THE STATUS of WANDOO SILVICULTURE (1980)

FOREWORD

In this paper Mr. Hart has summarised a not inconsiderable body of information on the silviculture of Wandoo. Investigation work on wandoo has been sporadic and rather fragmented, and this document puts it all together for the first time allowing a review of the subject and permitting the identification of further necessary fields of research.

The limited areas of wandoo woodland in State Forest are not only beautiful to look at, but also provide a high class specialty timber and harbour some of the State's rapidly diminishing species of fauna. A comprehensive knowledge of management of wandoo is essential to perpetuate this valuable resource.

In addition, wandoo is seen as having considerable potential in the rehabilitation of bauxite mines, and for the reforestation of pastured lands for the control of salinity in gulleys and streams.

P.C. KIMBER - INSPECTOR

TABLE OF CONTENTS

WANDOO SILVICULTURE IN WESTERN AUSTRALIA

- THE PRESENT STATE AND RESEARCH NEEDED

by A.J. Hart, Silviculturist - October 17 1980

1. EXISTING INFORMATION

1.1 REGENERATION

1.1.1 Natural Regeneration

Observations on development of wandoo natural regeneration documented by Mr P. Hewett on February 20, 1963, at the following locations:

(a) Windabinaring Road - map ref. AN/AO.88 (8.10) Field Book T/9 refers. Sample 2' x 2' quadrats x 3. AR1 and AR2.

(b) Julimar S.F. near junction of Gakaling Road and Cook's Road as per Field Book T/9 - established 15/2/63 in "wheatfield" regeneration: AR3.

The latter has been remeasured four times since establishment.

Data to date summarised as per Table 1 and Graph 1. These indicate the extensive losses which occur from germination onwards, and severe competition between seedlings. Predictions from these results suggest single stem natural selection requires 30-35 years in that area to occur. Seedling regeneration where the bole section of the tree had burnt was noted as better than that occurring where the crown had burnt.

(c) In J.B. Campbell's "Silvicultural Note on Wandoo" records at page 23, details of stocking of 60 year old regrowth in the Boddington district (this area has now been largely if not completely bulldozed for farming purposes). A large proportion of this was evidently coppice. (See Table 2).

(d) There appears to have been no attempts made to correlate resulting germination (only obtained on ashbeds) with the following:

i) intensity of burns, even in generalised terms;

ii) the intensity or paucity or seed crops present and nature of the crop, e.g. "double" crop etc.

iii) The manner in which seed dispersal occurs from seed trees, e.g. distance of seed throw in relation to tree height and time taken to release all seed from capsules after the passage of the fire. This could have important implications for obtaining optimum spatial distribution of the new crop by enabling post burn cultivation of seed beds near seed trees.

1.1.2 Artificial Regeneration - Seeding

(a) Practice in this regard has tended to be guided by mallet forest techniques at Dryandra. Mr R. Underwood's thesis which includes "The Wandoo Formation" at pages 6-18 records some of the earliest attempts at devising a successful

technique for artificial regeneration in the Mundaring division.

These experiments were inspected by the writer about 1976 and apart from one or two very unthrifty specimens, all plots had failed.

(b) The feasibility of such an approach is evidenced by the successful establishment of Euc. falcata and gardneri in Greystones Cpt 35 on ashbeds in 1951 and a similar treatment in Collie division (Palmer Block, 1970) with reasonable results which highlighted the effects of the type of seed bed used.

(c) The writer has been investigating techniques for wandoo regeneration in dieback areas of Jarrahdale and resumed P.W.D. catchments in Collie with encouraging results. (See progress report to Supt. Grace and N. Ashcroft 19/9/78 and Broadcast Seeding Trials results Frollett Road (May 1976) as per letter of 28/9/76).

The latter were sown at a rate of 1.037 and 1.016 kg/ha with the "Makita" broadcaster on disc cultivated seed beds and subsequently fertilised with "Agras".

Later trials in 1978 and 1980 were made with primitive mechanical sowing devices attached to a M.F.3 disc plow and an improved attachment in 1980 which included a fertiliser dispenser and seed drop at regular intervals so that seed bed preparation, sowing and fertilising were done in one pass of the machine.

To date these trials have emphasised importance of quality of seed and time of sowing.

Trials with wandoo in P.W.D. Collie and bauxite pits areas Jarrahdale in 1980 have included pelletted seed, both local and interstate preparation, also with encouraging results. Details of this work is on files of the writer.

- Planting

(a) The experience by this Department with plantings of wandoo has been documented by A. Hart in the three (3) reports on "Assessment of Exotic Eucalypt Plantings in Northern, Southern Forest Regions" 1974-76 and 1975-77 respectively and "Tree Growth in Rehabilitated Bauxite Pits of the Northern Jarrah Forest" 1976.

These reports indicate that, in comparison to other species under trial, wandoo exhibits very good prospects of filling the requirements of a rehabilitation species for bauxite pit areas and also dieback areas of jarrah forest of suitable soil types.

In passing, it should be noted that some problems were experienced in propagating seedlings in nurseries in pots. This was found to be related to sowing time and in part perhaps viability of the seed used. Most plantings of this type have demonstrated:

i) the need for care in selecting parent seed trees to avoid hybridized stock;

ii) the apparent need for closer spacing or provision of "nurse" crops/species which act as competitors to generate desirable form in developing trees planted initially at wide spacings of 5mx 5m (taller acacias seem to be the ideal species to use for this purpose);

iii) the need to carry out early form side pruning if straight single boled trees are to be obtained where this is necessary.

1.1.3 Coppice

Use of this means of replacing growing stock is commonly advocated in eucalypt forests.

Experience in wandoo forests has recorded data on height/diameter growths at a number of localities (Mundaring-Julimar). Graph 3 indicates results of growth rate measurements compared to seedling regrowth and that of butt damaged seedlings at Yarra Road, Mundaring. These results indicate approximately twice the growth rate by seedlings compared to coppice.

To examine coppice growth closer, the advantages of it are:

i) New growth is almost always straight stemmed;

ii) A good selection is available; as many stems result, particularly from large stumps;

iii) Replacement is certain and immediate.

These advantages are available with more certainty if stumps are no higher than 25-40 cm and of some size ($>$ 50-60 cm Diam. O.B.).

Date from Julimar suggests that coppice growth is poorest on stumps in upland situations where presumably competition for moisture is severe after removal of the original stem and efficiency of the revised translocatory systems is fully tested.

More efficient growth seems to result from coppice actually located below ground level (Mdg Plot 2).

It is claimed that with increasing size, coppice tends to blow down; this would be regarded as more accurate in the case of stems arising high up on the original stump and on large size stumps.

Height growth has been monitored over a period of years (Hewett's records Mdg) and the Julimar 2 plot indicates a growth rate averaging 0.75m/annum which is probably about 0.25m better than seedling growth on poor sites and approximately equal to fertilised seedling growth rates (see Table 5) elsewhere.

Graph 2 indicates a marked decline in diameter growth at about 25cm D.O.B. and therefore later growth is very suspect and likely to be much below seedling stock - coppice diameter growth being approximately half that of normal seedlings.

1.2 STAND DYNAMICS

1.2.1 Site Variations

Most documented data on this aspect is recorded in J.B. Campbell's "Silvicultural Note on Wandoo" at pages 26-28, appendices 2A, 2B, 2C, 2D, 2E.

Hewett and Underwood in "The Wandoo Forest" describe in a general way, the ecological variations of the wandoo forest, particularly soils and associated species and vegetative formations.

Recently established (1974) thinning plots on Yarra Road, Mundaring may, in the future, indicate the effect of site variations on growth and stand development (plots JL1 & 2; Mdg 1 & 2).

Some basic data of normal forest heights and basal area can be obtained for the two major sites encountered, i.e. the wide mature gully flats and the steeper sloping gullies of shallower and often rockier soils.

Indications of this are given in J.B. Campbell's "Silvicultural Note on Wandoo" as per appendices 21 - 2c and pages 21-22.

1.2.2 K/D Ratios

Since the investigations into this aspect of crown diameter relationship by J.B. Campbell, there appear to have been no further documentation of data. The graph of the K/D vs. diameter over bark drawn by him appears to be accurate for smaller and intermediate size classes but becomes unreliable for over-mature and large size classes. Observations in the forest tend to suggest that variations in this area, are related to site factors, i.e. on shallower rockier sites (or rather open grown) trees tend to adopt a stumpier habit with wider spreading crowns which influences the K/D ratio markedly. Trees which have had a reasonably continuous history of competition appear to have smaller crowns and taller habit and tend to fit the general trend of the graph.

The importance at this end of the graph is considered relatively small since this type of tree, under proper management for timber wood production, would have little claim to retention in the forest after regeneration. In areas of pristine beauty or deliberate preservation, this would not apply, but nor would the management procedures adopted elsewhere.

1.2.3 Crown Cover

Crown cover studies have been made of plots recently remeasured to assess how this aspect of stand development can be used to maintain growth in growing stock. It would seem that when crown cover percent exceeds approximately 70% the stand is in need of thinning. Below 50% seems to be inadequately stocked so that there is considered to be a crown cover range of 50-70% which can be regarded as a silvicultural optimum.

1.2.4 Stocking Levels

Stocking levels have been recorded for growth plots in Mundaring and Julimar S.F. (plots JL 1 & 2, Mdg 1 & 2) as well as thinning plots on Yarra Road.

On the basis of K/D ratios, these latter plots cover a range of stems per ha from 117 to 322. With a respective range of BAOB (m^2) from 1.17 m^2/ha to 3.92 m^2/ha. Greater BA is recorded for a plot with 283 stems/ha of 4.44 m^2 which is in the vicinity of half stocking for normal virgin wandoo, as estimated by J.B. Campbell and 14% overstocked on the basis of K/D ratio inference. Other plots range from 22.5% to 72.38% stocked on this basis.

A major difficulty which has to be resolved is the proportion of size classes which will make up the total growing stock. There is very obviously (as per 1.1.1 above) a loss of productivity potential by retention of subdominant and dominated growing stock and the losses due to incorrect spatial distribution of dominants and co-dominants. Where these canopy classes are confounded by differing age classes (and hence growth rates) the problem of generating stand normalcy of a desired number of age classes is considerable but not insurmountable. There is little doubt that overmature trees have no place in the managed forest and should be removed. Correction of other imbalances seems to be best achieved by removal of (i) subdominant and dominated stems; (ii) competing coppice; (iii) finally, spatial adjustment of dominants and co-dominants for optimum growth conditions.

1.2.5 Bark Growth Factors

The intriguing manner in which wandoo bark undergoes transition from the rough-barked stem to the smooth mottled whitish yellow, has attracted attention for some time. The reason is mainly due to the effects on fire behaviour and the overall flammability of the forest when control burnt and the damage or risk posed to growing stock.

Mr Hewett on 12/2/63 (Field Book MG 1 & 2 and Field Book JL 1 & 2 on 15/2/63) painted GBHOB positions to enable the bark shedding process to be followed up.

At the last remeasurement on 16/9/80, some trees had considerable paint left on them.

The basic factors concerning bark shedding appear to be:

1. Suppressed and dominated trees retain rough bark for much longer periods than actively growing dominants and co-dominants (see Table 2). Slow growing trees appear to retain the feature in part for an extremely long time, i.e. wood growth causes growth of bark and attendant "sloughing" of old bark.

2. Co-dominant and dominant trees generally seem to change to smooth bark at an age of approximately 20-25 years or 20-25 cm D.O.B. (at Yarra Road at least).

3. The rapidly growing trees have the thicker bark (usually $\geq$ 1.25 cm) i.e. wood growth is partly matched by bark growth.

4. Bark thickness varies in relation to exposure to the sun - north side bark thickness generally being thicker, as one would expect, than south side.

5. Occlusion from fire or mechanical damage results in abnormal bark thickening.

6. Shedding of the bark occurs rather continuously as patchy flaking but is greatest at early spring and early autumn? Burning severity evidently precipitates additional shedding after a period from time of burning. This time period is not known.

7. The ratio of bark to wood increment (in B.A. (m^2) terms) seems to be of the order of 2.2:1 (i.e. 2.2 units of bark to 1 of wood based on increments in plot MDG.2 between 1961 and 1980 and assuming:

   BARK INCT (m^2) = Wood Increment for the period 1961-80 + (BAOB 1980 - BAOB 1961)

8. The position of accumulation of shed bark at the base of trees enhances the risk of fire damage at the base and therefore control burning regimes should perhaps recognise the fact that less burning is necessary or desirable in low site quality wandoo forest and more regular mild burning in better site qualities to remove this hazard.

1.2.7 Growth Rates

Remeasurements have been made in plots established by Mr Hewett and others in 1961 in Mundaring and Julimar. These can be augmented by measurements in plantation situations and other artificial plantings as shown in Table 5.

The relationship betwen DBOB and BAUB Increment is shown in the attached Graph 2. It is evident that:

(1) Growing stock in the 30-40cm DOB class grow wood at a relatively rapid rate compared to other classes.

(2) There could be other factors influencing rates of growth in the early life of the tree, e.g. crown position and early freedom from competition (see regeneration stocking and height growth Graph 1).

(3) There are management implications for sustaining optimum growth which should not be ignored.

1.2.8 Diameter Size Class Transition

The attached Tables 3 and 4 demonstrate the progress of growing stock through diameter classes and suppression of others.

1.3 STAND TREATMENTS

1.3.1 Early Cleaning

It is recorded in management records of mallet plantations (H.O. file/circular 21/3/1934, page 3) that the need for early cleaning of regeneration (either artificial or natural) was necessary to avoid stagnation. This treatment is justified in wandoo by the data on AR1, 2 & 3 in Julimar and Mundaring. The importance of this action is highlighted by the fact that in AR 1 & 2, very little regeneration has survived through lack of cleaning and in AR3 development of new growing stock, although reasonably assured now, will be retarded by approximately 12-14 years in terms of height growth at least.

Mallet tending calls for cleaning to be done within 3 years and observations in artificial wandoo regeneration at Jarrahdale, indicate this would be applicable to wandoo. The opportunity to attend to appropriate spacing is also optimal at this stage of growth.

1.3.2 Thinning

There are extensive and rather precise schedules available for thinning in mallet plantations and these could possibly have application in similar areas but modified for height/basal area factors.

An area in Julimar S.F. was subjected to thinning for P.M.G. poles in 1966/67. There was no set schedule; poles were extracted in sizes required, if present. (Refer Julimar Plan grid LE73 with A. Hart).

Rehabilitation plantings of wandoo in Jarrahdale bauxite pits of P.YR. 1974 and 1969 Mundlimup (Plot 14/69) were thinned on the basis of form and vigour in 1979. The prescription (Jarrahdale letter 18/4/79, P. Jones) required all double leadered stock to be singled, and major side limbs up to 2m to be side pruned away. Runts and malformed stems were cut down to allow new straight stems to develop.

Thinning has been carried out in Mundaring in the past (Mdg file HG/11; 11/7/73) however, the results of these operations do not appear to be documented and the situation culminated in establishment of thinning plots (5 in all plus control) in 1975, (File 2/1/2 of 27/7/73) to ascertain optimal thinning levels to be adopted.

These plots have been remeasured once (1980) after complete enumeration in 1976. Results so far are set out in Table 6.

1.3.3 Culling

Improvement of wandoo stands has been attempted in Collie Division. (Collie files 4E1 and Insp. G/7/1 of 7.7.75 and 18.8.75 refer). These outline prescriptions used as per Job Prescription No 29 - 75/76 ex Collie.

The aim of the work was:

(1) to remove by poisoning with "Tordon": cull trees of wandoo and jarrah, leaving crop trees and seed trees at 50' (15m) spacing. (Culls removed where 3 or more W. regrowth were present);

(2) malformed trees of W cut down to obtain coppice regrowth;

(3) small patches of dead saplings were thinned out to 3-4m spacing✓firebreaked to protect from fire;

(4) regeneration procurement by burning in April 1975 when seed crops were expected.

The interim results of this treatment over 526.3 ha have been reported on by F/G J. Kenbeek on 14/5/76 (Collie file 7C5 25/5/76). No stocking of some ashbeds is reported in that report, and "wheatfield" results on others, indicate either discontinuous fuel to open capsules and/or non-presence of mature seed capsules.

Mundaring Division have implemented a similar project in Talbot Block aimed at:

(1) monitoring the effect of heavy cutting in salinity;

(2) produce wandoo regeneration;

(3) improve water purity by regeneration (see Mdg File 12/1/74 of 3/7/79). Area completed by 3/79 - 122 ha.

Harvey Division - proposal for culling and stand improvement work (as per P. Kimber's letter of 2/7/73, file 2/1/1 Res. Dwgp) were transferred to Mundaring.

Mr Ashcroft's wandoo regeneration prescription of 8/5/78 requires seed trees retained at spacings equal to twice tree height. The basis for this is open to question, as no field data have been found regarding seed dispersal patterns in this species.

1.4 SILVICULTURAL SYSTEMS

J.B. Campbell in his "Silvicultural Note on Wandoo" considers "the silvicultural system of wandoo will depend on economical considerations", (page 30). The past system has been nearly clear felling with seed trees. This was seen as inducive to salinity problems and advocated a loose group selection system could be desirable.

1.4.1 Group Selection

In the past, this system has not been followed due to the harvest necessarily being confined to millable logs and logs suitable for tannin extracts and firewood.

Most of the wandoo cutting of late has been controlled by girth restrictions by retention of growing stock of 25cm diam. and below and stems above that size left, because of defects.

1.4.2 Clear Felling (with restrictions)

The above type of operation has to be categorised as a clear felling with limits down to the girth limit adopted. This approach minimises costs of permit control yet ensures retention of young growing stock. It does not overcome problems of spatial distribution or removal of overmature and cull trees.

The result of adopting this type of system appears to be rapid depletion of the most active growing stocks - as shown in Graph 2; data collected so far indicate the lower girth limit should possibly be not less than 24cm D.O.B. which would retain prime growing stock of the new crop and enable removal of mature and over-mature stems only. The cut would be much lower.

Retention of smaller trees by this method reduces the seed tree potential and increases the desirable number of trees per unit area to enable full stocking to be regained.

1.4.3 Clear Felling with Seed Trees

With some adjustment this is the system which is currently used in wandoo forests except that seed trees are not marked for retention, but have to emerge from stock below 25cm D.O.B. or be found in cull type trees not removed in the trade operation. Either source is not the best but has to suffice in an operation which returns a low yield per unit area at present.

1.4.4 Virgin Forest Areas (Natural Silviculture)

Study of the nature and character of virgin forests of wandoo can be very rewarding. Such areas are to be found in (1) the Julimar S.F. (poor quality W & J mixtures); (2) Russell Block, Brookton Highway; (3) Boonarring Block, Dwellingup and (4) Stene Block, Harvey/Collie.

General observations in virgin wandoo indicate the following:

1. The forest has a wide range of age classes and diameter classes but predominantly large sizes.

2. Lack of thinning has resulted in crowded, ill-spaced stems with consequent bent and deformed stems.

3. Fire events in stands of this type appear to cause high levels of butt damage due to fire being concentrated in bark debris at the base of leaning trees - (thinning of regenerating stands should thus aim at removing leaning trees).

4. Regeneration where it is has occurred is overcrowded and sporadic which presents management problems in treatment.

5. That the physiological age of the wandoo forest could be of the order of 300 years plus, which suggests that to obtain a uniform yield, requires reduction of age classes to approximately 3 and adoption of a rotation age (for small saw logs) of about 50-60 years, depending on site (vide growth rates Table 5).

6. Ability of wandoo to tolerate some overlap of crowns which suggests using the square of the crown diameter for canopy cover investigations.

1.5 IMPACTS OF MANAGEMENT

F. Batini and A. Selkirk's report on salinity indicates that under:

1. light selection cut to

2. virtual clearfelling, since 1950

increases in base flow of ground waters have not been observed.

Areas of jarrah were more heavily cut for firewood production.

In their report they state "wandoo flats and ridges have a considerable store of salt in the profile and are often associated with a saline groundwater table in the lower topographic positions" - this refers to the areas of greatest wandoo occurrence and hence operations have greatest potential for upsetting balances, as may exist naturally.

The statement is also made "a drastic change to the silvicultural system and a heavy firewood cut in wandoo cannot be undertaken with confidence. However, a carefully planned selective operation could be considered".

At page 4 of a report by Batini, Hatch and Selkirk, the statement is made:

"Some relationship between site type and salinity was observed. The 'Y' site types (W1 H15, K3) tended to have a store of salt in the region between 3 and 11m, but the rest of the profile was low in salinity" and "all of the type 'F' and two of the 'F/J' were non-saline. Both 'M/G' types relatively non-saline; 3 'H/G' profiles were saline at lower depths".

In 1973, management impacts were looked at by D. Grace with control sought by retention of 50% canopy, plus possible need to delineate stands of less than 15% canopy rather than 10% and excising from trade operations.

Mr Kimber's comments were, in the same context, "if an area is not adequately regenerated such conditions can cause salinity problems" and more clarity was requested (presumably of levels of control envisaged if operating in salt prone areas).

The relevant Como file at p.91 recommends:

1. the 1st non-commercial thinning should be at 20-30 years;

2. do not remove marri in culling operations;

3. older regeneration, i.e. mixed age stands causing problems in regenerating other areas, was recognised;

4. a need was observed for a general wandoo prescription (in June 1978) with specific variations for each block (with HOCS sheets).

To date, there appears no documented data to relate necessary levels of wandoo stocking to avoid effects of salinity. From a timber productivity point of view, there is no gain in leaving large areas unstocked - therefore, the salinity risk disappears with maintenance of full stocking.

The impacts on fauna have been recognised but the levels of reduction in stocking which cause problems of risk to fauna have not been defined clearly.

There would appear to be a risk that clearing of wandoo could afford an undesirable advantage to marri (temporarily perhaps) which is regarded as an invader. In this, however, could be the safeguard against loss of cover by wandoo during the regeneration of wandoo to full stocking.

1.6 SOURCES OF INFORMATION

Data available but not necessarily used in this paper have been obtained as follows:

1.6.1 Library Material

i) "A Silvicultural Note on Wandoo" - J.B. Campbell, 1956.

ii) "A Report on Field Work Carried out During 1963" - R.J. Underwood.

iii) "The Wandoo Forest" - P.N. Hewett.

iv) "Ashbed Effects on W.A. Forest Soils" - A.B. Hatch, 1960.

v) "Wandoo Botanical Notes" - Forest Focus No 3, 1970.

vi) F.D. Bulletin 86 - Site Vegetation Mapping in the N. Jarrah Forest - J.J. Havel.

1.6.2 Field Books

i) Permanent Increment Plots 1961

- No MG1, MG2)
- No JL1, JL2) Established by P.N. Hewett, 1961.

- T/9 Wandoo Dendrometers and Seedling Survival Plots AR1, AR2 and AR3.

ii) Euc. wandoo - Thinning Plots Data Remeasurements - Yarra Road, Mundaring, established 1975.

1.6.3 Departmental Files

i) Ex Mundaring - C1/4B, C1/4C, C1/4D, C1/4E.
- 12/12/74, H/G 11, H/G 13 and H/T-7.

ii) A. Hart's File, Como - 21/14 plus silviculture notes and data on Euc. wandoo.

iii) Dwellingup Research File 2/1/1.

iv) Collie Division File - 7C5, 4E1.

v) Como Northern Region File - 12/12 and NR42.2.
H.O. File - 124/72, 476/69, 983/58 and H/R4.
Research Working Plan No 15/58 - Report in September 1960 and Final Report January 1959.

(All field books ex Mundaring are being held by A. Hart, Como).

2. RECOMMENDATIONS FOR RESEARCH

2.1 GAPS IN SILVICULTURAL KNOWLEDGE

The major gaps would have been covered if W/P Research Experiments No 11-14/58 inclusive had been implemented in 1958 (see attached summary of titles).

Data on seedling survival and growth is thin but data on hand indicate treatments such as early cleaning are essential and urgent.

Information on seed crops, development, retention and dispersal are very important but nowhere researched apparently.

Present coppice development data are not comprehensive. Indications are that it is a mediocre second best form of regeneration compared to seedlings and, therefore, not of pressing importance.

Regeneration - the importance of ascertaining whether wandoo can be regenerated by direct seeding (either broadcast or spot sown) is related to possible improvement in spatial distribution of wandoo growing stock with consequent gains in (a) stocking per se and (b) overall productivity. Trials at Jarrahdale suggest this could be done.

Stand Dynamics

More data on growth rates and thinning regimes, particularly over a range of sites, are required to expand confidence on these aspects. There seems no argument against early cleaning and thinning. Evidence suggests regular thinning would be beneficial, productively.

The queries raised on K/D ratios for large size classes appear largely of academic value since these sizes are considered to have no place in the managed forest.

Development of wedge prisms to control thinning operations to desirable BA levels is considered very desirable.

Commercial Operations

The extent to which these can be integrated to improve the condition of the forest needs investigation (my letter of 19/2/76 suggested 45-70m^2/ha should be removed as 20-30cm DOB stems and culls). The mixed age and size classes of the wandoo forest require an operation such as firewood, cord wood etc., to be available for correct and timely management operations.

Stand Treatments

Investigation of results of early cleaning of regeneration from natural regeneration methods is urgently needed, as also the extension of thinning results over a greater range of sites.

Silvicultural Systems

The condition of large areas of wandoo forest now suggest that higher girth restrictions with marked seed trees is desirable to maintain timber output; seed trees could be removed with early thinnings. Failures in natural regeneration could be overcome by artificial seeding and full stocking, properly spaced, achieved. The proof of success with artificial methods is yet to be had from the main wandoo areas, as Underwood's trials were limiting in the methods used.

Impacts of Management

Insufficient is known at present about the effects of logging on salinity with accuracy (see Batini and Selkirk's statement). A possible approach could be in the identification of surface plant indicators of areas where saline stores recur at depth (refer "Wildland Shrubs - their Biology and Utilisation" U.S. Forest Service. Gen. Tech. Rep. INT-1 1972, page 13).

2.2 RECOMMENDED SUBJECTS FOR INVESTIGATION

2.2.1 Seed maturation, Retention, Dispersal (including flowering cycles).

2.2.2 Establishment of areas of wandoo forest nominally treated for regeneration by burning, i.e. map records.

2.2.3 Closer definition of effects of logging in saline prone areas and the possibility of identifying surface plant indicators of high saline stores in the profile.

2.2.4 Artificial regeneration methods including direct sowing by spots and broadcast sowing.

2.2.5 Comparison of effects of early cleaning and non-cleaning in wandoo regeneration.

2.2.6 Derivation of wedge prims(s) for thinning control by B.A., average and stem size.

2.2.7 The extent to which trade operations for forest produce can be integrated into a thinning treatment programme.

ACKNOWLEDGEMENTS:

It is wished to acknowledge the assistance of Mr P. Kimber in checking the draft of this material and also Messrs P. Hewett and R. Underwood's careful field observations, notes and measurements in the wandoo forest as well as Mr J.B. Campbell's "Silvicultural Note on Wandoo: of 1956.

SUMMARY OF RESEARCH WORKING PLANS

W/Plan No	Title	Final Report Yes	Final Report No.	Last Report Date
11/58	Wandoo Bud Formation Flowering seedsetting, maturation and retention of seed (Dryandra & Boddington)		No	No reports
12/58	Wandoo Seed Dispersal studies		No	No reports
13/58	Wandoo Seedlings Survival studies (Dryandra & Boddington). Assessments 6 months intervals Nov & May.		No	No reports
14/58	Development of Wandoo Seedlings through the lignotuberous stage (Dryandra & Boddington).		No	No reports
15/58	Response of released trees to the removal of edge trees in Mallet plantations.	Jan 1959 of 10 largest related to stocking (P. 1922)		Jan 1959 F.B. 942 697 698 + one F.B — Sept 1960 increased growth within 2 years of release
1/59	Wandoo Germination studies (Dryandra & Boddington)	No		No reports
2/59	Wandoo Coppice Studies (Dryandra & Boddington)	No		No reports

TABLE 1

EUCALYPTUS WANDOO - SEEDLING REGROWTH PLOT AR3
COOK'S ROAD - JULIMAR S.F. - REGENERATION BURN 3/62

Date of Observation	QUADRAT 1 (2' x 2') (.3717 m^2)			QUADRAT 2 (2' x 2') (.3717 m^2)			QUADRAT 1
	No. Seedlings	No/Ha.	Estd Mean Ht (cm)	No. Seedlings	Qty/Ha.	Estd Periodic Mean Ht/Ann	% Seedling Survival
15/2/63	24	645 334	20.32	18	484 260	30.48	100.00
2/9/63	21	564 668	22.86	18	484 260	18.28	87.5
12/12/63	21	564 668	38.10	18	484 260	23.40	87.5
16/4/64	21	564 668	38.10	18	484 260	20.78	87.5
20/1/65	16	430 223	45.72	16	430 455	17.70	66.70
2/9/80	5	134 445	220.00	7	134 520	26.67	20.00

TABLE 2

COMPARISON BETWEEN SITE QUALITIES IN 60 YEAR OLD WANDOO REGROWTH
AT LOCATION 2296, BODDINGTON (NOW CLEARED)

Site Class	AVERAGE BASAL AREA PER ACRE		Average height Class 1 trees (m)	Average bole length of merch. trees (m)	AVERAGE VOLUME		
	For all classes (m^2)	Class 1 trees only (m^2)			per merch. tree (m^3)	per hectare (m^3)	Increment per/ha annum
1	4.897	3.997	18.28	7.42	0.149	29.837	0.497
2	3.596	2.591	15.39	6.10	0.125	14.253	0.237
3	4.616	3.572	13.85	5.35	0.117	11.520	0.192

(Thanks are accorded to Mr J.B. Campbell for the above data, originally shown in Imperial measures in "Silvicultural Note on Wandoo" of 1956.)

TABLE 3

EUCALYPTUS WANDOO

1980 BARK TRANSITION DATA - YARRA ROAD, MUNDARING

Bark Type	Plot number						Total	% of Total
	1	2	3	4	5	6		
Smooth bark (No. stems) IN Dominant C/Class	1	-	1	-	-	-	2	8
Co-dominant "								
Rough bark IN Sub-dominants and dominated C/Classes	5	7	4	2	3	2	23	92
Totals	6	7	5	2	3	2	25	100

TABLE 4

JULIMAR S.F. - PLOT 2. REMEASUREMENT 2/9/80

Diameter Class (cm)	No. Trees 1961		No. Trees 1980	Recruitment	CROWN CLASSIFICATION OF STOCKING (1980)				
					111	112	121	122	123
4.10 - 9.00)	-)								
9.10 - 14.00)	3)	4	11	7	-	1	2	7	2
14.10 - 19.00)	1)								
19.10 - 24.00)	3)								
24.10 - 29.00)	1)								
29.10 - 34.00	5)	10	6	-4	-	1	-	4	-
34.10 - 39.00)	1)								
39.10 - 44.00)	1)								
44.10 - 49.00)	3)	4	4	0	-	2	-	-	-
49.10 - 54.00)	-)								
54.10 - 59.00)	-)								
59.10 - 64.00)	1)	1	-	-1	-	-	-	-	-
64.10 - 69.00)	-)								
69.10 - 74.00)	-)								
74.10 +	3)	3	1	-2	-	-	1	-	-
Total	22		22	Net 0	-	4	3	11	2

TABLE 5

EUCALYPTUS WANDOO - YARRA ROAD, MUNDARING
AUGUST 1980. REASSESSMENT OF THINNING PLOTS ESTD 1975

Plot No.	Total Stems	CROWN CLASSIFICATION				Dead	Coppice Incl.	Original Top Ht (m)
		Dominant	Co-dominant	Sub-dominant	Suppressed			
1	50	6	31	13	-	-	2	28.0
2	55	3	23	29	1	2	-	18.8
3	43	4	16	26	8	-	-	18.06
4	41	2	17	22	-	3	1	20.0
5	41	1	12	25	3	2	10	19.0
6	21	3	6	10	2	1	-	15.0

TABLE 6

EUCALYPTUS WANDOO - GROWTH RATES EX VARIOUS OBSERVATIONS

(as at September 1980)

Method of Establishment	Locality of Planting/ Regen^{n}	P.Yr	Fertilizer Treatment	B.A. Inct. U.B. (m^2/ann/stem)	Mean Diam. U.B. (1980)	D.O.B. Inct per annum as per age	Mean Height Inct/ Annum	% Canopy Cover (1980)
NATURAL REGENERATION	Julimar S.F. Plot 1	1957	A/bed	Crown Class^{n} 111 = ·00325 112 = ·00273 121 = ·00336 122 = ·00175 123 = ·00100 122 = ·0014086 (Old growth)	26.110	-	0.85 m	128.02
	Julimar Plot 2	1962 -63	A/bed	.006536	31.50		1.05 m	61.10
	Mundaring Plot 1	1967 -68	A/bed	.001503	22.66		1.15 m approx.	74.4
	Mundaring Plot 2	approx 1931	A/bed	.000596	15.822		0.41 approx.	110.59
	Mundaring Thinning Plots 1-6	approx 1931	A/bed after clearing	←		See Table 3	→	

TABLE 6 (cont'd)

EUCALYPTUS WANDOO - GROWTH RATES EX VARIOUS OBSERVATIONS

(as at September 1980)

Method of Establishment	Locality of Planting/ Regen^{n}	P. Yr	Fertilizer Treatment	BA Inct U.B.I. (m^2/ann/ stem)	DOB Inct(cm) per annum as per age	Mean Height Inct/ annum
Seedlings pit planted or J/P	Collie (various blocks)	1959 -1970 +	Early plant-ings nil or super - later "Agras"	N/Avail.	15yr = 0.318 10-15yr = 0.813 5-9 yr = 0.787	0.365 m 0.463 m 0.53 m
	Dwellingup	1965	NPK 50 gm/tree	"	3yr = N/Av. 5yr = N/Av. 10yr = 1.05m	0.84 m 0.87 m 0.73 m
	Harvey (Hml & Hvy HQs)	1948 (Hvy) 1965 (Hml)	? Pot 'E'	"	*28yr = 0.424 11yr = 0.45	0.43 m 0.77 m
	Mundaring (Various blocks)	1956 -1976+	?	"	15-20yr = 0.80 10-14yr = 1.145	0.32 m 0.78 m
	Jarrahdale (Bauxite pit)	1969 -1974+	Super & B&B "Agras"	"	→ 7yr = 1.45	0.86 m
	Jarrahdale (Dieback)	1963-73	Super & B&B	"	10-15yr - 1.02	0.62 m
	Manjimup (Talling & Stoate)	1970	?	"	All failed	
	Nannup (McCorkhill)	1969	?	N o	r e s u l t s	
	Pemberton (Westcliffe)	1965	"Nutrifert"		Failed	
	Walpole (Various blocks)	1965 -1971	" "	N/Avail.	Failed in all fert. trials	
	Narrogin -Dryandra	1958	? Super (?)	"	N/Avail. 20 yrs = 0.55m	
Direct Seeded	Jarrahdale (A. Hart Trials)	1976 -1978	"Agras"	"	4yr - N/Av.	0.55 m

*Single tree

TABLE 7

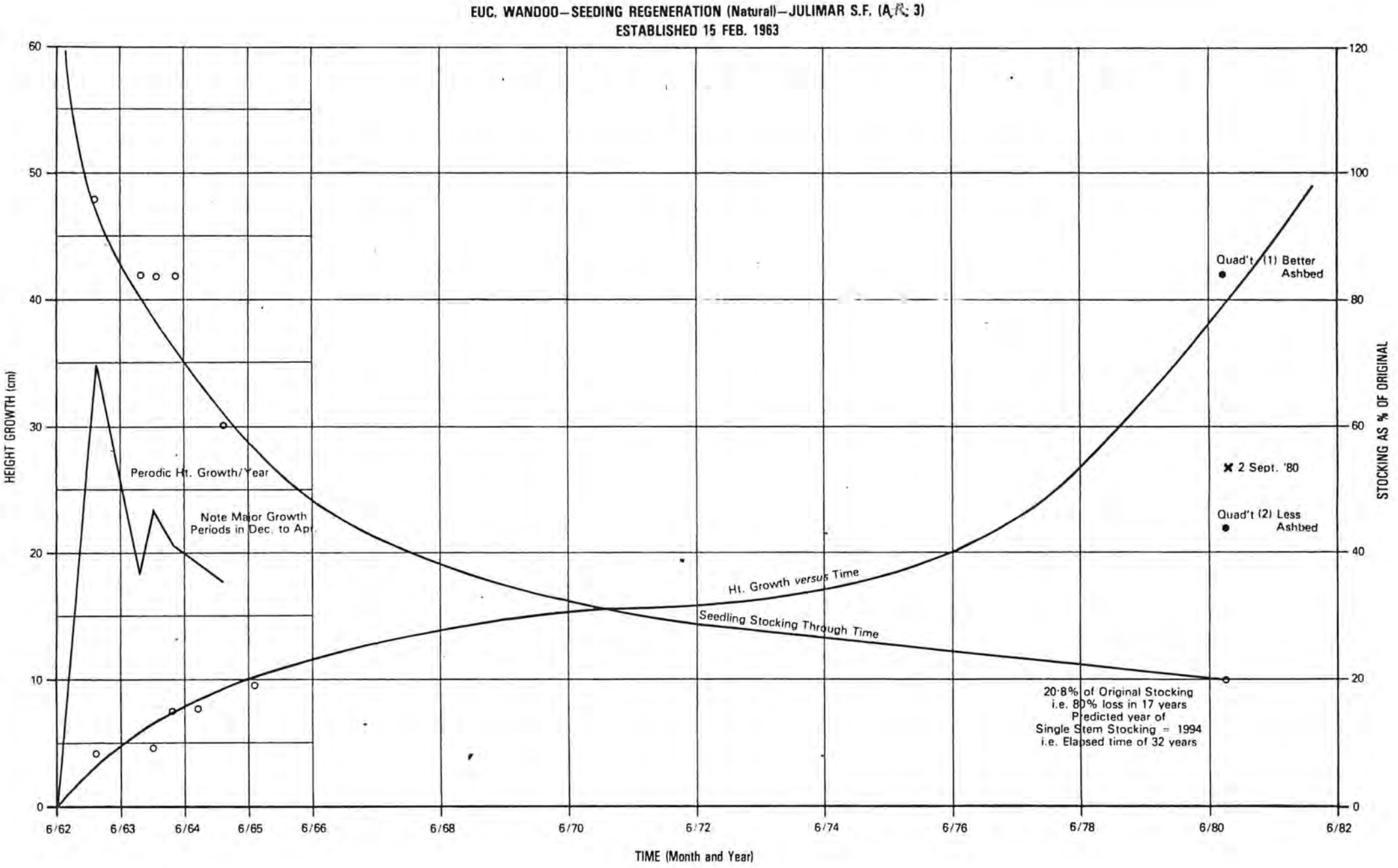
EUCALYPTUS WANDOO - THINNING PLOTS - YARRA ROAD, MUNDARING

20/8/80 REMEASUREMENTS

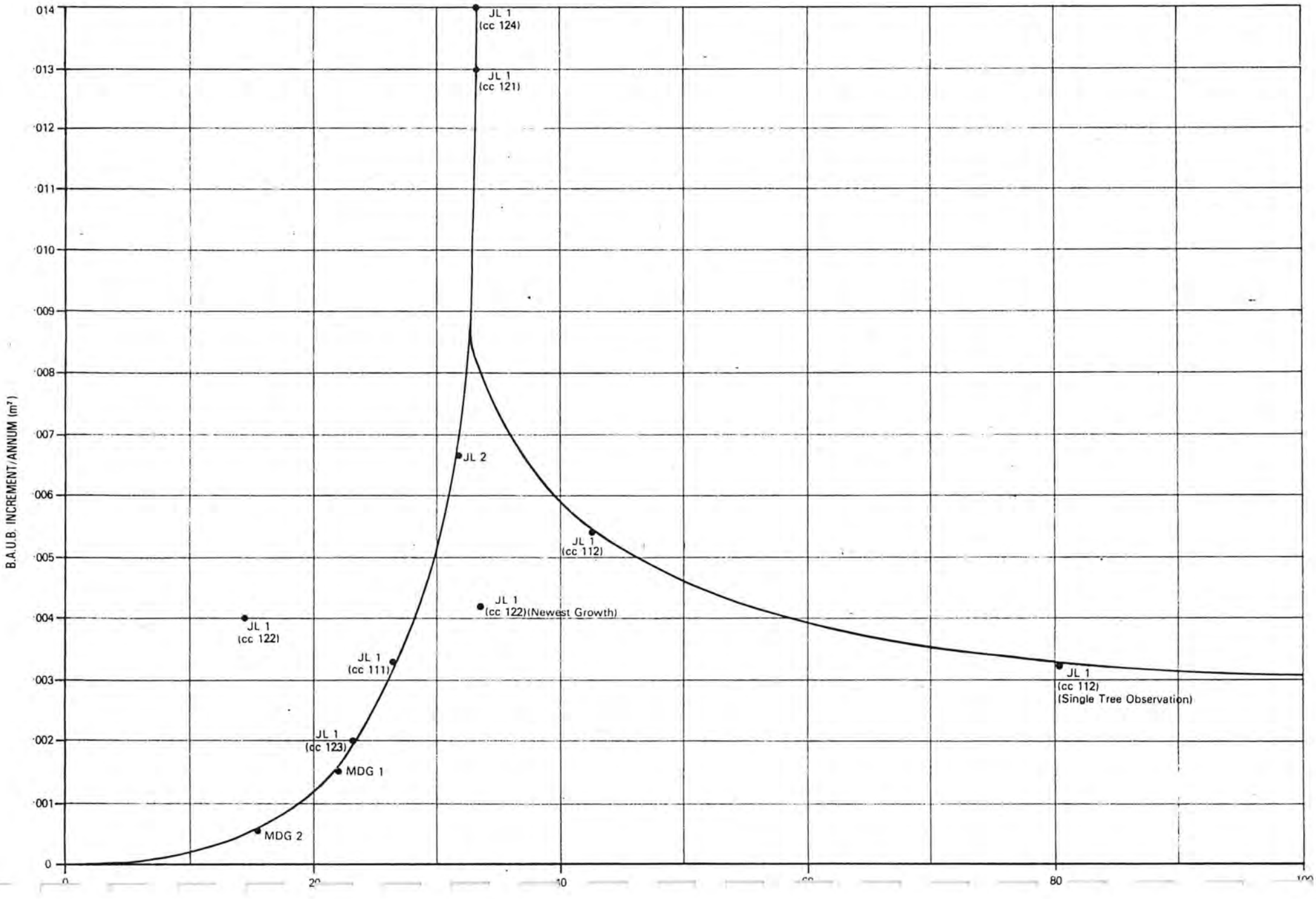
AREA/PLOT = 0.18 ha

MEASUREMENT	PLOT 1		PLOT 2		PLOT 3		PLOT 4		PLOT 6		PLOT 6 (Control)	
	1980	1976	1980	1976	1980	1976	1980	1976	1980	1976	1980	1976
Total No. Stems	50	51	58	57	54	58	41	41	21	21	44	43
Equiv. Stock/ha	283		317		322		239		150		244	
Mean D.B.H.O.B.	21.33	19.70	17.76	15.20	17.19	15.60	17.88	16.40	15.47	14.2	16.01	15.90
Estimated B.A.O.B.	1.818	1.00m	1.437	0.67	1.155	0.705	1.029	0.55	0.395	0.21	0.886	0.53
B.A.O.B. Inct. Per annum (m^2)	0.818	-	0.767	-	0.450	-	0.479	-	0.185	-	0.356	-
Mean D.B.H.O.B.	18.583	17.992	13.627	12.980	14.360	13.258	15.044	13.922	12.90	11.454	13.924	13.75
B.A.U.B. Inct. Per annum (m^2)	0.661		0.647		1.102		1.122		1.446		0.174	
Per annum/ha	3.672		3.59		6.12		6.23		8.03		0.967	
BARK (B.A. Equiv. m^2)	0.49		0.593		0.280		0.300		0.120		0.218	
% of B.A.O.B. (1980)	27		41.2		24		29.2		30.0		24.6	
ESTIMATED HEIGHT CLASSES												
Dominant	28.0m		18.80		18.10		20.0		15.0		24.50	
Co-dominant	21.10m		17.40		13.30		17.80		13.70		19.00	
Sub-dominant	16.00m		12.25		10.00		12.00		10.50		13.50	

Graph 1


EUC. WANDOO—SEEDING REGENERATION (Natural)—JULIMAR S.F. (A.R. 3)
ESTABLISHED 15 FEB. 1963
HEIGHT GROWTH (cm)
STOCKING AS % OF ORIGINAL
TIME (Month and Year)
Perodic Ht. Growth/Year
Note Major Growth Periods in Dec. to Apr.
Ht. Growth versus Time
Seedling Stocking Through Time
Quad't (1) Better Ashbed
2 Sept. '80
Quad't (2) Less Ashbed
20·8% of Original Stocking
i.e. 80% loss in 17 years
Predicted year of
Single Stem Stocking = 1994
i.e. Elapsed time of 32 years
6/62
6/63
6/64
6/65
6/66
6/68
6/70
6/72
6/74
6/76
6/78
6/80
6/82

EUC. WANDOO—B.A.U.B. INCREMENT/ANNUM *versus* MEAN DIAMETER O.B.



EUC. WANDOO—YARRA ROAD—U.B. INCREMENT COMPARISON FOR DIFFERENT CATEGORY GROWING STOCK