>1946-50</td>
<td>6,187</td>
</tr>
<tr>
<td>1951-55</td>
<td>15,558</td>
</tr>
<tr>
<td>1956-60</td>
<td>22,115</td>
</tr>
<tr>
<td>1961-65</td>
<td>30,088</td>
</tr>
</tbody>
</table>

6. Climatic zones: *P. radiata* has been widely planted throughout the eastern half of N.S.W. from the coastal lowlands, up to the tablelands which roughly parallel the coast throughout the length of N.S.W., and over on to parts of the western slopes. Within this area rainfall ranges from about 25 inches per annum on the western slopes to over 60 inches on parts of the coast and associated highlands, while temperatures range from a mean annual temperature of 67°F on the far North Coast to below 45°F in parts of the Southern Tablelands. Over most of N.S.W. the rainfall is more or less uniformly distributed, though in the northern districts there is a tendency towards a summer-autumn maximum, with dry springs, and in the southern districts towards a winter maximum, with dry summers. The variability of the rainfall throughout the State tends to be
high, with the greatest reliability in the southern areas.
Generally the most successful plantations of *P. radiata*
have been established in those areas with a mean annual
temperature of between 50 and 60°F, and with a mean annual
rainfall in excess of 35 inches, falling either predominantly
in the winter months or more or less uniformly distributed.
In areas with mean annual temperature of below 50°,
snow damage is frequently experienced, while in areas with
temperatures above about 62° initially satisfactory growth
is commonly followed by the onset of various disorders in
the stands.

Although plantations have been established in
localities with a mean annual rainfall below 35 inches,
growth rates tend to be depressed and difficulties can be
experienced in early establishment due to frequent dry
periods following planting. *P. radiata* has, however, shown
an ability to survive fairly severe drought periods as an
established stand provided that soil depth is adequate.

Hail storms are encountered in some areas, particularly,
but not exclusively, in the more northern, summer-rainfall plantations. These storms have caused some
physical damage and deformation, and more importantly have
led to the development of various pathological disorders.

Heavy wind storms, sometimes associated with cyclonic
storms, have destroyed some stands in the past, and small
localised frost hollows can cause difficulties in initial
establishment.

7. Soils and Sites: The best development of *P. radiata* has
been obtained on deep, well-drained soils derived from
igneous parent materials. Such sites, in the preferred
climatic zones, normally carry tall, moist eucalypt forest
containing such species as *Eucalyptus viminalis*,
*E. cypellocarpa* (syn. *E. sonicolyx*), *E. obliqua*, *E. fastigata*,
*E. dalrympleana* and *E. robertsonii*.

Many of the plantations which were established prior
to 1935, and which showed unsatisfactory growth, have since
been proved to be located on nutrient deficient sites.
Phosphorus is the nutrient most frequently in short supply,
and phosphatic fertilisers are being widely used to improve
the productivity of these plantations. The type of ferti­
lisier used varies to some extent with the nature of the
soil, but at present the most widely used treatment is the
application of 10 oz. of lime-superphosphate per stem,
applied around the seedling shortly after planting. By
this use of fertiliser, extensive areas derived from sedi­
mentary parent materials (shales, sandstones, conglomerates
and mudstones, and including much of the infertile Hawkesbury
Sandstone series of the Central Coast and Tablelands) are
now regarded as suitable for the growth of *P. radiata*.
These sites naturally carry poor quality dry sclerophyll
forest, containing such species as *Eucalyptus haemastoma*,
*E. rossii*, *E. raesema* (syn. *E. mitranthe*), *E. sieberi*,
*E. piperita*, *E. dives*, *E. mannifera* (syn. *E. maculosa*),
*E. radiata* and various stringybarks. (See references to
papers by Humphreys, Gentile and others and by Brookwell
and Ludbrook).
In addition to the phosphorus deficiencies, there are indications that calcium may be limiting in a few sites, while notable responses to nitrogen (in association with phosphorus) have been obtained by Waring (1962) in second rotation plantings of *P. radiata* in one Hawkesbury sandstone plantation. There is also considerable evidence to suggest a deficiency of boron in some areas where soils are otherwise of high fertility: in a few sites classical symptoms of boron deficiency have been encountered, but elsewhere this suspected deficiency manifests itself in the deaths of scattered stems (up to about five years of age), preceded by the foliage turning red and the damage probably being associated with severe frosts.

Besides these chemical aspects of the soils, it is necessary to avoid shallow soils and soils that are prone to waterlogging. The altitudinal and latitudinal limits of successful *P. radiata* in N.S.W. are primarily those imposed by climatic limits (see 6, above). West of the tablelands, the altitudinal limit is determined by decreasing rainfall. The upper altitude ranges from about 3000 ft. in southern N.S.W. to perhaps 4500 ft. in the Northern Tablelands. On the coastal side of the tablelands it appears that the species can grow successfully from slightly above sea level on the lower South Coast, whereas in northern N.S.W. it can only be planted with safety above about 2500 to 3000 ft. Within these limits, *P. radiata* is planted throughout the latitudinal range of N.S.W. from about 29°S to 37°S.

8. Establishment Techniques: *P. radiata* is invariably established in N.S.W. by the planting of 1+0 seedlings raised in nurseries.

Nurseries are located in most major plantation areas, with the present trend towards having a few large central nurseries, rather than more numerous and smaller nurseries associated with each plantation.

The nurseries, which must initially be inoculated with suitable mycorrhiza (usually by incorporating soil taken from under existing healthy stands of *P. radiata*), are prepared by ploughing and hoeing until a suitable tilth is achieved. As far as practicable, beds are left in fallow, or under a green crop, every third year, and fertilizers are periodically applied to maintain fertility.

Seed is sown in drills during September–October, at the rate of 18 to 20 seeds per foot of drill. The size of the individual beds, and the distance between drills, vary between nurseries and are largely governed by the items of nursery equipment used locally.

The seed is not normally given any special treatment prior to sowing, though there is some evidence that some form of stratification may be desirable to promote even germination.

Irrigation is available at each nursery (overhead watering systems) but is used only sparingly. Chemical weedicides of the triazine group are being increasingly (but cautiously) used as pre-emergent weedicides in the nurseries, and subsequent weed growth is controlled by
mechanical cultivation and hand methods. Most areas being planted have previously carried native eucalypt forest. This forest is cleared, chiefly by mechanical means (tractor with tree pusher) during the spring and summer, and the resultant debris is burnt during the following late summer or early autumn. Where grassland is to be planted, planting lines are usually ripped across the area during the autumn.

Planting is carried out in the winter (June to early August), using narrow-bladed planting spades and the slit-method of planting. Planting holes are not usually prepared prior to planting. The spacing adopted is almost universally 8 ft. x 8 ft., though in the past both narrower (7 ft. x 7 ft.) and wider (up to 10 ft. x 10 ft.) espacements have been used.

Because of the danger of severe rabbit damage to new plantings, planting coupes are normally either fenced with netting or given aerial poison treatments, using 1080 as the poison and carrots as the bait.

9. Early Crop Development: Early height growth varies between localities. On an average site a height of up to 15 ft. can be expected in five years from planting. Thereafter height growth increases rapidly and by seven to eight years the height normally reaches 30 ft.

Weed growth is a problem in many sites, and is of two main types: coppice from the stumps and lignotubers of the eucalypts in the previous forest, and wattles (Acacia spp.) which spring up rapidly following the debris-burn from seed stored in the soil. To control these weeds brushing and "sucker-bashing" (knocking coppice off stumps with mattock) are customarily carried out in the first and third years after planting, though in some localities additional weed control operations are required.

Because of the cost of these manual weed control measures, increasing attention is being given to the use of hormone-type weedicides, particularly 2,4,5-T compounds. Coupled with this, thought is also being directed at having an earlier debris-burn so as to promote weed growth, which could then be controlled by heavier hormone applications prior to planting.

In a few plantations, established on previously cleared land, Blackberry (Rubus fruticosus) can also be troublesome, particularly in impeding access through the plantation for pruning and other operations. Control is readily effected by spraying with 2,4,5-T.

10. (a) Thinning: Stands of *P. radiata* receive a first thinning between 13 and 16 years of age, depending on development. At this thinning basal area is reduced to 90 square feet per acre (Gentle, Henry and Shepherd, 1962). Subsequent thinnings are carried out at five-yearly intervals, these thinnings reducing the basal area to between 100 and 130 square feet per acre depending on the development of the individual stands. In terms of numbers of stems per acre the first thinning results in a reduction of the stand to about 300 trees per acre. Following the last thinning at about age 40 years some 50-60 trees per acre are left to form the final crop.
7.

No non-commercial thinning is practised.

(b) Pruning: All stands of *P. radiata* are low pruned, all stems being pruned in this operation. This operation is carried out when the predominant height of the stand is 30 to 35 feet (age about 8 or 9 years), stems being pruned to 10 feet. Stems less than 30 feet at time of pruning are pruned to one-third of their height (Shepherd, 1961). Low pruning is carried out with shears manufactured to a design of the Forestry Commission.

Subsequent high pruning is currently restricted to 120 selected stems per acre which are pruned to 16 to 17 feet. This high pruning is carried out four years after low pruning. High pruning is carried out by the use of long-handled saws.

No pruning to a height greater than 17 feet is at present carried out in N.S.W.

11. Costs:

(a) Cost of land: The cost of land suitable for planting varies considerably depending on its location and state of improvement. Over a 17-year period from 1947-48 to 1963-64 the Commission purchased some 97,497 acres at an average price of $12-20 per acre. In addition, it must be borne in mind that the Commission holds large areas of land for planting which have always been owned by the Crown and carry no cost to the Commission.

(b) Nursery costs: $6 - $6-50 per 1,000 plants including cost of seed.

(c) Ground preparation, including fencing and vermin destruction: $17 per acre.

(d) Planting, including lifting and carting plants: $15 per acre.

(e) Refilling, scrubbing, etc.: This is a variable item, average cost is about $8 per acre. Range 0 to $24.

(f) Roading (intensity about 15 miles per 1000 acres): $12 per acre.

(g) Pruning: Low pruning-$22 per acre; High pruning - $16 per acre.

(h) No thinning to waste is carried out.

12. Silvicultural Characteristics of Importance: The fast rate of growth and adaptability to a wide range of climatic conditions of *P. radiata* give this species a particularly important place in exotic forestry in N.S.W.

13. Growth and Yield: A yield table for Jenolan State Forest is attached (Table 1); this forest would be close to the N.S.W. average in volume growth. Yield tables for other areas have been published by Lugton (1963a, 1963b). Rotation length is expected to be about 45 years in most areas.
8.

<table>
<thead>
<tr>
<th>Age</th>
<th>Mean Dom.</th>
<th>Height ft.</th>
<th>Before Thinning</th>
<th>Thinnings Removed</th>
<th>After Thinning</th>
<th>Volume Production</th>
</tr>
</thead>
<tbody>
<tr>
<td>14</td>
<td>53</td>
<td>550</td>
<td>148</td>
<td>2,100</td>
<td>58</td>
<td>850*</td>
</tr>
<tr>
<td>19</td>
<td>72</td>
<td>310</td>
<td>155</td>
<td>2,880</td>
<td>50</td>
<td>920*</td>
</tr>
<tr>
<td>25</td>
<td>92</td>
<td>180</td>
<td>170</td>
<td>4,000</td>
<td>50</td>
<td>1,200</td>
</tr>
<tr>
<td>30</td>
<td>106</td>
<td>120</td>
<td>160</td>
<td>4,350</td>
<td>40</td>
<td>1,100</td>
</tr>
<tr>
<td>35</td>
<td>118</td>
<td>90</td>
<td>155</td>
<td>4,750</td>
<td>35</td>
<td>1,080</td>
</tr>
<tr>
<td>40</td>
<td>124</td>
<td>70</td>
<td>155</td>
<td>5,000</td>
<td>35</td>
<td>1,180</td>
</tr>
<tr>
<td>45</td>
<td>130</td>
<td>50</td>
<td>150</td>
<td>5,400</td>
<td>150</td>
<td>5,400</td>
</tr>
</tbody>
</table>

*Pulpwood only. No sawlogs are obtained from thinnings until age 25 years.
14. Continuous plantation inventory is in operation now.

15. Diseases: There are no major diseases of _P. radiata_ present in N.S.W., though _Diplodia_ and other associated fungi have caused dead-topping and even deaths in some plantations which have suffered previous mechanical damage (e.g. by hail). _Armillaria mellea_ occasionally caused minor losses in young plantations. Damping-off diseases occur in most nurseries and cause some seedling loss (which can be controlled when severe); they probably also result in a higher, but generally undetected, loss in the pre-emergent stage.

Pests: There are no major insect pests of _P. radiata_ known in N.S.W. Insects recorded as damaging the species in this State are listed by Moore (1962).

Rabbits are serious pest in most _P. radiata_ plantation areas, and the appropriate control measures (netting, poisoning) are taken as a matter of course during the establishment of each planting coupe (see 8, above). In some areas wallabies also attack newly planted and young pines. _Possums_ (_Trichosurus spp._) have damaged older stems in some localities by removing the bark in the upper crown.

Certain cockatoo species cause heavy loss of seed in some plantations by destroying cones, and precautions against these birds have to be taken in seed orchards.

16. Other Damage: Heavy snowfalls may damage and deform _P. radiata_ at the higher altitudes, and thus tend to limit the planting of the species in some localities. Hail has caused physical damage in certain areas, particularly in northern N.S.W., while periodic cyclonic storms have also caused extensive damage to some plantations in the northern areas. The species is also sensitive to fire damage.

17. Seed-Bearing: Seed is generally produced in sufficient quantities to meet local needs for planting. Current requirements are obtained from cones taken from trees removed during late thinning operations, the seed being extracted in solar kilns. Seed not required for use within about six months is stored dry at a temperature of about 38°F. As far as practicable, twelve month's supply of seed is kept in store. Some 50 acres of seed orchard have been established in the Southern Tablelands, using grafted clones obtained from elite trees. This orchard is being expanded and a further orchard is in the process of establishment in the Central Tablelands, to give a total planned area of about 300 acres. The older orchard plantings are already yielding seed, which is currently being used in progeny trials. (Wilson, 1965).

18. Natural Regeneration: Little deliberate use is at present made of natural regeneration, except in areas where stands of seed-bearing age have been destroyed by fire; in such areas dense regeneration is normally obtained, and this is thinned to a reasonable stocking and subsequently managed as plantation.
Research is under way on the use of natural regeneration as a means of re-establishing *P. radiata* at the end of the first rotation, thus avoiding the need to carry out hazardous debris-burns within existing plantations.

19. **End Uses:** Small thinnings are used for particle board manufacture. Larger thinnings and clearfellings are used for sawtimber.

Some small billets are used for production of treated fence posts. The species is also suitable for pulp and paper manufacture and for treated poles.

20. **Wood Properties:** *P. radiata* yields a highly versatile timber which has been found suitable for many purposes.

21. **Timber Defects:** The timber of *P. radiata* has no outstanding defects. The chief problem in utilization lies in the juvenile core where fibre length is short and spiral grain is prevalent. This juvenile core is formed during the first 12 years' growth and is therefore up to 6" in diameter. Although suitable for pulp, particle board manufacture and case timber production, joinery should be free of juvenile core, whilst scantling, flooring and weatherboard can carry strictly limited quantities.

22. **Potentialities:** More than any other single species, *P. radiata* is being relied upon to meet the State's future timber needs. It is expected that plantations totalling some 750,000 acres will have been established with *P. radiata* by the end of this century, when the annual cut of this one species is estimated to be 70 million cubic feet true.

23. **References:**


1. **Scientific Name:** Pinus elliottii Engelmann.

2. **Common Name:** Slash Pine.

3. **Origin:** Seed originally obtained from the south-eastern U.S.A., probably from the area of northern Florida and southern Georgia.

4. **Historical:** *P. elliottii* is believed to have been introduced to N.S.W. by Mr. A.D. Helms in 1923, following a visit to the U.S.A. sponsored by the Forestry Commission of N.S.W. The first plantings were made at Banyabba State Forest, on the North Coast of N.S.W., in 1924, when 2 acres were planted.

   Plantings subsequently were extended at Banyabba and at Woodburn State Forest on the South Coast, and smaller experimental plantings were made in a number of other coastal locations prior to the general cessation of plantation establishment in 1935.

   Following the 1939-45 war, *P. elliottii* was used on a larger scale in several plantation projects, mostly on the North Coast.

5. **Extent of Plantings:**

   (a) The total area planted with *P. elliottii* on State Forests at the end of 1965 was 8,500 acres. Planting is currently proceeding at the rate of about 200 acres a year, and this is expected to increase to about 500 acres a year over the next 10 years.

   (b) The age distribution of existing stands of *P. elliottii* is as follows:

<table>
<thead>
<tr>
<th>Period of Planting</th>
<th>Area Established (acres)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1921-25</td>
<td>6</td>
</tr>
<tr>
<td>1926-30</td>
<td>136</td>
</tr>
<tr>
<td>1931-35</td>
<td>576</td>
</tr>
<tr>
<td>1936-40</td>
<td>1</td>
</tr>
<tr>
<td>1941-45</td>
<td>66</td>
</tr>
<tr>
<td>1946-50</td>
<td>1,637</td>
</tr>
<tr>
<td>1951-55</td>
<td>2,470</td>
</tr>
<tr>
<td>1956-60</td>
<td>1,922</td>
</tr>
<tr>
<td>1961-65</td>
<td>1,645</td>
</tr>
</tbody>
</table>
6. Climatic Zones: P. elliottii has shown its best development in the sub-tropical and warm temperate regions of N.S.W., with a mean annual rainfall exceeding 40 inches and with a mean annual temperature in excess of about 60°F. These climatic regions cover most of the coastal lowlands of the State and extend into the escarpment of the tablelands in northern N.S.W., and they include both the summer and uniform rainfall zones.

It tolerates winter frosts down to at least 12°F, and later light frosts, but it has suffered snow damage at the higher altitudes. Young plantings have experienced wind-blow damage during cyclonic disturbances, but older stands appear to be wind-firm.

7. Soils and Sites: Successful plantings have been made on soils ranging from littoral sands to basaltic red loams. In areas carrying less than 24 to 30 inches of soil over the parent rock, P. elliottii has failed during summer droughts. It makes poor growth on swampy sites, though such sites may be made suitable for satisfactory growth by drainage treatments.

P. elliottii appears more tolerant of low soil fertility levels than the other major conifers planted in N.S.W., but nonetheless phosphorus has been found to be deficient in many of the coastal plantations, and suitable fertiliser treatments are applied to such areas as a matter of course. Soils showing a deficiency in phosphorus are derived from a wide range of sedimentary parent materials, including Palaeozoic mudstones and shales, Mesozoic sandstones, and Recent sands. In the iron-rich Palaeozoic areas, applied phosphate becomes tightly bound in the soil after some years. Periodic reapplications may be necessary in these areas. By contrast, in the littoral sands difficulty is being experienced in obtaining a phosphate source which is not rapidly leached from the soil. An indication of the response obtained from phosphatic fertilisers is given by the following figures, obtained from an eleven-year old stand situated on extremely infertile Jurassic conglomerate on the North Coast. Treated plots received a dressing of 6 cwt. superphosphate per acre one year after planting:

<table>
<thead>
<tr>
<th>Phosphate applied</th>
<th>Control (no phosphate)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stems per acre</td>
<td>276</td>
</tr>
<tr>
<td>B.A. per acre</td>
<td>62 sq. ft.</td>
</tr>
<tr>
<td>Mean D.B.H.</td>
<td>6.9 inches</td>
</tr>
<tr>
<td>Mean Height</td>
<td>33 ft.</td>
</tr>
</tbody>
</table>

Studies on responses to phosphorus and on the uptake of this element have been reported by Baur (1959a, 1959b) and by Humphreys and Kelly (1962).

In addition to the widespread phosphorus deficiencies, tentative indications of responses to potassium and molybdenum have been obtained in one area.
Vegetation types planted with *P. elliottii* vary greatly. The most vigorous growth has been obtained on sites formerly carrying rainforest, whereas dry sclerophyll forest sites containing such species as *Eucalyptus racemosa* (syn. *E. microcarpa*), *E. haemastoma*, *E. blandoviana*, *E. gunnifera* and *E. intermedia* are usually phosphorus-deficient. Rather open woodlands of *E. tereticornis*, *E. searsii* and *Angophora intermedia* have given generally satisfactory growth.

The main plantations of *P. elliottii* are located at altitudes of below about 500 ft. in the coastal areas of N.S.W., from the far north (lat. 29°S) to about lat. 35°30'S, though there is no reason to doubt that it will grow successfully at higher latitudes. Plantings have survived at elevations up to 4000 ft. in northern N.S.W., but it is not healthy at this altitude. In the northern areas it forms vigorous and thrifty stands at elevations up to 2500 ft., though *P. taeda* seems the better species at altitudes above 1000 ft.

8. Establishment Techniques

(a) Direct Sowing: Direct sowing of *P. elliottii* has given promising results experimentally in coastal woodland areas adjacent to existing plantations (Forrest, 1965). In these studies the best results have come from late summer and autumn sowings (broadcast at about 1 lb. seed per acre) on to sites which have received a grass burn about 6 months previously. The presence of tree cover appears to aid initial establishment, but this should be removed a year or so later to promote growth. Little success has resulted from direct sowing in sites remote from plantations, due to the absence of suitable mycorrhizal fungi. Studies on means of inoculating areas with mycorrhiza at low cost are currently in progress; if this problem can be solved, direct seeding could be used to establish *P. elliottii* over about 100,000 acres of low quality native woodland in northern N.S.W.

(b) Planting: Seed is normally sown in nurseries in August (late winter, early spring), after about 4 weeks' period of moist cold stratification (Forrest, 1964 a and b). Nursery beds are prepared as for *P. radiata*, and the seed is drill sown with about 8 inches between rows, with the aim of producing about 20 seedlings per foot of row (Baur, 1960). Triazine-type weedicides are being increasingly used as a pre-emergent weedicide, and mineral spirits coupled with hand weeding are used for later weed control. The beds are watered as required, particularly during dry weather.

Planting coupes are cleared during the spring and summer and the debris burnt about autumn. Planting commences when the seedlings harden off about May, and continues until about July when rainfall becomes
limiting in most North Coast sites. The planting stock used is 1+0, open-root, and it is established by bar (slit) planting into previously unprepared slits at 8 ft. x 8 ft. spacing. Where formerly cleared land is to be planted, the rows are ploughed or ripped some months before planting.

9. Early Crop Development

Early height growth varies greatly, but on average sites, or on poorer sites which have received an appropriate fertiliser treatment within about one year of planting P. elliottii has an average height of 9 to 10 ft. at 4 years and of 18 to 20 ft. at 8 years. On some iron-rich clay soils, early growth may be up to average, but after 5 or 6 years phosphorus deficiencies lead to reduced growth and crowns become sparse and unthrifty. Fertilising at this stage will lead to a resumption of vigorous growth, though in older stands response to fertiliser is much slower. On soils of naturally high fertility (e.g. soils derived from basalt) early growth may be much more rapid, with a mean height of up to 13 ft. at 4 years.

Weed competition, from seedlings of wattle (Acacia spp.) and from coppice of eucalypts and Casuarina spp., is severe in most coastal plantations. Control of these weeds is almost universally by chemical means, using 1 to 2 per cent a.e. 2,4,5-T ester in water for the coppice and 0.2 per cent for the more susceptible wattles. This treatment is applied from knapsack misting machines during the winter, when the young pines are least susceptible to the hormone. The treatment is also sometimes applied before coppices are planted, to weed growth which has developed since the debris burn. Certain more resistant species (e.g. some Eucalyptus spp., Tristania conferta, Syncarpia glomulifera) may require special treatment (Forrest and Richardson, 1965). In former rainforest sites, where weed growth is particularly vigorous, further special treatments may also be required.

10. (a) Thinning

Non-commercial thinning to waste is now carried out on the North Coast plantations as routine operations, the stands being reduced to a stocking of about 350 stems per acre at about age 6-7 years.

Owing to market difficulties, commercial thinning has been delayed longer than is desirable in most areas. Currently first thinning is being carried out in stands which are aged 18-19 years and which did not receive an earlier thinning to waste. These stands are reduced to about 300 stems per acre, equivalent to a basal area of 80 to 90 sq.ft. per acre. Subsequent thinnings aim to keep the stands within the B.A. range of about 85 to 130 sq.ft. per acre (see section 13). In the higher quality plantations of the escarpment zone, where most future plantings will probably be with P. taeda, higher residual B.A. limits are expected (range 110 to 160 sq.ft. per acre).

(b) Pruning

All stems are pruned to a height of 8 to 9 ft. when the height of the dominant trees is between 20 and 25 ft. (age 7 to 8 years, after non-commercial thinning).
16. Subsequently the dominant stems (about 150 to 200 per acre) are pruned to a height of 15 ft. when between 30 and 35 ft. tall (about age 10 years), and to a height of 22 ft. when about 40 ft. tall (about age 12 years). Pruning is carried out by saw.

11. Costs:

(a) Land: Virtually all land planted with *P.elliottii* has always been held by the Crown, and carries no cost to the Forestry Commission.

(b) Nursery: Nursery costs average from $15-$20 per 1000 plantable seedlings, including the cost of seed (about 80c per 1000).

(c) Ground Preparation: The costs of clearing, burning and, where necessary, fencing average about $14 an acre, but range between $11-50 and $20.

(d) Planting: Planting costs average about $12 an acre, with a range of from $9 to $13-20.

(e) Refilling and Tending: Refilling costs vary between no cost, where survival has been good, up to the complete cost of a second planting as sometimes happens when the original planting is followed by a severe drought and all plants die. Average costs are about $2 an acre, taken over a sequence of seasons. Cleaning costs (weed control) also vary considerably, but in the coastal plantations range between about $10-50 and $35 an acre, with $20 to $25 an acre about average.

(f) Road Making: The cost of road making varies with topography, and in the coastal plantations ranges between $5 and $24 per acre planted.

(g) Pruning: The average cost of low pruning is about $11 an acre, and high pruning costs about $20 an acre.

(h) Thinning: Non-commercial thinning averages in cost about $9-50 an acre.

12. Silvicultural Characteristics of Importance: *P.elliottii* shows a high resistance to fire damage.

13. Growth and Yield: There are no published yield tables for *P.elliottii* in N.S.W., but based on the growth obtained from continuous inventory plots and experimental plots, the yield table attached (Table 2) has been prepared for the better coastal sites. Better growth (volume M.A.I. to 250 c.f.t. or more per acre) is obtained in the escarpment zone, but *P.taeda* is preferred in these areas. Rotation length in coastal plantations is expected to be 40 or 45 years.
TABLE 2.

P. ELLIOTTII YIELD TABLE — GOOD COASTAL SITES.
(Volumes expressed in cubic feet).

<table>
<thead>
<tr>
<th>Age</th>
<th>Mean Dom. Height</th>
<th>Before Thinning</th>
<th>Thinnings Removed</th>
<th>After Thinning</th>
<th>Total Volume Production</th>
<th>Merch. M.A.I.</th>
<th>C.A.I.</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>30</td>
<td>680</td>
<td>70</td>
<td>350</td>
<td>20</td>
<td>350</td>
<td>50</td>
</tr>
<tr>
<td>15</td>
<td>53</td>
<td>350</td>
<td>130</td>
<td>1,850</td>
<td>40</td>
<td>240</td>
<td>100</td>
</tr>
<tr>
<td>22</td>
<td>68</td>
<td>240</td>
<td>150</td>
<td>2,550</td>
<td>50</td>
<td>140</td>
<td>100</td>
</tr>
<tr>
<td>28</td>
<td>82</td>
<td>140</td>
<td>125</td>
<td>2,560</td>
<td>40</td>
<td>80</td>
<td>85</td>
</tr>
<tr>
<td>35</td>
<td>95</td>
<td>80</td>
<td>110</td>
<td>2,850</td>
<td>40</td>
<td>45</td>
<td>80</td>
</tr>
<tr>
<td>40</td>
<td>100</td>
<td>45</td>
<td>90</td>
<td>2,520</td>
<td>90</td>
<td>5,670</td>
<td>142</td>
</tr>
</tbody>
</table>
14. Continuous inventory operates in all existing plantations.

15. Diseases: There appear to be no major diseases of *P.elliottii* in N.S.W. *Armillaria mellea* has caused localised deaths in a few plantations, and damping-off fungi may at times cause some nursery losses.

   Pests: No major insect pests of *P.elliottii* have been recorded in N.S.W. (Moore, 1962). Wallabies and kangaroos cause occasional damage to young plantings, but except in former rainforest sites species control measures are usually not warranted. Rabbits are only troublesome in a few higher altitude plantations adjoining cleared land; in such sites netting or poisoning is carried out. Possums (*Trichosurus* spp.) are a serious pest in former rainforest sites, ringbarking stems in the lower crown (sometimes near ground level in young plantations) and causing death or severe malformation: no suitable control measure has yet been devised, but the problem is receiving active study.

16. Other Damage: None of significance.

17. Seed-Bearing: *P.elliottii* usually produces viable seed from age 10 years, and heavy seed crops can be obtained from trees over 20 years of age. Up until recent years seed was collected from local plantations, but at present seed obtained from superior stems is being purchased from the Queensland Department of Forestry. A small seed orchard, containing stock obtained from Queensland, is just reaching seed-bearing age. Seed stocks are stored in sealed containers at a temperature of about 38-40°F until required for stratification and sowing.

18. Natural Regeneration: *P.elliottii* is an aggressive species which readily colonises adjacent cleared land and plantation gaps, and use has been made of this in a few localities. However no deliberate use has yet been made of natural regeneration on a routine scale (but see comments on direct sowing).

19. End Uses: Early commercial thinnings from N.S.W. plantations have so far been mainly used to produce case timber. Larger sawlogs have been used for the production of crate timber, flooring and internal joinery. The timber is also suitable for the manufacture of fibreboard and pulp. Standing trees have given satisfactory yields of naval stores in experimental studies.

20. Wood Properties: None of particular note - a good, general purpose softwood.

21. Timber Defects: The timber is not unduly prone to any major defects.

22. Potentialities: *P.elliottii* is currently the main species for use in reforestation projects on the North
Coast of N.S.W. Planting in this area is at present on a relatively small scale, but will increase over the next decade, and the species is likely to receive wide use in direct seeding operations in parts of the North Coast if the mycorrhizal inoculation problem can be satisfactorily resolved.

23. References:


1. **Scientific Name:** Pinus taeda Linnaeus.

2. **Common Name:** Loblolly Pine.

3. **Origin:** *P. taeda* has a wide range in the south-eastern U.S.A., and the existence of distinct provenances within this range has been long recognised (see Burgess, 1965, for references). Only one provenance trial is currently in existence in N.S.W., located in a particularly favourable site. Sources represented in this trial are unfortunately limited (a series of more comprehensive trials are due for planting in 1967), but they suggest that the most suitable sources come from an arc extending from south-eastern Texas through to the coastal areas of North Carolina. The least satisfactory sources came from the north-western limits of the species range, in Arkansas and northern Texas (Burgess, 1965).

4. **Historical:** The source of the seed originally planted in N.S.W. is not known, but it is believed to have originated in the area between southern Georgia and Mississippi. The first planting by the Forestry Commission took place in 1925, at Banyabba State Forest on the North Coast. Planting continued on a small scale at Banyabba with this species, and plantings of a trial nature were made in other coastal areas prior to the general cessation of pine planting in 1935, when some 270 acres of *P. taeda* had been established.

   Following the 1939-45 war, *P. taeda* was used fairly widely, together with *P.elliottii*, in plantations on the North Coast, and smaller plantings were made in a number of other areas in the Northern Tablelands and in the escarpment region between the tablelands and the coast. Experience after some years showed that the species was not well suited to the generally infertile soils of the North Coast, and the planting of this species was curtailed in this area during the early 1950's. However the plantings made on better soils in the escarpment region showed particularly vigorous and healthy growth, and it is proposed to use *P. taeda* as the main species in planned major plantation projects within this area.

5. **Extent of Plantings:**

   (a) At the end of 1965 some 1150 acres of *P. taeda* existed in Forestry Commission plantations in N.S.W. Current planting is at the rate of about 100 acres a year, but this figure is expected to increase to about 4000 acres a year within the next 10 years as new plantation schemes are commenced in the northern escarpment region.
21.

(b) The age distribution of existing plantings is as follows:

<table>
<thead>
<tr>
<th>Period of Planting</th>
<th>Area established (acres)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1921-25</td>
<td>5</td>
</tr>
<tr>
<td>1926-30</td>
<td>76</td>
</tr>
<tr>
<td>1931-35</td>
<td>187</td>
</tr>
<tr>
<td>1936-40</td>
<td>12</td>
</tr>
<tr>
<td>1941-45</td>
<td>12</td>
</tr>
<tr>
<td>1946-50</td>
<td>553</td>
</tr>
<tr>
<td>1951-55</td>
<td>305</td>
</tr>
<tr>
<td>1956-60</td>
<td>12</td>
</tr>
<tr>
<td>1961-65</td>
<td>3</td>
</tr>
</tbody>
</table>

6. Climatic Zones: *P. taeda* has shown a wide tolerance of climatic conditions in N.S.W., having produced satisfactory establishment and growth in areas with mean annual rainfalls between 30 inches and 70 inches, and with mean annual temperatures ranging from above 65°F to below 50°F. At the extremes other species give better growth, and it seems that the most suitable climatic conditions for the strain (or strains) of *P. taeda* currently available in N.S.W. are in the mean annual temperature range of about 55°F to 65°F, with an annual rainfall in excess of 40 inches. The present plantations of this species are all located in the summer rainfall belt, but smaller plantings elsewhere suggest that satisfactory growth is also obtained in the uniform and winter rainfall belts. It is thought that other U.S. provenances may prove more suitable for use in both colder and drier sites.

Some snow damage has been experienced in the colder localities.

7. Soils and Sites: *P. taeda* has a greater nutrient demand than *P. elliotii*, though it is probably more tolerant of low fertility levels than *P. radiata*. With a few exceptions most coastal plantings have not been very satisfactory because of soils which tend to be generally infertile, and particularly to be deficient in phosphorus. Although plantings on such sites respond well to phosphatic fertilisers, *P. elliotii* with its lower nutrient requirements has been preferred for use on such sites (Baur, 1959).

The best growth of *P. taeda* has been obtained on basaltic red loams which previously supported rainforest, but growth nearly as good has been obtained on certain deep soils derived from Palaeozoic sediments; these again originally supported either rainforest (dominated by *Ceratopetalum anetatum*) or tall, moist eucalypt forest (wet sclerophyll forest) containing such species as *Eucalyptus saligna*, *E. microcorys* and *Tristania conferta*. Satisfactory growth has also been obtained on deep sands of moderate fertility, granitic soils and various other parent materials.

In northern N.S.W. the areas where *P. taeda* is the preferred species lie mostly between the elevations of 1000 and 3000 ft. above sea level.
8. Establishment Techniques: P.taeda is planted as 1+0 open root nursery stock, raised in the same manner as P.elliottii.

Vigorous weed growth in the former rainforest sites which will form the main future planting areas for this species are a major problem, and in the initial years of the planting programme cleared grazing lands and the more open eucalypt forest areas will be planted while a satisfactory weed control technique is developed: this is expected to involve early clearing and burning, the encouragement of weed and coppice growth, and the spraying of the weeds by chemicals prior to planting.

Currently grassed areas are ploughed or ripped ahead of planting. Spacing is normally 8 ft. x 8 ft.

9. Early Crop Development: On the sites where the main future plantings of P.taeda are proposed, the following early height growths have been obtained:

<table>
<thead>
<tr>
<th>Age (yrs.)</th>
<th>Mean Stand Height (ft.)</th>
<th>Best Height (ft.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>6</td>
<td>14</td>
</tr>
<tr>
<td>5</td>
<td>13</td>
<td>25</td>
</tr>
<tr>
<td>7</td>
<td>22</td>
<td>36</td>
</tr>
<tr>
<td>10</td>
<td>30</td>
<td>47</td>
</tr>
</tbody>
</table>

The best heights have invariably been obtained in former rainforest sites located on deep basaltic red loams.

The problem of weed control in these high rainfall areas has already been mentioned (section 8). Besides the competition that the weeds offer, they appear also to increase the risk of animal pest attack, and control measures are essential to obtain satisfactory growth. In the past this has been obtained by manual methods, and by hormone spraying within the established pines. The weeds include coppice from the eucalypts and rainforest trees; secondary species such as certain Acacia spp.; and the shrubby composite, Helichrysum diosmifolium, which forms extremely dense thickets in former rainforest sites.

10. (a) Thinnings: In the coastal areas, where the main existing plantings are situated, P.taeda is thinned in the same manner as P.elliottii. In the escarpment zone, where most future plantings will be established and where growth is far more vigorous (see growth figures, section 13), it is expected that first thinning will take place about age 12 years, reducing the stand to a residual basal area of about 100 sq.ft. per acre. Subsequent thinnings will aim to keep the stands within the range of 100 to 160 sq.ft. of B.A. per acre.
11. Costs: In the coastal plantations, establishment and tending costs are in the same order as for *P.elliottii*. No reliable cost figures are available for plantations in the escarpment zone, as plantings in this area to date have been on a relatively small scale. However the costs of site preparation (clearing, burning and fencing) and of subsequent weed and vermin control will undoubtedly be appreciably more costly.

12. Silvicultural Characteristics of Importance: The high rate of growth shown by this species in the escarpment zone is its feature of major silvicultural interest.

13. Growth and Yield: The Forestry Commission has no yield tables for *P.taeda* in N.S.W. Growth plots established in stands in the areas intended for major planting programmes have given the trends of growth shown in Table 3. The rotation length is expected to be in the order of 40 to 45 years.

14. Continuous plantation inventory is in operation in existing plantations containing *P.taeda*.

15. Diseases and Pests: There are no major diseases or insect pests of *P.taeda* known in N.S.W. Animal pests provide a major problem in the moist plantation areas of the escarpment zone. Wallabies can cause severe damage to young plantings, and it is necessary to fence planting coupes with netting (the use of poisons against native mammals is forbidden in N.S.W.). Possums (*Trichosorus* spp.) enter plantations and ringbark stems in the area of thin bark in the upper crown. In young plantings this damage may occur near ground level, killing the stems; in older plantings the damage occurs at great heights, and the stems are seriously malformed. Control is currently by trapping, but the problem is currently being studied with the view to developing more effective controls.

16. Other Damage: *P.taeda* is highly susceptible to fire damage.

17. Seed-Bearing: Seed is produced in quantity by stems older than about 12 years, and in the past adequate supplies have been collected locally. Currently seed supplies are purchased from Queensland, whence seed from superior stems is available, and the Commission is undertaking a programme of tree improvement with *P.taeda*, with the object of establishing a seed orchard by 1969.

18. Natural Regeneration: *P.taeda* produces copious natural regeneration in clearings adjacent to existing stands, but at present no routine use is made of this.
<table>
<thead>
<tr>
<th>Age (yrs.)</th>
<th>Stems/acre</th>
<th>B.A./acre (sq.ft.)</th>
<th>Mean D.B.H. (in.)</th>
<th>Mean Dome. Ht. (ft.)</th>
<th>Vol./acre (c.f.t.)</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>560</td>
<td>68</td>
<td>4.7</td>
<td>29</td>
<td>414</td>
<td>Good coastal site</td>
</tr>
<tr>
<td>6</td>
<td>662</td>
<td>72</td>
<td>4.5</td>
<td>26</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>571</td>
<td>83</td>
<td>5.2</td>
<td>30</td>
<td>600</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>646</td>
<td>196</td>
<td>7.5</td>
<td>45</td>
<td>2,680</td>
<td>Basaltic soil</td>
</tr>
<tr>
<td>11</td>
<td>646</td>
<td>153</td>
<td>6.6</td>
<td>38</td>
<td>1,630</td>
<td>Basaltic soil</td>
</tr>
<tr>
<td>13</td>
<td>626</td>
<td>264</td>
<td>8.8</td>
<td>59</td>
<td>5,170</td>
<td>Basaltic soil</td>
</tr>
<tr>
<td>14</td>
<td>700</td>
<td>256</td>
<td>8.2</td>
<td>50</td>
<td>4,050</td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>700</td>
<td>287</td>
<td>8.7</td>
<td>56</td>
<td>5,170</td>
<td></td>
</tr>
<tr>
<td>30</td>
<td>155</td>
<td>130</td>
<td>12.3</td>
<td>79</td>
<td>3,544</td>
<td>Old coastal site, thinned.</td>
</tr>
</tbody>
</table>
19. **End Uses:** The timber produced from existing plantations of *P. taeda* in N.S.W. is used in the same manner, and for the same purposes, as that of *P. elliottii*.

20. **Wood Properties:** *P. taeda* produces a good general grade of softwood, with no particular features of excellence.

21. **Timber Defects:** The timber is not known to suffer from any major defects.

22. **Potentialities:** *P. taeda*, on present planning, is likely to become the second most widely planted conifer in N.S.W., with over 100,000 acres of plantation established by the end of this century. Although existing plantings are relatively small, this future use supplies the reason for including *P. taeda* in the list of major species in N.S.W.

23. **References:**


1. **Scientific Name:** Pseudotsuga menziesii (Mirb.) Franco.

2. **Common Name:** Douglas Fir.

3. **Origin:** The origin of the earlier seed batches of Douglas Fir planted in N.S.W. is not known. However, following a comparison of climates of the areas of N.S.W. where the species was expected to be planted with those of Douglas Fir in its native habitat, plantings since 1966 have been made with stock raised from seed from the Pea Ell and Elma localities in southern Oregon. These sources, in subsequent provenance trials, have so far proved equal to or better than any other sources planted, though more recent studies have shown sources from further south (central California) to have more rapid nursery development. The Oregon sources have a necessary resistance to late season frosts.

4. **Historical:** The first plantings by the Forestry Commission were made in 1924, when 9 acres were established on Bago State Forest in the Southern Tablelands. This plantation had been commenced several years previously, using Pinus radiata, but this species had proved liable to snow damage in this high altitude area (3000 ft. elevation and over).

Small plantings continued in the Southern Tablelands (mostly at Bago) up until 1931, and no further plantings were made until 1960 when, following an examination of the growth of the earlier plantings, it was decided to use Douglas Fir at elevations above the satisfactory level for P. radiata. Subsequent plantings have mostly been in the Southern Tablelands, with trial plantings in more northerly tableland localities.

5. **Extent of Plantings:**

(a) At the end of 1965, the Forestry Commission had established some 1500 acres of Douglas Fir in N.S.W. plantation. Planting is currently at the rate of about 500 acres a year, and is likely to continue at this rate for some time.

(b) The age distribution of Douglas Fir in N.S.W. is as follows:

<table>
<thead>
<tr>
<th>Period of Planting</th>
<th>Area Established (acres)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1921-25</td>
<td>17</td>
</tr>
<tr>
<td>1926-30</td>
<td>56</td>
</tr>
<tr>
<td>1931-35</td>
<td>4</td>
</tr>
<tr>
<td>1936-55</td>
<td>-</td>
</tr>
<tr>
<td>1956-60</td>
<td>89</td>
</tr>
<tr>
<td>1961-65</td>
<td>1,327</td>
</tr>
</tbody>
</table>
6. Climatic Zones: Existing plantings of any extent or age are located in the Southern Tablelands of N.S.W. at elevations above 3000 ft. These plantings generally receive a precipitation in excess of 45 to 50 inches a year, with a distinct winter maximum. Part of this precipitation is in the form of snow. The mean annual temperature is below about 52°F. Although Douglas Fir is performing well in this climatic region, there is some evidence from very young plantings that better growth may be obtained in slightly warmer localities, where Douglas Fir would be an alternative crop to P. radiata, rather than a replacement for P. radiata at the higher elevations. In similarly young trial plantings, Douglas Fir is also showing satisfactory development in more northerly localities subject to uniform rainfall conditions, or even with a tendency towards a summer rainfall.

At the higher altitudes, Douglas Fir shows some susceptibility to damage from late season frosts in local frost pockets.

7. Soils and Sites: Apart from some recent experimental plantings, Douglas Fir in N.S.W. has only been planted on deep soil of moderate to high fertility, derived from granites and basalts. These sites formerly carried tall wet sclerophyll forest containing E. delegatensis, E. dalrympleana, E. viminalis, E. robertsonii and E. pauciflora. The main future plantings are expected to take place in sites with similar conditions, at elevations of from about 3300 ft. to 4000 ft. in the Southern Tablelands (lat. 35° to 37°S).

8. Establishment Techniques: Douglas Fir is established by the planting of 1 + 1 stock raised in nurseries. Seed is stratified (moist cold stored) for about 30 days before sowing, and is sown about September either broadcast or in close drills in nursery beds under 50% shade. The beds are kept well watered (overhead irrigation system), and are treated with the fungicide, Thiafox, several times during the first year.

Seedlings are lifted about May or June (early winter, about 9 months after sowing), and are lined out in transplant beds at a spacing of about 8 seedlings per foot of transplant row. The transplant beds are treated with the weedicide Diuron before lining out. Watering is maintained during the second year, but no shading is given. Planting takes place in the second winter (May to July), using open-root stock planted by spade (slit planting). Spacing used has varied over the years from 6 ft. x 6 ft. to 9 ft. x 9 ft., but at present 8 ft. x 8 ft. spacing is almost universally used. Sites planted are previously cleared and burnt, and rabbit control measures are required.

9. Early Crop Development: Early growth is rather slow, and during this stage the plants may be damaged by late spring frosts. Typical early height growth expected on favourable sites is as follows:
Some weed growth is experienced, from eucalypt coppice and wattle (Acacia spp.), and a manual tending to remove this competition is usually given at about age 2 years. Moderate growth of wattle may be retained to act as a nurse crop for the Douglas Fir during the early, frost-susceptible stages.

10. Thinning and Pruning: Apart from some recent experimental thinnings, the stands of Douglas Fir planted from 1924 to 1931 have been unthinned, while the plantings established since 1960 are too young to have been thinned.

The same comments apply to pruning, but it is expected that recent stands will receive a low pruning, to a height of about 9 ft. on all stems when the stands average 25 to 30 ft. in height (age about 11 to 12 years).

11. Costs: On the Commission's limited experience to date, the costs of land, site preparation, planting, refilling, tending and road making for Douglas Fir plantations are in the same order as the costs for establishing Pinus radiata. No knowledge of pruning and thinning costs is yet available. Seed costs between $11.00 and $11.50 per 1000 plantable seedlings, and the nursery costs for the raising of planting stock are about $21.00 per 1000 seedlings.

12. Silvicultural Characteristics of Importance: Douglas Fir appears to have the ability to maintain a substantial rate of growth for many years in an unthinned condition, and withstands snow damage well.

13. Growth and Yield: No yield tables have been prepared for Douglas Fir in N.S.W. An indication of the growth to be expected in the main area of current and future planting is given by the following figures, taken from routine continuous inventory plots—

<table>
<thead>
<tr>
<th>Age (yrs.)</th>
<th>Stems per ac.</th>
<th>B.A. per ac.</th>
<th>Mean D.B.H. (in.)</th>
<th>Mean Dom.Ht. (ft.)</th>
<th>Merch. Volume (c.f.t.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>30</td>
<td>488</td>
<td>261</td>
<td>9.9</td>
<td>64</td>
<td>6,360</td>
</tr>
<tr>
<td>33</td>
<td>356</td>
<td>225</td>
<td>10.8</td>
<td>72</td>
<td>6,313</td>
</tr>
<tr>
<td>36</td>
<td>486</td>
<td>222</td>
<td>9.3</td>
<td>67</td>
<td>6,134</td>
</tr>
</tbody>
</table>

Rotation length is expected to be at least 60 years.
14. Continuous inventory is currently in operation in the existing older plantings.

15. Disease and Pests: Douglas Fir is not known to be subject to any major diseases or pests in N.S.W.

16. Other Damage: The susceptibility of at least some strains of Douglas Fir to damage from late frosts has previously been mentioned.

17. Seed-Bearing: The older stands of Douglas Fir in N.S.W. produce some cones, but the locally produced seed is not currently collected or used. Seed supplies are purchased from the U.S.A. (see section 3).

18. Natural Regeneration: Regeneration of Douglas Fir has occurred on the outskirts of some of the older plantings, but no thought has been given to using this in any way.

19. End-Uses: Not definitely known at this stage, though the planting programme aims at producing sawn timber for scantling and general building purposes.

20. Wood Properties: Not known from locally produced timber.


22. Potentialities: The potentialities of Douglas Fir in N.S.W. are far from being fully known, but it is hoped that it will help supplement the State's timber supplies with a high quality building material produced from certain sites which are not suitable for the growth of P. radiata.

23. References: None.
1. **Scientific Name:** *Pinus ponderosa* Dougl. ex Laws.

2. **Common Names:** Ponderosa Pine, Western Yellow Pine.

3. **Origin:** From western North America. The most successful strain planted in N.S.W. has come from seed from Plumas Co. (near Quincy), California. More northerly and inland strains have given unsatisfactory growth in the sites planted in N.S.W.

4. **Historical:** The first planting of *P. ponderosa* by the Forest Service was made at Armidale State Forest, in the Northern Tablelands of N.S.W., in 1916 when 4 acres were established with stock of unknown origin. Following Mr. A.D. Helm's visit to the U.S.A., sponsored by the Forestry Commission, plantings were made at a number of tableland plantation sites in 1923, using stock from seed collected by Mr. Helm in Plumas Co., California. Planting continued over the next decade or so, but the later plantings during this period were made using seed obtained from British Columbia. Following the general cessation of pine planting in N.S.W. during the late 1930's and subsequent war years, further plantings of *P. ponderosa* were started in 1955, using seed obtained from the earlier stands of Plumas origin. Planting has continued at a slow rate to the present.

5. **Extent of Plantings:**

   (a) The area planted with *P. ponderosa* by the Forestry Commission to the end of 1965 was 2,600 acres. The current rate of planting is about 50 acres a year, but it is likely to increase to about 300 acres a year over the next 10 years.

   (b) The age distribution of *P. ponderosa* in N.S.W. at the end of 1965 was:

<table>
<thead>
<tr>
<th>Period of Planting</th>
<th>Area Established (acres)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1916-20</td>
<td>4</td>
</tr>
<tr>
<td>1921-25</td>
<td>109</td>
</tr>
<tr>
<td>1926-30</td>
<td>628</td>
</tr>
<tr>
<td>1931-35</td>
<td>1,539</td>
</tr>
<tr>
<td>1936-40</td>
<td>106</td>
</tr>
<tr>
<td>1941-50</td>
<td>-</td>
</tr>
<tr>
<td>1951-55</td>
<td>15</td>
</tr>
<tr>
<td>1956-60</td>
<td>80</td>
</tr>
<tr>
<td>1961-65</td>
<td>152</td>
</tr>
</tbody>
</table>
6. Climatic Zones: Small plantings of *P. ponderosa* have been established in most tableland plantations, but the most successful stands have developed in the higher altitude sites with a mean annual temperature below about 52°F and with an annual precipitation in excess of about 45 inches, part of the precipitation falling as snow. Successful plantings occur from areas with the rainfall showing a distinct winter maximum to those with a tendency towards a summer maximum. The species show a marked tolerance to severe frosts, and withstands snow damage well.

7. Soils and Sites: The main plantings of *P. ponderosa* in N.S.W. have occurred on deep soils of moderate to high fertility, derived from granites and basalts. Sites which tend to become waterlogged during the winter months have supported satisfactory stands, though the species is intolerant of true swamps.

Sites successfully planted range in altitude between about 2500 ft. and 4500 ft., and usually originally supported tall, wet solerophyll forest with such species as Eucalyptus delegatensis, *E. fastigate*, *E. obliqua*, *E. viminalis*, *E. dalrympleana*, *E. robertsonii* and *E. pauciflora*. The latitudes of the main plantings in N.S.W. range from about 31°S to 37°S.

8. Establishment Techniques: *P. ponderosa* is established by the planting of either 1 + 1 or 2 + 0 nursery stock. Unstratified seed is drill sown in open nursery beds in the spring (about September). Watering is used as necessary (overhead irrigation system). Seedlings are usually lifted and replanted in transplant beds during the first winter, though increasingly they are being kept in the sowing bed for two years. Slit planting of open root stock takes place in the second winter, using an espacement of 8 ft. x 8 ft. in sites previously cleared and burnt. Rabbit control measures (netting or poisoning) are required in the planting coupes.

9. Early Crop Development: The species makes slow early height growth. Mean heights of the Plumas strain on suitable sites average about 2 to 2½ ft. at age 3 years, about 6 ft. at age 6 years and about 10 to 12 ft. at age 8 years. As in other higher altitude tableland plantations, weed competition from eucalypt coppice and wattle usually occurs and is controlled by a manual scrubbing or brushing operation at about age 2 years.

10. Thinning and Pruning: The older plantings have been subject to no set thinning regime, but stands have been thinned as markets have become available, with the object of reducing the very high basal areas developed by the Plumas strain whilst avoiding a severe opening of the stand at one time. In such thinnings the B.A. has been reduced by up to 50% from initial levels of 350 to 400 sq. ft. per acre at ages of from 30 to 40 years. Post-war stands are as yet too young to have been considered for thinning.
Low pruning has been carried out on most old stands at a late stage. Recent plantings will receive a low pruning (to about 9 ft.) when the stands average 25 to 30 ft. in height, and it is expected that selected stems will receive subsequent high prunings.

11. Costs: Establishment and tending costs with *P. ponderosa* are generally in the same order as for *P. radiata*, except for seed costs (up to $120-00 per 1000 seedlings raised) and nursery costs (about $12 to $15 per 1000 seedlings). There is no information on the costs of thinning and pruning.

12. Silvicultural Characteristics of Importance: The most outstanding characteristics are the hardness of the species, particularly in relation to frost and also to tussock grass competition, and its ability to maintain good growth rates at very high stockings.

13. Growth and Yield: There are no published yield tables for *P. ponderosa* in N.S.W. Growth rates shown by some of the older plantings of the Plumas strain are as follows—

<table>
<thead>
<tr>
<th>Age (yrs)</th>
<th>Stems/ ac.</th>
<th>B.A./ (sq.ft)</th>
<th>Mean B.B.H. (in.)</th>
<th>Mean Dom. Ht. (ft.)</th>
<th>Mean Meroh. Vol. per ac. (c. ft.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>24</td>
<td>516</td>
<td>342</td>
<td>10.7</td>
<td>65</td>
<td>7,200 (a)</td>
</tr>
<tr>
<td>26</td>
<td>508</td>
<td>368</td>
<td>11.5</td>
<td>69</td>
<td>8,500 (a)</td>
</tr>
<tr>
<td>32</td>
<td>456</td>
<td>382</td>
<td>10.7</td>
<td>80</td>
<td>7,300</td>
</tr>
<tr>
<td>34</td>
<td>336</td>
<td>224</td>
<td>10.9</td>
<td>79</td>
<td>5,500 (b)</td>
</tr>
<tr>
<td>34</td>
<td>400</td>
<td>306</td>
<td>11.8</td>
<td>97</td>
<td>9,900</td>
</tr>
<tr>
<td>34</td>
<td>424</td>
<td>396</td>
<td>13.1</td>
<td>90</td>
<td>14,500 (a)</td>
</tr>
<tr>
<td>35</td>
<td>272</td>
<td>267</td>
<td>13.4</td>
<td>97</td>
<td>9,000</td>
</tr>
<tr>
<td>37</td>
<td>332</td>
<td>252</td>
<td>11.6</td>
<td>82</td>
<td>8,300 (b)</td>
</tr>
</tbody>
</table>

*(NOTE: Growth figures shown (a) and (b) represent successive measurements of the same two plots)*.

Growth figures from northern strains are much below the figures shown above.

Rotation age for *P. ponderosa* is expected to be in excess of 60 years.

14. Continuous inventory operates in all major plantations containing *P. ponderosa*. 
15. **Diseases and Pests:** There are no major diseases or pests of *P. ponderosa* known in N.S.W., though damping-off regularly causes appreciable nursery loss, whilst rabbits and, in the older stands, possums (*Trichosurus spp.*) may damage or destroy plants in the field.

16. **Other Damage:** The species is not notably susceptible to any other sources of damage.

17. **Seed-Bearing:** The Plumas strain bears small quantities of cones from about age 20 years, and these are collected from the better stems to provide future planting stock. Lack of suitable seed is a major reason for the limited use made of *P. ponderosa* in N.S.W. at present.

18. **Natural regeneration** is usually sparse, and no use is currently made of this.

19. **End-Uses:** *P. ponderosa* is envisaged as providing sawn timber for scantling and other building purposes, and it is expected that earlier thinnings will be suitable for pulp and particle board.

20. **Wood Properties:** Not known for local product.

21. **Timber Defects:** Not known for local products.

22. **Potentialities:** *P. ponderosa* can produce large volumes of timber from areas at, or above, the altitudinal limit for *P. radiata* in N.S.W. and its main potential is in the reforestation of these sites to supplement the State's general need for coniferous timbers.

23. **References:** None.
**Eucalyptus grandis (Flooded Gum)**

1. **Scientific Name:** Eucalyptus grandis Hill ex Maiden.
2. **Common Name:** Flooded Gum. **Trade Name:** Rose Gum.
3. **Origin:** A native of the North Coast of N.S.W., and hence into the coastal areas of Queensland. It extends up into the escarpment zone to altitudes of about 2500 ft. in parts of northern N.S.W. No significant differences in growth or performance have yet been found between different sources when grown together, though it is suspected that true provenance differences do in fact exist.

4. **Historical:** Flooded Gum was for many years regarded as an inferior timber species, and it was not until the late 1930's that a market developed for the timber in high quality uses such as mouldings and joinery. Difficulties were experienced in regenerating the species naturally, and although efforts at natural regeneration persisted for many years (using clear felling with seed trees), early attention was paid to artificial regeneration.

   Seedlings raised in metal tubes were first planted in 1940, when 17 acres of the species were planted on Pine Creek State Forest, near Coff's Harbour on the North Coast of N.S.W.; this forest contained many fine natural stands of Flooded Gum.

   The planting of tubed stock continued at a slow rate for the next decade, both in the vicinity of Coff's Harbour (lat. 30° 30'S) and on the far North Coast (lat. 28° 30'S). About 1950 the use of direct sowing was considered, and this soon became widely accepted. Initially broadcast sowing was practised, but following the work of Floyd (1960, 1962) this was largely replaced by spot sowing by about 1960, and this has remained the most usual establishment technique, with nursery seedlings being used when difficult sites (e.g. old grasslands) have to be established. With this cheaper technique, the areas established each year increased and new localities as far south as the Bulahdelah area (lat. 32°30'S) were being regenerated, with some 800 acres being established in 1964. At that stage doubts about the quality of the timber from the artificially established stands became widespread, and in the last few years establishment has been curtailed.

5. **Extent of Plantings:**

   (a) By the winter of 1966 some 6700 acres of Flooded Gum had been established by the Forestry Commission. Despite the curtailment of planting mentioned above, and the knowledge that much of the timber produced is likely to be of low quality, it is expected that an annual establishment rate of about 800 acres a year will be attained within 5 years.
(b) The age distribution of artificially regenerated stands of Flooded Gum in N.S.W. is:

<table>
<thead>
<tr>
<th>Period of Establishment</th>
<th>Area Established (acres)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1935-40</td>
<td>17</td>
</tr>
<tr>
<td>1941-45</td>
<td>164</td>
</tr>
<tr>
<td>1946-50</td>
<td>251</td>
</tr>
<tr>
<td>1951-55</td>
<td>429</td>
</tr>
<tr>
<td>1956-60</td>
<td>2,160</td>
</tr>
<tr>
<td>1961-65</td>
<td>3,588</td>
</tr>
<tr>
<td>1966</td>
<td>154</td>
</tr>
</tbody>
</table>

6. Climatic Zones: Flooded Gum has only been planted in N.S.W. within the species' natural climatic range. This is along the North Coast, extending up into the escarpment zone. Within this area the rainfall shows a decided summer-autumn maximum, with the annual rainfall in excess of about 45 inches. Temperature regimes are mostly subtropical with mean annual temperature in the range of 64 to 69°F, though in the escarpment zone where Flooded Gum occurs the mean annual temperature drops to about 62°F. Winter frosts are experienced throughout the area, and may be severe (down to about 16°F) in parts of the escarpment. Flooded Gum has shown a previously unexpected tolerance of these low winter temperatures whilst in the small seedling stage. The species is not markedly prone to other climatic hazards, though small, localised stands have been destroyed by cyclonic storms.

7. Soils and Sites: Flooded Gum is typically a tree of the moist, alluvial gullies. Such sites normally support rainforest, though when disturbed (by storm, fire or logging) Flooded Gum frequently regenerates in these sites, to be succeeded in time by rainforest. The species also occurs out of the gullies in the moister localities (annual rainfall in excess of 60 inches), again appearing as a pioneer in the secondary succession to rainforest. These are the sites in which Flooded Gum has been regenerated, the areas often having previously supported Flooded Gum, though frequently being in later stages of the succession to rainforest.

The soils are characteristically deep and of moderate to high fertility. Many are derived from alluvium, though in the main rainforest areas they may be derived from basalt, shale or various other parent materials. Although the soils are often of heavy texture, the species is intolerant of swampy conditions. It will, however, tolerate short periods of flooding.

Within its natural occurrence in N.S.W., Flooded Gum occurs from near sea level to elevations of about 2500 ft.,
north from about lat. 32° 30'S. It has been artificially established throughout this region.

8. Establishment Techniques: Flooded Gum is mostly established by a direct spot-sowing technique. Where planting stock is to be established (as in planting grassland), the technique used is as described for Eucalyptus pilularis (Blackbutt).

Sites to be established are cleared of existing forest cover during the spring, summer and early autumn, usually by mechanical means (e.g. bulldozer with tree-pusher). The debris from the clearing is burnt from mid-summer through to late autumn, and sowing is carried out immediately following the burn and before any weed growth can become established. Where large areas are to be established, clearing and burning are often carried out progressively so that individual sections of the coupe may be sown over a period of six or more months.

Seed is sown from hand-carried containers (screw-topped jars or plastic containers), with the lid perforated with holes through which the seed can be shaken, but will not flow freely. The holes are calibrated to yield 4 ounces of seed from 680 shakes (70 holes of 1/16th inch diameter). Spots sown are spaced about 8ft. by 8ft., but the spacing is kept flexible so that advantage can be taken of locally favourable microsites (local accumulations of loose top soil, soil enriched by ash and charcoal, etc.). Sowing rates vary with site from 4 oz. to 8 oz. seed per acre, distributed over these small (up to about 8 inch diameter) spots at the specified spacing.

The seed used is not normally treated in any way before sowing, except for storage (see section 17).

9. Early Crop Development: Provided moisture conditions are favourable, seed will germinate within a week of sowing. (At the time of the year when sowing is carried out, rainfall is normally reliable. If moisture conditions do not favour immediate germination, the seed will lie in and on the soil with little loss until rain falls). The spots usually germinate as distinct clumps, and the better stems in each spot attain a height of about one foot within 3 months. Thereafter growth accelerates, and heights of about 6-8 ft. can be expected at age 12 months. On particularly favourable sites heights in excess of 12 ft. are sometimes encountered at this age, and these stems may continue to average a foot a month in height growth (faster in summer, slower in winter) for up to 5 or even more years. However average growth rates on the better stems are usually less than this with stands averaging about 15-20 ft. in height at 2 years, about 30 ft. at 3 years and about 40 ft. at 4 years.

Clumps are thinned when the better stems average about 4 ft. in height (usually about age 8 months). Thinning is by hand (cane-knife or machette) and the clumps are reduced to the best single stem present. Weed control is not carried out, as the Gum will keep ahead of this and its
37.

presence helps to promote height growth and restrict branching. This initial clump thinning, to leave a plantation-like stand at 8 ft. x 8 ft. spacing, should not be delayed unduly, as increasing weed growth makes access difficult and the clumps hard to locate.

10. Thinning and Pruning: Pruning is not practised in Flooded Gum. Stands usually remain unthinned till about age 20 years, when stocking has been reduced naturally to about 400 stems per acre, of which about 100 are showing active growth. Stands receive subsequent thinnings to leave a final stocking of about 40 stems per acre. (No artificially regenerated stands yet approach this age, and the information is based on experience with natural stands).

11. Costs:

(a) Areas where Flooded Gum is established have mostly always been owned by the Crown, and there are no land costs chargeable to the Forestry Commission.

(b) The cost of seed used in sowing (8 oz. per acre) averages about $A 4-50 per acre.

(c) Ground preparation costs average about $30 an acre for clearing, plus about $5 an acre for the burning of the debris.

(d) Spot sowing costs (excluding seed, see (b) above) are about $5 an acre.

(e) Clump thinning, at about age 8 months, costs about $2 an acre.

(f) Specific roading costs are not available.

12. Silvicultural Characteristics of Importance: Flooded Gum is an extremely fast growing species and is very light demanding.

13. Growth and Yield: There are no published yield tables for Flooded Gum, but from research plot data, preliminary estimates of yields are as shown:

**TABLE 4.**

<table>
<thead>
<tr>
<th>Age (yrs)</th>
<th>Stems/acre</th>
<th>Mean D.B.H. (inches)</th>
<th>B.A./acre (sq.ft.)</th>
<th>Vol./acre (c.ft.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>15</td>
<td>132</td>
<td>10.0</td>
<td>72</td>
<td>2,160</td>
</tr>
<tr>
<td>20</td>
<td>145</td>
<td>11.2</td>
<td>99</td>
<td>2,970</td>
</tr>
<tr>
<td>25</td>
<td>138</td>
<td>12.5</td>
<td>118</td>
<td>3,540</td>
</tr>
<tr>
<td>30</td>
<td>136</td>
<td>13.5</td>
<td>135</td>
<td>4,050</td>
</tr>
<tr>
<td>35</td>
<td>126</td>
<td>14.5</td>
<td>145</td>
<td>4,350</td>
</tr>
<tr>
<td>40</td>
<td>115</td>
<td>15.6</td>
<td>153</td>
<td>4,590</td>
</tr>
</tbody>
</table>
### TABLE 5.

**YIELD TABLE FOR THINNED STANDS OF FLOODED GUM.**  
(Age sites; stems over 8" d.b.h.)

<table>
<thead>
<tr>
<th>Age (yrs)</th>
<th>Stems/ac</th>
<th>Mean D.B.H. (inches)</th>
<th>B.A./ac (sq.ft.)</th>
<th>Vol./ac (c.ft.)</th>
<th>Stems/ac</th>
<th>Mean D.B.H. (inches)</th>
<th>B.A./ac (sq.ft.)</th>
<th>Vol./ac (c.ft.)</th>
<th>Total Production B.A./ac (sq.ft.)</th>
<th>Vol./ac (c.ft.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>15</td>
<td>132</td>
<td>10.0</td>
<td>72</td>
<td>2,160</td>
<td>24</td>
<td>10.0</td>
<td>12</td>
<td>360</td>
<td>72</td>
<td>2,160</td>
</tr>
<tr>
<td>20</td>
<td>108</td>
<td>12.4</td>
<td>91</td>
<td>2,730</td>
<td>31</td>
<td>12.4</td>
<td>21</td>
<td>630</td>
<td>103</td>
<td>3,090</td>
</tr>
<tr>
<td>25</td>
<td>77</td>
<td>15.0</td>
<td>94</td>
<td>2,820</td>
<td>22</td>
<td>15.0</td>
<td>19</td>
<td>570</td>
<td>127</td>
<td>3,810</td>
</tr>
<tr>
<td>30</td>
<td>55</td>
<td>17.6</td>
<td>93</td>
<td>2,790</td>
<td>13</td>
<td>17.6</td>
<td>13</td>
<td>390</td>
<td>145</td>
<td>4,350</td>
</tr>
<tr>
<td>35</td>
<td>42</td>
<td>20.1</td>
<td>93</td>
<td>2,790</td>
<td>11</td>
<td>20.1</td>
<td>13</td>
<td>390</td>
<td>158</td>
<td>4,740</td>
</tr>
<tr>
<td>40</td>
<td>31</td>
<td>23.0</td>
<td>90</td>
<td>2,700</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

**NOTE:** Stands of natural origin are likely to be considerably lower in productivity than listed above. Planted stands are likely to be higher yielding.
Rotation length is expected to be 40 years, though this may be varied if paper pulp factories commence operating in the area.

14. Continuous inventory now operates in most forests where plantations or their equivalent have been established.

15. Diseases and Pests: Flooded Gum is not markedly subject to attack by diseases or pests which affect its growth rate. The main exception to this comes from certain lerp insects (Psyllidæ, particularly Cardiaspina maniformis and C. fiscoella), which may periodically occur in localised plague proportions and virtually defoliate the affected stems.

The growing stems are however highly subject to damage from certain wood-destroying insects and fungi, and it was this damage that led to the reduction of Flooded Gum establishment following 1964 (see Section 4). Damage comes from the larvae of several wood moths and beetles, and from one or more rot-forming fungi which are probably initially associated with the borers. The damage is most marked in stands which have been relatively widely spaced since establishment, and is believed due in part to the incomplete shedding of the larger branches on these fast growing stems, and to the subsequent slow occlusion of the branch stubs. Affected timber is unsuitable for any of the higher quality uses.

16. Other Damage: Flooded Gum is intolerant of fire damage. Fire not only kills many stems in burnt stands, but leads to timber defects in the survivors, in the form of gum-veins and the entry of timber borers and fungi.

Mechanical damage, caused by such means as logging damage, falling branches, or the trees whipping together in storms, also produces gum-veins and, where the bark is damaged, leads to the entry of borers and fungi.

17. Seed Bearing: Stands produce seed from an early age, and normally adequate seed is available each year for local needs. However the occasional presence of a very poor seed year necessitates always keeping about one year's seed supply in storage. Seed is collected from trees removed in logging operations and, after extraction from the capsules, the seed not required for early sowing is stored in sealed containers at room temperature, with the addition of 1/4 oz. of paradichlorobenzene per pound of seed to prevent the destruction of seed by insects. Seed will keep satisfactorily for about 4 years in this manner; if longer storage is required, the seed should be cold stored (35-40°F).

18. Natural Regeneration: Early efforts to regenerate Flooded Gum largely involved the use of natural regeneration (see section 3), but these techniques subsequently were abandoned in favour of artificial regeneration which was both more reliable and which enabled sites with no Gum present to be regenerated.
19. **End-Uses.** Large stems of Flooded Gum, free from the defects mentioned above (sections 15 and 16), provide a valuable and versatile light hardwood well suited for use as a cabinet and joinery timber. Smaller stems, from thinnings, are currently used mostly to produce case timber, but they are also highly suited to the production of paper pulp. (A major pulp and paper company, Australian Paper Manufacturers' Ltd., is currently engaged in establishing large plantations of Flooded Gum on the North Coast, mostly on abandoned and sub-marginal farm lands, with the view to erecting a pulp factory near Coff's Harbour). Stems free from rot are also suitable for use as treated poles and posts.

20. **Wood Properties:** Apart from its suitability for pulp, the timber of Flooded Gum has an attractive figure and is readily worked.

21. **Timber Defects:** Major defects are those previously mentioned in relation to the growing tree (sections 15 and 16), plus the presence of growth stresses, with an associated tendency for logs to split, in young stems.

22. **Potentialities:** Flooded Gum is probably the individually fastest growing species native to N.S.W., and is by far the most suitable species available for growth in the coastal gully sites.

Until recently, the establishment of this species was based on the hope that it would yield high value timber of joinery quality, but the defects previously discussed cast doubt on its ability to produce worthwhile quantities of such timber. Nonetheless it remains very suitable as a source of pulpwood and for lower quality milling purposes, and it is likely to remain a major species for the establishment on the North Coast, with perhaps 18,000 acres established by the Forestry Commission by 1985 plus large areas established by industrial concerns.

23. **References:**


1. Scientific Name: *Eucalyptus pilularis* Sm.

2. Common Name: Blackbutt.

3. Origin: Blackbutt is the most important native forest species in N.S.W., occurring in the coastal areas of the State from near the Victorian border in the far South (lat. 37°S) northwards into Queensland (Fraser Is., lat. 25°S), and extending from sea level up to the escarpment zone of northern N.S.W. and rarely on to the Northern Tablelands proper. One named variety is known (*E. pilularis* var. *pyriformis* Maiden), with a scattered occurrence on the North Coast of N.S.W., and the species shows hybrid introgression in various localities with a number of related eucalypts of the section Renantherae (Florence, 1961).

Recent provenance trials with Blackbutt in N.S.W. indicate considerable differences in behaviour between stock from different sources, with var. *pyriformis* showing the most promising development in most sites planted (Burgess, 1965). However, at present most artificial establishment is carried out using seed from the same general area as the regeneration coupe.

4. Historical: Blackbutt has long occupied a major role in forestry in N.S.W., and from the earliest years of the Forestry Commission efforts have been directed at regenerating this species (group selection and clear-felling with seed trees systems, see Jacobs, 1955). These efforts have had considerable success in most areas where they have operated, but they have failed in many of the moister Blackbutt stands, where there is a dense understorey and weed growth is prolific, and they are unsuitable in sites where the species no longer is present (e.g. grassland clearings; forest types apparently suitable for, but lacking in, Blackbutt growth).

The first artificial establishment of Blackbutt occurred in 1939, when a small planting of tubed seedlings was made on Whian Whian State Forest, a somewhat elevated and very high rainfall site on the far North Coast (lat. 28°30’S). This is an area of fine native Blackbutt development, but contains local sites where natural regeneration is difficult to obtain. Planting continued on a small scale in this area, and subsequently extended to areas further south along the North Coast where submarginal, and grassed, agricultural lands had been acquired by the Forestry Commission and required reforestation. Following the successes obtained by direct spot sowing with *E. grandis* (see notes on this species), the technique was adapted for use with Blackbutt during the late 1950’s, and applied to increasingly large areas of moist Blackbutt forest. Whilst the results were generally of high promise, it was apparent that, under certain circumstances, planting rather than
sowing was required. Stock raised in metal tubes was costly, and nursery losses were high, and following some early studies on the planting of Flooded Gum (Baur, 1959) the work was extended to Blackbutt and resulted in the development of a cheap technique for raising the planting Blackbutt seedlings (Floyd 1965b). This has led to a further increase in the use of artificial establishment with Blackbutt.

5. Extent of Plantings:

(a) By the winter of 1966 some 8300 acres had been artificially established with Blackbutt by the Forestry Commission of N.S.W. Extension at the rate of about 3500 acres a year has been proposed over the next 5 years.

(b) The present age distribution of Blackbutt artificially established by the Forestry Commission is as follows:

<table>
<thead>
<tr>
<th>Period of Establishment</th>
<th>Area Established (acres)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1939-40</td>
<td>11</td>
</tr>
<tr>
<td>1941-45</td>
<td>35</td>
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<tr>
<td>1946-50</td>
<td>101</td>
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<tr>
<td>1951-55</td>
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<td>1956-60</td>
<td>1,669</td>
</tr>
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<td>1961-65</td>
<td>3,834</td>
</tr>
<tr>
<td>1966</td>
<td>2,396</td>
</tr>
</tbody>
</table>

6. Climatic Zones: Blackbutt occurs naturally in N.S.W. in areas with an annual rainfall in excess of about 40 inches, distributed both uniformly (in southern and central coastal districts) and with a strong tendency towards a summer-autumn maximum (North Coast). Mean annual temperature is above 60°F, though in one anomalous occurrence on the Northern Tablelands it is below this level. Light to moderate winter frosts occur throughout its natural occurrence.

Apart from some minor experimental work, artificial regeneration with Blackbutt has been confined to the North coast and adjacent escarpment districts, where rainfall exceeds 45 inches a year and where the mean annual temperature is above 65°F. In local frost pockets the species may suffer frost damage in the seedling stage, though such sites are usually more favourable in any case for the growth of Flooded Gum. Stands are occasionally damaged or destroyed by localised severe wind storms, though the species generally is fairly wind-firm.
7. Soils and Sites: Blackbutt occurs on soils derived from a wide range of parent materials, including coastal sands, sandstone, conglomerate, shale, mudstone, schist, granite rhyolite and trachyte, but it naturally avoids basaltic soils. According to Florence (1964), "Distribution of Blackbutt is limited by physical properties of the soil which restrict aeration, moisture permeability or penetration of roots to depth... Soil fertility status is not a determining factor in the delimitation of Blackbutt ... communities; but with each community a gradient of increasing soil fertility is largely responsible for the vegetational gradient: from dry sclerophyll forest to rainforest". In brief, it requires a deep, well drained soil of light texture or good structure, and it avoids the most infertile soils. Such soils are those being artificially regenerated, though these may not naturally carry a Blackbutt forest type. Species occurring on the non-Blackbutt sites being regenerated include *E. micracarpa*, *E. saligna*, *E. aomenoides*, *E. resinifera*, *E. deocarpa* and *E. propinqua*. Artificial regeneration is being carried out north of lat. 32° 30'S, and at elevations of from near sea level to about 2500 ft., usually on the slopes and ridges, whilst avoiding the moist gully sites.

8. Establishment Techniques:

(a) Direct Sowing: More than half the current artificial establishment of Blackbutt is by direct seeding, using an adaptation of the method developed for Flooded Gum (see report on *E. grandis*). Spot sowing is used, at rates of from 8 oz. to 1 lb. per acre at 8 ft. x 8 ft. spacing. In some areas the seed is treated with TMTD formulations as a fungicide, and dieldrin is also routinely applied to seed prior to sowing to avoid the depredations of ants which are plentiful on the higher topographic positions usually sown. (Ants do not normally occur in the gully sites where Flooded Gum is sown). Sowing is mostly carried out during the summer and autumn.

Sites are in most cases completely cleared of existing cover, and in the moister sites burning is as far as practicable avoided so as to reduce the aggressive development of fire-weeds (Floyd, 1965a). However, besides this complete clearing, considerable use is also made of "snig-track extension", wherein logging tracks made by tractors are extended to clear up to 50% of the surface, whilst retaining any patches of immature advance growth. The cleared tracks are then spot sown.

(b) Planting: Planting is being increasingly employed for Blackbutt regeneration. It is used in all cases where grassland sites are to be reforested, and on a larger scale each year in other sites, both completely cleared and those prepared by snig-track extension.
The technique has been fully reported by Floyd (1965b), and involves the use of small, square-section peat pots ("Jiffy pots") joined in units of 12. Sand or light-textured soil are used in the pots, the latter being fumigated with methyl bromide, and blood and bone fertiliser is incorporated with the soil (3 lb. per 1000 pots) prior to use. About 50 seeds are sprinkled on to each pot (1\(\frac{1}{2}\) inch cross section at top) and these are covered by peat moss. About 4 oz. of seed is required per 1000 pots. The pots are initially shaded (50% sarlon weave or 80% wooden slots), the shade being removed when the second pair of leaves are produced. Regular watering is applied, and TMTD is applied weekly to deter fungal loss.

Stock is ready for planting when the seedlings are about 5-6 inches high (about 8 weeks from sowing during the summer). Two crops of seedlings can be raised in a season, with sowing taking place from about late October and again from January.

Planting is normally at 10 ft. x 10 ft. spacing (or at equivalent distances along snig-tracks), the whole pot being planted in a shallow hole made with a small hand hoe. Although a number of seeds usually germinate in each pot, one only achieves dominance and continues to grow.

When grassland is to be planted, the sward is usually scalded away by bulldozer along planting lines, which are then ripped.

9. Early Crop Development: Early growth of Blackbutt, from seed or from planted seedlings, is relatively slow and tends to be variable. Average figures from a range of sites show, for planted stock, a mean height of about 1 ft. at 6 months, 2.5 ft. at 12 months, and 4.5 ft. at 18 months. Comparable heights for direct sown stock are 0.5 ft., 1.5 ft. and 2.5 ft. However in both cases growth may be far more rapid, with mean heights up to about 7 ft. at 18 months on particularly favourable sites, and with individual stems up to twice this height.

Subsequently growth accelerates, and on good average sites dominant heights of about 15-20 ft. at 3 years and about 35-40 ft. at 5 years can be expected. On lower quality sites this accelerated growth is delayed and 5 year old stands may have mean dominant heights of only about 15 ft.

Planted stands normally receive no tending, but in spot sown stands clump thinning is carried out as for Flooded Gum, but at a later age (about 18 months).

10. Thinning and Pruning: Pruning is not carried out on Blackbutt.

Non-commercial thinning to reduce basal area on the better sites to below 60 sq.ft. per acre at about ages 6 and 12 years and has been recommended, but is not normally carried out. Early thinnings of regenerated stands are
usually commercial and dependent upon the markets available: pit props, posts, case timber, etc. Such thinnings have taken place as early as age 12 years, but more usually have been delayed until beyond age 20 years.

11. Costs:

(a) Costs for direct sowing operations are in the same order as for Flooded Gum (q.v.), with the cost of seed about $A6 per acre.

(b) Current costs for raising planting stock are about $30 per 1000 plants, but this figure is expected to be halved (equivalent to $5 to $7-50 per acre) as the nursery technique becomes routine. Blackbutt seed costs about $7 to $8 per pound. Planting and carting nursery stock costs about $15 an acre.

12. Silvicultural Characteristics of Importance: Blackbutt is a relatively rapid-growing species yielding a valuable general purpose hardwood. It is fairly fire-hardy once beyond the small sapling size.

13. Growth and Yield: There are no published yield tables for Blackbutt in N.S.W. Growth rates obtained from experimental plots are as shown in Tables 6 and 7:

**TABLE 6.**

<table>
<thead>
<tr>
<th>Age (yrs)</th>
<th>Stems/acre</th>
<th>Mean Ht. (ft.)</th>
<th>Mean B.A. (sq.ft.)</th>
<th>40 best D.B.H. (in.)</th>
<th>100 best D.B.H. (in.)</th>
<th>Note</th>
</tr>
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<tr>
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<td>-</td>
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<td>-</td>
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<td>89</td>
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</tr>
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<tr>
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<td>106</td>
<td>109</td>
<td>12.7</td>
<td>12.3</td>
<td>(b)</td>
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<tr>
<td>21</td>
<td>178</td>
<td>-</td>
<td>92</td>
<td>11.4</td>
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</tr>
</tbody>
</table>

Note: (a), (b)... represent successive measurements of the same plots.
### TABLE 7. BLACKBUTT GROWTH DATA - DRY SITES.

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<thead>
<tr>
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<td>47</td>
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<td>(d)</td>
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<td>97</td>
<td>93</td>
<td>68</td>
<td>11.8</td>
<td>11.4</td>
<td>(b)</td>
</tr>
</tbody>
</table>

Note: (a), (b) ... represent successive measurements of the same plots.

Rotation length is not known, but could be in the order of 50 years on the better sites and 60 years on the poorer.

14. **Continuous inventory** currently operates in most forests where Blackbutt is being artificially established.

15. **Diseases and Pests:** There are no major diseases or pests of Blackbutt, except for certain termites (notably *Coptotermes acinaciformis*) which enter stems from the soil and destroy the heartwood. These are not expected to be a major problem in properly managed forests, and control seems practicable (see Greaves, 1962). Wallabies occasionally damage young plantings and sowings.

16. Other Damage: Fire or mechanical damage will produce gum veins in the timber.

17. **Seed-Bearing:** Some seed is normally produced each year, but it has been found desirable to keep at least one year's supply in store. Seed is stored in sealed containers as for Flooded Gum. Cold storage is required if the seed is to be kept for longer than 2 years.

18. Natural Regeneration: As stated above (section 4), natural regeneration is used to re-establish Blackbutt in most natural stands. Artificial regeneration is only used.
in the more difficult sites or where Blackbutt seed trees are absent. Observations on the use of natural regeneration have been reported by Floyd (1962).

19. **End-Uses:** Blackbutt stands are managed with the primary aim of producing sawlogs which will yield general construction timber (scantling, flooring, etc.). Smaller stems yield poles, posts and pit-props (all treated), case timber, etc. and the timber is suitable for pulping.

20. **Wood Properties:** Blackbutt provides a particularly desirable construction timber, with good strength and durability characteristics.

21. **Timber Defects:** The timber is usually free of major defects except for a cylinder of low strength timber in the heart. Gum veins may be present, but usually only to a slight extent. Young, fast-grown stems may show excessive growth stresses.

22. **Potentialities:** Blackbutt currently yields about a quarter of the sawn timber produced in N.S.W., and is likely always to remain the main native timber producer, though its current preminence will ultimately be taken over by *Pinus radiata*.

23. **References:**


LIST OF PROMISING MINOR SPECIES.

Somewhat in excess of 100 forest tree species have been planted experimentally (and in some cases on a routine scale) by the Forestry Commission of N.S.W. Many of these are as yet too young to be adequately evaluated, but among the species showing promise are the following:

**Araucaria bidwillii** (Bunya Pine). Native of south-eastern Queensland. Planted over 750 acres of former rainforest during period 1938–1954, until planting was curtailed due to high establishment costs. Has shown good development and growth in the higher altitude (up to 3000 ft.) rainforest sites where *A. cunninghamii* was unsuccessful due to frost damage.

**Araucaria cunninghamii** (Hoop Pine). Native to north-eastern N.S.W. Established in open plantations over some 3000 acres of rainforest site during the period 1938–54, until plantation establishment was curtailed due to very high costs. Subsequently has been used for enrichment planting in certain types of rainforest at rate of 100 to 150 acres a year. On suitable sites gives high volume production (M.A.T. about 300 c.f.t. per acre at age 30 years) and produces one of the State's most valuable timbers (used chiefly for veneer).

**Eucalyptus oloeziana** (Gympie Messmate). Native of Queensland. A tree of good form, fairly rapid growth, and good timber properties used to a limited extent for restocking blanks in eucalypt forests of the North Coast of N.S.W.

**Pinus canariensis** (Canary Is. Pine). Tree of very good form and considerable fire resistance. Growth rather slow, but survives and grows well in the drier areas of N.S.W. (annual rainfall in range 15 to 30 inches). 74 acres planted.

**P. caribaea** (Caribbaean Pine). Shows growth rates somewhat in excess of those of *P. elliottii* on the North Coast of N.S.W., but its use is restricted by seed supply (species will not produce cones in N.S.W.) and by need to use costly tubed planting stock. Some 70 acres have been planted, mostly from British Honduras origin, but with some old (1933) Cuban sources and some recent plantings from seed from the Bahamas.

**P. contorta** (Lodgepole Pine). Has been planted over 530 acres in past. Growth is slower than for some of the other pines planted in the tablelands of N.S.W., but the species has shown the best survival and development of all conifers tried at very high altitudes (4000 to 5500 ft.), and has also given good results in somewhat swampy areas. Regenerates vigorously. Various strains have been planted, the most successful generally being *P. contorta* spp. *murrayana* from the Sierra Nevada, California.
P. halepensis (Aleppo Pine). A drought-hardy species from the eastern Mediterranean, this tree has given good results when planted in the drier areas of N.S.W. (annual rainfall 15 to 25 inches). 90 acres have been established in plantations, and the species has been extensively used for windbreaks, shelterbelts, etc. Growth rates tend to be rather slow.

P. insularis. From the Philippines. A variable species which has produced some individuals of exceptional growth rate and vigour in trial plantings on the North Coast. For this reason it warrants further study.

P. jeffreyi (Jeffrey Pine). From California. Has given good results in small plantings (total area 25 acres) on the tablelands, though growth tends to be below that of the better strains of P. ponderosa.

P. lambertiana (Sugar Pine). Native of western U.S.A. A slow starting species which ultimately produces high volumes in the higher areas of the Southern Tablelands, where 25 acres have been planted. Difficulties in raising nursery stock have limited its wider use.

P. monticola (Western White Pine). Performance generally as for P. lambertiana but volume production somewhat lower.

P. nigra (Calabrian Pine). Various strains of P. nigra have been planted in N.S.W., where over 2000 acres of this species have been established. The best strain appears to be the var. corsicana, from Corsica, which seems well suited to areas somewhat too cold for the growth of P. radiata. A tree of beautiful form.

P. patula. This Mexican species is very well suited to growth in the escarpment region of northern N.S.W. and hence up on to the Northern Tablelands. In the escarpment region it shows slightly faster rates of growth than P. taeda, while on the Northern Tablelands its growth is somewhat behind that of P. radiata but it is less prone to damage from various sources. Inability to establish the species as open-root planting stock has restricted its wider use in N.S.W. up to the present; current plantations are limited to 114 acres.

P. pinaster (Maritime Pine). From Southern Europe. Up until the cessation of pine planting in 1935, P. pinaster was used rather widely for planting on soils considered too poor for the satisfactory growth of P. radiata, but in recent years such sites have been fertilised to improve their potential for the more vigorous and productive species. 300 acres of P. pinaster still remain in N.S.W., and some small recent plantings have been made using the Lieria strain of better form and growth. The older plantings have generally shown fair growth, but form is atrocious.
P. pseudostrobus. This is a fairly recent introduction from Mexico, and early growth (to age 10 years) suggests a growth rate approaching that of P. patula on similar sites.

**P. strobus (Eastern White Pine).** From eastern North America. Only small plantings of this species have been made to date. Initial growth is slow but increases with age, and form is generally excellent. It appears to have some promise at higher altitudes in the tablelands, particularly in northern N.S.W.

**Populus deltoides (Cottonwood).** From eastern U.S.A., and also hybrids (X P. euramericana) with the European P. nigra. The Forestry Commission has planted little poplar itself, but since 1960 several large concerns have undertaken fairly large plantings, and more recently private landholders in various parts of the State, under the guidance of the Forestry Commission, have shown an interest in the growth of poplar plantations. Plantings have been confined to deep alluvial soils in parts of the coast and tablelands. On the North Coast, where a match-manufacturing company is engaged in routine plantings on a large scale, P. deltoides var. angulata is the most suitable strain, while in the Southern Tablelands certain Italian hybrids are preferred. Very rapid growth rates (in excess of 10 ft. in height a year for the first 4 years) have been obtained from these plantings.