REPORT ON MEASUREMENTS OF THE GROWTH OF AUSTRALIAN TREES ON THE NILGIRIS

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REPORT

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REPORT ON MEASUREMENTS OF THE GROWTH OF AUSTRALIAN TREES ON THE NILGIRIS.

By D. E. HUTCHINS, *Deputy Conservator of Forests, Mysore, on Special Duty, dated Ootacamund, 9th October* 1882.

INTRODUCTION.

THE object and the scope of the work regarding which I have now the honor to submit the report, is explained briefly by the Inspector-General of Forests, in his note to the Government of Madras, dated 19th May 1882, in the following terms:—

> "The plantations of Australian trees on the Nilgiris now cover a considerable area, and some of them have already been cut over. The oldest of these plantations date back as far as 1857, and, considering the extremely rapid growth of the Blue-gum and the large Acacia, it is time now that the rate of growth and the timber production per acre of these trees be accurately determined, and that tables of growth and tables of growing stock per acre, at different ages, be drawn up. These tables must be based upon the examination in detail of most of the existing plantations on the plateau, and they will furnish data for estimating the outturn of thinnings and the final crop at different ages. The enquiries which must be made for this purpose will probably also lead to clearer views regarding the principles by which thinnings, the formation, and the treatment generally of these plantations, should be regulated.
>
> "It will doubtless be found necessary, sooner or later, considerably to extend these plantations on the plateau, and the results, which the enquiries here suggested will furnish, will be found useful in arranging these operations in a systematic manner."

2. Regarding the first planting of Australian trees on the Nílgiris some notes have been kindly communicated by General Morgan: the following summary of these notes will be read with interest as introductory to the tables which exhibit the growth at the present day of the trees:—

> Some trees of *Eucalyptus globulus* were planted as early 1843 by General (then Captain) Cotton at Gayton-park and Woodcot in Ootacamund. The first planting on a large scale was done by General Morgan in 1856. In 1857, Blue-gum plants were sold at the Government gardens at the rate of 12 annas each. The first Government Blue-gum plantation was made in 1862 under the orders of Sir William Denison, then Governor of Madras. There was a large Blue-gum tree at Gayton-park which, till the head was broken off by the wind, was one of the sights of Ootacamund; it has now a girth of 14 feet and a bole 100 feet high. General Morgan has some Blue-gums near his house "The Retreat," now twenty-three years old, with a height of 140 feet and a girth of $7\frac{1}{2}$ feet. In 1868, General Morgan cut down a tree at Tudor Hall which at eight years gave a yearly increment of 3 cubic feet of wood. General Morgan can speak from experience of the powerful draining action of the Blue-gum tree. He has seen ponds and streams on the Nílgiris dried up locally, after the planting of this tree near them. There are no trees on the hills sufficiently old to thoroughly test the value of Blue-gum wood for building purposes. In 1862, General Morgan tried several varieties of Eucalypts; the valuable Jarrah failed as it has failed uniformly in Southern India. *Eucalyptus rostrata*, the Red-gum of Sydney, succeeded, as did also *Eucalyptus amygdalina*, which in Australia grows to such a gigantic size. General Morgan recommends planting 6′ × 6′, and thinning at eight years or before; he considers that the growth of *Eucalyptus globulus* is about twice that of teak, and teak about twice that of the European oak. *Acacia melanoxylon* and *Acacia dealbata* were introduced on the Nílgiris a few years before 1845, coming probably at first from the Cape. General Morgan remembers *Acacia melanoxylon* as a rare plant in 1851 from the circumstance that in that year some plants were stolen from General Watson's grounds, and found afterwards in a priest's garden. Last year General Morgan felled an *Acacia melanoxylon* that had been planted before 1845, and was therefore about thirty-eight years of age. It furnished sufficient planks to board a room 24′ × 15′. Some other trees forty years of age have each produced 50 cubic feet of timber.

3. In the tables of growth accompanying this report it will be observed that two forms have been used; first, that exhibiting the measurements and cubical contents of the trees in the sample areas selected; and, secondly, a form showing the calculation of the Reducing-factor. I shall proceed to discuss and explain the figures in these two forms, column by column, but before doing so some preliminary observations are necessary with regard to the method of working which was adopted.

4. The first point being to determine average rates of growth of the Blue-gum or *Eucalyptus globulus* at different ages, the first plantation selected for measurement was the oldest of the plantations belonging to the class of forest known as High-timber or "*futaie*," namely, the *Arambi* plantation, close to Ootacamund, which is now nineteen years of age. Then followed *Norwood* plantation, now ten years old, and then, after the *Marlimund* and *Brooklands* standards and some other work, *Bathri* plantation, which is now five years old and the youngest of the plantations measured. My time on special duty was then extended so that the measurements might embrace the fine Eucalypt plantations growing in the somewhat different climate of the neighbourhood of Coonoor and Wellington. Of these, the *Newman, Ralia,* and *Old Forest* plantations, all about ten years of age, have been measured and also *Black-bridge*, Eucalypt plantation lying at a low elevation near the Wellington race-course and only six years of age. *Bleak-house*, an old *Acacia melanoxylon* plantation near Coonoor, was also measured. In addition to this and during the course of the work, measurements were taken in order to compare the growth of other Australian trees with that of *Eucalyptus globulus*. In the *Ralia* table will be found figures of the comparative rates of growth of—

- *Eucalyptus globulus* or Blue-gum.
- *Acacia melanoxylon* or Australian blackwood.
- *Eucalyptus obliqua* or Stringy-bark gum.
- *Eucalyptus calophylla*, a small tree with corky bark, and very poor growth on the Nilgiris.

Weighings were taken of the *Acacia dealbata* coppice or Wattle at *Bleak-house*. My work was begun on the 15th of June last: owing to a little difficulty in getting together the necessary instruments, finding a suitable table of cubical contents, unusually wet weather, and high winds, during which it was impossible to take heights correctly with a dendrometer, there was some delay in completing the measurements of the first plantation taken in hand, *Arambi;* afterwards the work proceeded steadily. I have to thank Mr. Gass, the Forest Officer of the division, for help and advice throughout. Latterly, valuable assistance has been rendered by Mr. Dickinson, Deputy Conservator, Coorg, enabling me to finish the work more rapidly than would otherwise have been possible.

5. It was of course impracticable to measure the whole of the stock in each plantation. A sample area of about an acre in extent was therefore marked off in the form of a band running through the most regular portion of the plantation. These sample areas being taken through that portion of the plantation where the stock was most complete, represent also that in which the growth is best. But in the *Old Forest* and in *Newman* plantations the sample area was taken through trees of only average growth, in order to avoid the complication of unrecorded thinnings. In the sample areas every tree was measured, the girth at 5 feet and the total height being taken. In the sample area table of stock these measurements are shown in full, exactly as they were taken in the field.

6. The cubical contents of the trees was calculated in the manner followed in European forestry whenever standing stock has to be measured. This consists briefly, in taking first the cubical content of an ideal cylinder, which is obtained by multiplying the sectional area (corresponding to the girth) by the height. By the sectional area is meant the area of a section taken through the tree at 5 feet from the ground, where the girth is measured: it equals πr^2, where $\pi = 3{\cdot}14159$ and $r =$ the radius or semi-diameter. The ideal cylinder thus obtained is of course a fixed quantity. The forms of trees vary, but within limits. It remains to convert the cubic content of the ideal cylinder into the true cubic content of the tree. The *Reducing-factor* or *Form-figure* is the fraction which expresses the relation between the true cubic

content of the tree and the cubic content of the ideal cylinder. In European forestry the Reducing-factor or Form-figure has been calculated for different classes of trees. In my work it was necessary to determine, by experiment beforehand, the Reducing-factor for the various classes of trees measured.

7. The ideal cylinder of each tree in the sample area having been obtained from the measurements of girth and height, and the Reducing-factor applied, the cubic content of each tree was obtained, and hence the total cubic content of the stock on the sample area. This being known, the annual increment of the stock equals the cubic content of the stock on the ground divided by its age, allowance being made for blank spaces among the planted trees and for previous thinnings. It should be mentioned that by "Increment" is meant the *yearly increase in the cubic content of a tree* or *of a mass of trees;* the former is spoken of as the "*Individual* increment," the second as the "*Acre* increment," or the increment per acre per annum.

HISTORY OF PLANTATIONS.

8. Before proceeding to the tables of growth, it will be well to give a brief history (such as could be gleaned from the office of the Deputy Conservator of Forests, Nilgiri Division) of each plantation in which measurements were taken. And to this history is added observations of elevation, gradient, and aspect, together with other information peculiar to each plantation.

ARAMBI PLANTATION.

Eucalyptus Globulus.

9. At an elevation of 7,460 feet; $1\frac{3}{4}$ miles from Ootacamund; area 58 acres; planted in 1863-64 and 1865 by the Jungle Conservancy Department, at 6′ × 6′ from basket-pots; the oldest portion where the sample area was taken is on shola land. Arambi is the oldest of the Eucalypt plantations, leaving out of consideration those where there are a few Eucalypt standards over Acacia coppice. Originally planted 6′ × 6′; it contains now (in the sample area) 498 trees per acre.

10. In 1876, there is a note in the annual report that a thorough weeding took place, and the whole of the dense undergrowth was levelled to the ground to increase the fertility of the soil. This same operation had to be repeated by me in order to get near the trees which were measured. The undergrowth grew again very rapidly, and it is unlikely that the clearing of the undergrowth was of any permanent benefit in either case. There is record of a thinning conducted by Mr. Gass in 1877, and there had previously been one or two light thinnings while the plantation was under Jungle Conservancy, which Colonel Beddome, in his report of June [illegible]5, stated to have been insufficient. No record has been preserved of the actual quantity of wood removed in the thinnings of any of the plantations, and in *Arambi*, where the thinnings have been most numerous, it is difficult to frame an estimate of their amount. The wood from Mr. Gass' thinning was put up to auction and realized Rs. 110-8-0 at Rs. 1-10-0 per bandy-load of 1,000 lb.; this would represent 68 bandy-loads or 68,000 lb. This, when sold, probably weighed about 60 lb. per cubic foot, and Mr. Gass' thinning may thus be estimated at 1,133 cubic feet. Thirty-eight acres were thinned, so that this calculation gives an average of only 29 cubic feet per acre of wood removed. But it is evident that this estimate is too low. The plantation was planted 6′ × 6′, which gives 1,220 trees per acre. It was planted from basket-pots, and I learn on inquiry that the failures were certainly under, rather than over, 10 per cent. But allowing 10 per cent., this would leave 1,098 trees per acre. There are now 498 trees per acre and the difference, namely 600 trees, has gone in thinnings. Mr. Gass' thinning took place when the plantation was thirteen years old and the previous thinnings were light and unimportant. It will probably be correct to estimate Mr. Gass' thinning alone and to take the age of the plantation then at ten instead of at thirteen years, so as to allow for the previous thinnings. Of the plantations examined, *The Old Forest* planted 6′ × 7′ in the sample area, and now nine years old and at a similar elevation, presents conditions most nearly corresponding to those at *Arambi* when it was thinned. The average Individual-increment there per year is 0·634 cubic foot; therefore the total stock removed in the thinning at *Arambi* may be estimated at—

Trees gone.		Age when thinned.		Individual-increment.	
600	×	10	×	·634	= 3,804 cubic feet, = 67·928 tons per acre.

This, therefore, divided by 19 years, the present age of the plantation, is added to the yearly Acre-increment: $67{\cdot}928 \div 19 = 3{\cdot}575$ tons. There has been no thinning since that done by Mr. Gass, and the appearance of the plantation now shows that thinning has been called for, for some years past.

11. *Arambi* plantation is of beautifully regular growth, with clean stems 110 and 120 feet up to the first branches. Many of these tall trees however have a head of foliage represented by ¼ or ⅕ of a head-load of green twigs and 30 or 40 lb. of branch-wood. Tree No. 10 of the Factor trees, for instance, had only 15 lb. of branch-wood and one-tenth of a head-load of twigs, and this tree was 63 feet in height. The yearly Individual-increment at *Arambi* is only about half that of *Norwood* when it might be expected to be double; thus the Individual-increment of *Norwood* or of *Ralia* (aged 10), is double that of *Bathri* (aged 5 years), the trees in these three plantations being well spaced and showing a progressive development. The mean Individual-increment at *Arambi*, ·953 cubic foot, is not ¼ that of the *Marlimund* standards which have 4·187 cubic feet. A severe but gradual thinning down to about 200 to the acre seems advisable. The sample area has an elevation of 7,460 feet, a westerly aspect, and a gradient of about 1 in 6: it is at the bottom of the oldest portion of the plantation.

BROOKLANDS PLANTATION.

Eucalyptus Globulus.

12. About 10 acres, situated near the head of the Sigúr ghât, in an exposed locality: ascertained by Colonel Beddome to have been planted about 1862. It consisted originally of *Acacia dealbata* (Wattle), *Acacia melanoxylon* and a few *Eucalyptus globulus*. The original owner, a missionary, sold it to some natives who cut over the Acacia, leaving the Eucalypts as standards. The assessment being in arrears the plantation was put up to auction and bought in by the Forest Department in 1875 or 1876. Since then the Wattle coppice has been cut twice. The rapid growth of the Wattle after being cut is noticed in the Nilgiri Forest Administration Report for 1876. The *Acacia melanoxylon* was cut, and failed to coppice. The Eucalypt standards, fully exposed to the south-west monsoon, have assumed a sturdy, branching and gnarled form, different to the usual appearance of a Eucalypt in this country. Of unusually large girth at the base, they taper rapidly to a point. For the trunks alone the "Reducing-factor" (the fraction which expresses the form of the tree) would be about ·30, but the low spreading heads give a very large weight of branch-wood, which raises the factor to ·39, thus approaching what it would be in High-timber plantation trees. Turning to the table of Individual-increments, it will be seen that the Individual-increment from these Eucalypt standards is as much as 4·32 cubic feet per annum. As has been noticed, in the closely-grown plantation trees at *Arambi*, at about the same age, this figure is barely 1 cubic foot (·9534 cubic foot). An attempt was made to get an increment per acre from *Brooklands* plantation by measuring the spread of the branches. This gave 100 trees or 8,636 cubic feet per acre, or an increment per acre per annum of 431·8 cubic feet = (at 40 lb. per cubic foot) 7·71 tons. Now this figure corresponds, within a fraction of a ton, with the Acre-increment, (without allowing for thinnings, in both cases) obtained from trees grown under exactly opposite conditions at *Arambi*. Turning to the table of Individual-increments (page 23), we see that a *Brooklands* tree is making wood at a rate nearly five times as fast as a tree of the same age in *Arambi*. Looking again at the measurements of the branch spread of the *Brooklands* trees we have the result, that 100 trees at *Brooklands* give nearly the same Acre-increment as 500 trees at *Arambi*. It would be assumed theoretically that 2 acres of ground completely covered with foliage of the same species would have the same increment, although the number of trees per acre varied. This appears to be true for *Eucalyptus globulus* within the wide limits of 100 trees per acre and 500 trees per acre. But apart from figures an examination of the two plantations would indicate the same deduction. A tree makes wood, other conditions being equal, in proportion to the leafy surface. The *Brooklands* Eucalypt standards have large shady heads: the *Arambi* trees have deplorably scanty heads. The *Arambi* trees have beautifully symmetrical growth, but are deficient in head and leafy surface. The *Brooklands* trees have comparatively shapeless trunks, but five times the leafy surface and five times the individual growth of the *Arambi* trees.

13. Intermediate in form between these two extremes are the Eucalypt standards at *Marlimund* plantation. With shapely trunks and ample heads, these trees leave nothing to be desired in their appearance, and though older than either *Brooklands* or *Arambi*, the *Marlimund* Eucalypts must have a high Acre-increment. Nine and a half tons have been obtained from the standing stocking now on the ground, and this figure, it must be remembered, is merely that calculated from the space (obtained by survey) which the trees now occupy, leaving out of account the previous heavy thinnings, which cannot be estimated and of which no record has been kept.

MARLIMUND PLANTATION.

Eucalyptus Globulus Standards.

14. A small plantation of 9 acres planted about 1860 by the Collector. In June 1876, Colonel Beddome reported that it contained 7,000 trees of *Acacia melanoxylon* with a few *Eucalyptus globulus*. The former were felled, and, as at *Brooklands*, failed to reshoot. One reason for felling all the *Acacia melanoxylon* trees was, that they had suffered much from *Loranths*. Most of the Eucalypts remain standing, and were measured, as many as could be thrown into

one group. The ground below and around the Eucalypt standards is now being replanted with young *Eucalyptus globulus*. The increment per acre was obtained by running a plane table traverse round where the trees were thickest and interpolating for blanks. We arrive thus at the true Acre-increment, less the thinnings, of which there is no record and of which I can form no estimate.

The sample area at *Marlimund* lies in a sheltered situation on good soil with subsoil moisture from a swamp: the gradient is about 1 in 5 and the elevation about 7,500 feet.

NORWOOD PLANTATION.

Eucalyptus Globulus.

15. Colonel Beddome reports as follows (12th June 1876), on taking over the plantation from the Jungle Conservancy Department: "*Norwood* plantation 1¼ miles from Ootacamund; 26 acres; planted in 1872 and 1873; 9′ × 9′ with 14,000 *Eucalyptus globulus*: stems more or less crooked from being planted too far apart, but growth good for a fuel plantation. Will be ready to fell for fuel in 1878-79, when it should give at least 100 tons to the acre, and produce again from the stools." On the 21st June 1881, Colonel Beddome reported that the plantation looked well.

16. At present there are 416 trees per acre (in the sample area): there is no sign now of the crookedness noticed in 1876, and the appearance of the trees generally leaves nothing to be desired. Colonel Beddome's estimate is equivalent to an annual increment per acre of 16·6 tons (dry wood). At the present moment, the increment of the growing stock is 12·4 tons per acre per annum, or, in other words, over a ton an acre of dry wood per month. If Colonel Beddome meant green or partially green wood, his Acre-increment estimated for the first six years would correspond with that now found to have been realized during the first ten years. An Order of Government, dated 4th September 1877, reserved *Norwood* plantation as an accessory to Government-house. If properly thinned it will be interesting nine years hence to compare its Acre-increment with that of *Arambi* and *Marlimund* at the present day. *Norwood* is now (at ten years of age) making wood at the very satisfactory figure of 12·4 tons per acre per annum (neglecting thinnings), while *Arambi* has fallen to 8⅓ tons per acre per annum (neglecting thinnings) at nineteen years of age, but *Marlimund*, where the trees are less crowded, shows an Acre-increment (neglecting thinnings) of 9½ tons at twenty-two years of age.

17. *Norwood* was carefully thinned out in 1879-80, I understand, under the personal superintendence of the Duke of Buckingham. One hundred and eighty-four rupees' worth of wood appears in the accounts as being then taken off the ground. At Rs. 1-4-0 per bandy-load, the net price obtained, this represents 148 bandy-loads = 148,000 lb., or at 60 lb. per cubic foot, 2,466 cubic feet, equivalent to 9⅓ cubic feet (1·68 tons) per acre. But it is difficult to believe that these figures are complete. The sample area has now 424 trees to the acre allowing for blanks. It was originally planted 9′ × 9′ or 537 to the acre, or, allowing 10 per cent. as failures, at 484 per acre. The loss by thinning has thus been 60 trees per acre. The sample area was thinned in 1879-80: the average yearly Individual-increment is now 1·6471 cubic feet. Two years ago it was a small fraction less than this, let us say 1·3 cubic feet (*Bathri*, planted 6′ × 6′, more than twice as close, has, at five years, an individual-increment of ·69 cubic foot), and assume that the sample area was thinned during the first year of thinning, *i.e.*, in 1879 (when it was only seven years old) so as to be on the safe side. Therefore the thinning amounted to—

Trees gone.		Individual-increment.		Age when thinned.	
60	×	1·3	×	7	= 546 cubic feet or 9·75 tons per acre or ·975 ton per acre per annum.

This figure therefore is added to the Acre-increment of the growing stock in calculating the full yearly Acre-increment.

18. A reducing-factor was taken and a table prepared for the *Acacia melanoxylon* trees which occur in the *Norwood* sample area, but it was subsequently found that there was uncertainty with regard to the age of these trees. Though dominated by the Eucalypts, they add considerably to the appearance and covert of the plantation, and their growth shows that the *Acacia melanoxylon* will grow under a covert where *Eucalyptus globulus* would not. The cubage of these Acacias will be useful possibly for future comparison, but owing to the uncertainty with regard to their age now, it has no present value. The Factor-figures obtained are interesting and show a curious correspondence with the same figures taken from *Ralia* plantation. Between the figures of the stock per acre of Blue-gum in the two plantations, there is a more remarkable correspondence. A difference of only 131 cubic feet in totals of 6,960 and 6,829 cubic feet must be held to be a coincidence, though *Norwood* and *Ralia* being the same age and planted the same distance apart, it would be expected that the figures of standing stock per acre should be very similar. It is worth mentioning that the cubage at *Norwood* was done by me, Mr. Higgens being present on two days, and that I took the heights with the dendrometer alone. The cubage

of the Eucalypts at *Ralia* was done by Mr. Dickinson, he using a 3-foot pole checked by the dendrometer for the heights of the trees. The girths were always taken in the same way with a tape.

19. The sample area at *Norwood* has an elevation of 7,550 feet and a gradient of 1 in 5. There were a few specimens of *Eucalyptus calophylla* in the sample area showing a very poor growth: they are included among the Blue-gums.

The growth and present appearance of *Norwood* plantation is eminently satisfactory; it has yielded the highest Acre-increment of any plantation measured and it has the best Individual-increment among the High-timber Blue-gum plantations.

BATHRI PLANTATION.

Eucalyptus Globulus.

20. On the 12th of June 1876, Colonel Beddome wrote: "I found the several fine sholas in the vicinity of Ooty had been cut down for fuel during the last two or three years, when our older Acacia plantations might have been felled at a great profit, and this year felling has commenced in the Buthery shola, a magnificent shola about a mile, or a mile and a half, behind Bishops-down." (This was under Jungle Conservancy.) "I have now ordered the felling departmentally of some of our older Acacia plantations for the fuel-supply of the station, and when this can be properly organized, the felling of the rest of the Buthery shola will be stopped." But it does not appear to have been stopped, and this denuded shola is now the more economically useful *Bathri* Eucalypt plantation. In 1878, Colonel Beddome writes again: "Buthery.—This shola was being felled at the date of my last report, and it was found necessary to fell nearly all of it. In June 1877, 20,000 *Eucalyptus globulus* were put down, but owing to the bad season about 3,500 failures occurred, which have mostly, however, been replaced; the remainder of this shola will be planted up this coming season, and the plantation should be treated as high-timber." Again in June 1881: "Buthery.—The greater part of this was planted on contract by a Badaga maistry at the rate of Rs. 600 for every 20,000 living and healthy plants (ten months old). In 1879-80, the contractor planted out 12,220 new plants over 10 acres and 8,656 casualties of the previous year's planting. In 1880-81, 4,000 failures were planted by him." The following statement of the cost of planting (years 1879 and 1880) is interesting, but it is impossible to make out the rates, as, except for weeding, the measurements of the work are not given:—

1879-80.

	RS.	A.	P.
New planting on contract, at 33 plants per rupee	366	9	7
Cost of seed	9	8	8
Replacing failures	259	10	11
Weeding 30 acres twice	236	0	0
Fire-tracing	21	8	0
Watchers	16	0	0
Total ...	909	5	2

1880-81.

	RS.	A.	P.
Replacing failures	120	0	0
Weeding 60 acres	240	0	0
Watchers	16	0	0
Fire-tracing	23	4	0
Total ...	399	4	0

There are no accounts to show to what area the above expenditure refers, or even what has been the total cost of the *Bathri* plantation, the totals for all the plantations having been lumped together year by year.

21. The *Bathri* plantation being only five years old, no thinnings have taken place, but the blanks are unusually numerous. The increment per acre per annum is 13 tons, but of this figure as much as 2·46 tons is from blanks. This is the youngest plantation measured. The area stocked is 60 acres, but having been planted in 1877, a year of drought, the growth is in parts irregular, and the stock incomplete. The plantation is on rich shola land, with boulders of laterite taking the place of the gneiss at *Arambi*, *Norwood*, and other plantations. The sample area has an elevation of 7,235 feet, an easterly aspect and a gradient of 1 in 5.

RALIA PLANTATION.

Eucalyptus Globulus, various Eucalypts, Acacia Melanoxylon.

22. In June 1876, Colonel Beddome writes with regard to *Ralia* plantation: "Sixty acres planted in 1872, 9′ × 9′ with *Eucalyptus globulus* and *Acacia melanoxylon*, in alternate broad

strips. The growth of the *Eucalyptus* is not straight, having been planted too far apart: this plantation may be treated as a coppice fuel plantation and felled over every five or six years." Again in 1881: "This plantation is now fit for the axe, and as soon as increased, sales are obtained for firewood, it will be carefully cut down and the stools trimmed to ensure good coppice; the present growth is not straight enough for timber."

23. The intermixture of two kinds of trees in this plantation—Eucalypts with a light shade, and *Acacia melanoxylon* with a dense shade—is interesting. Under the latter, there is a nearly clean soil: under the Gum trees there is the usual undergrowth of *Rubus* and succulent plants. Fire entered the plantation and did some damage three years ago; and here it may be remarked that had the *Acacia melanoxylon* been planted in a band entirely round the plantation, it would probably have constituted an efficient bar to the entrance of fire. A permanent fire-line, composed of a band of any species of tree throwing a dense shade, would seem to be desirable generally round plantations of Blue-gum or other Eucalypts. *Acacia melanoxylon* would, in addition, be some barrier against the wind. *Acacia decurrens* or *Acacia pycnantha* throw a good shade and afford valuable tanning barks. These species can be seen apparently thriving at the Government Gardens, Ooty, but there is some doubt whether they are hardy enough for planting on a large scale

24. Another interesting feature in the *Ralia* plantation is the fair show of Stringy-barks, *Eucalyptus obliqua*. Some of these are of very good girth (after allowing for the thick bark), but both here and at *Arambi*, where there are a few trees, the average height rarely equals that of the *Eucalyptus globulus*. In the same band with the Stringy-barks there are some trees of *Eucalyptus calophylla* presenting a meagre appearance similar to those of the same age in *Norwood* plantation.

The following are the Individual-increments of trees of the four species at *Ralia*:—

Species.	Individual-increment per annum.	Remarks.
	C. FT.	
Eucalyptus globulus ...	1·33	The Individual-increment from two Stringy-barks at *Arambi* is 1·53, the same figure for the Blue-gums, there being ·95.
Acacia melanoxylon ...	·65	
Eucalyptus obliqua ...	1·52	
Eucalyptus calophylla ...	·17	

A small clump of 11 Stringy-bark trees growing outside the sample area gave, as will be seen from a table appended, an Individual-increment of 1·64 cubic feet. These figures show a growth rather better than that of the Blue-gum, but were a large number of Stringy-barks available for measurement, it is certain that the difference would be in favor of the Blue-gum, though probably not so much as it is usually supposed to be.

The sample area had an elevation of 7,215 feet and a northerly aspect, gradient moderate.

NEWMAN PLANTATION.

Eucalyptus Globulus.

25. In his report of June 1876, Colonel Beddome writes with regard to *Newman* plantation: "Thirty-five acres, of which 25 were shola and 10 grass land; it was planted in 1870 and 1871 entirely with *Eucalyptus globulus* 6′ × 6′, and there are about 40,000 trees, and the growth is certainly splendid and beyond anything I have ever seen in any country. This plantation must be treated as a High-timber forest and be considerably thinned out."

In 1878, Colonel Beddome writes: "Fire unfortunately got into the outskirts of this plantation last year and much damaged some 2 or 3 acres, which necessitated the taking out of a great many trees which were more or less damaged by fire, so that any one now entering it by the road from Wellington (the side where the fire occurred) would fancy that it had been thinned most injudiciously: the rest requires thinning, but this was in progress at the time of my visit; the growth here is splendid and fine building timber will be available in time; it will be treated as a High-timber plantation."

And again in 1881: "This is one of the best Eucalyptus plantations on the Wellington side. It requires a little judicious thinning."

Concerning the fire in this plantation, Major Jago writes in the Administration Report for 1877-78: "Fire which got into the plantation during the previous year damaged about 3 acres, which necessitated the removal of several trees."

26. The thinnings in 1877-78 amounted to 412 bandy-loads, which realized 422 rupees, exclusive of the cutting charges. In 1879, 40 cart-loads were removed, and in 1880, 30 cart-loads,

but these figures are of little service in estimating the thinnings on the sample area, since the thinnings were not done regularly. Our first object therefore in choosing the sample area was to get a piece of ground nearly free from thinnings, but, after a long search, and much chaining over steep ground, we had, in order to make the sample area of sufficient size, to take in ground where thinnings had taken place. But the thinning had been sufficiently recent to make it easy for us to count the stumps of each tree which had been cut: this was accordingly done while the "cubage" was in progress, and the thinning has been accurately estimated, taking as the unit 0·4 cubic foot which is slightly below the Individual-increment obtained from this plantation now. This Individual-increment is a very low figure, and it is evident that it was scarcely appreciably affected by the little thinning which had been done in the sample area three years ago.

The sample area had an elevation of 7,185 feet, a gradient of 1 in 6, and an easterly aspect. It was on good shola land, immediately above a ravine, differing in this respect from the upper part of the plantation, where the soil was gravelly and appeared to have been formerly grass land.

OLD FOREST PLANTATION.

Eucalyptus Globulus.

27. Conspicuously placed, crowning the summit of a hill to the west of the Coonoor ghât (750 feet above Coonoor church), this plantation has long been considered as one of the best on the Nilgiris. Colonel Beddome writes thus on taking over the plantation from the Jungle Conservancy Department: "Two hundred acres planted in 1872-73 9′ × 9′ with *Eucalyptus globulus*: this is the best soil and aspect of any of the plantations, and would have been a magnificent plantation if it had been planted 6′ × 6′; it was, however, planted 9′ × 9′, and the trees have consequently grown crooked: the growth has been exceedingly rapid, the average height being 59¼ feet and the average girth 17¾ inches, and, although there are only 587 trees to the acre, the weight per acre (exclusive of tops and branches which averaged 70 lb. per tree) was computed at 39 tons per acre; if there was a sufficient demand for the wood it might be treated at great profit as a coppice fuel plantation." In this estimate the Acre-increment (as far as can be gathered from the figures) is probably too low, and the number of trees varies considerably from 537 per acre, the planting having been somewhat irregular, and done without the check of a working plan. As will be mentioned later, the sample area is planted about 7′ × 6′. Two years afterwards Colonel Beddome writes: "The growth here from the wide planting is so crooked and contorted that the plantation can never be treated as high timber; it will be far better to clean fell over as many acres as may be required for the fuel-supply, and then replant alternately with the coppice, which will give 4½′ × 4½′ instead of 9′ × 9′ and we shall get straight growth: at present the department has commenced thinning out only for the fuel-supply." We have here the expression of extreme views of the advantages of dense planting. In the lower part of the plantation the growth from coppice has been already so fine as to render intermediate planting quite unnecessary. In the upper portion thinnings have not yet taken place. A small portion of this, apparently where the wind strikes in, presents a growth not as regular as could be wished, but the rest shows the finest growth I have seen for a plantation only ten years old. Mr. Dickinson took an equally favorable view of the appearance of the growth. This plantation, said to have been planted 9′ × 9′, has in parts been planted closer. The sample area presented the appearance of planting 7′ × 6′. It will be seen that it now carries 1,045 trees to the acre (horizontal measurement), and it so happens that it is just this dense portion of the plantation where the wind strikes in that there is the only growth which is not quite satisfactory. As at *Norwood*, the general conclusion to be drawn from the growth at ten years from planting 9′ × 9′ is, that the forebodings of a bad growth from planting at this distance are not borne out by later experience. The cost of planting 9′ × 9′ is about one-half that of planting 6′ × 6′, and, though a plantation planted 9′ × 9′ may, for some years, look patchy and uneven (as is, in fact, the case with all but the best natural reproduction), at ten years, or as soon as the plantation has closed overhead, there will be no loss in the Acre-increment and a far better Individual-increment for the planting done 9′ × 9′. Writing a year ago, Colonel Beddome says: "This plantation looks remarkably well. It is now being cut down for fuel-supply. The stools have been carefully trimmed and have thrown up good coppice." The coppice growth at this plantation Mr. Dickinson thought was remarkable; a portion stated to have been cut over four years ago looks to me double that age.

28. In our choice of the sample area we were restricted by the necessity of getting a piece free from thinnings. After the area had been marked off and the "cubage" nearly finished, we found that a piece with far better growth might have been obtained; in this fine plantation, the sample area represents *no more* (or probably less) *than the average growth throughout the whole of the plantation.*

The sample area has an elevation of 6,694 feet, a slope of 1 in 4, and a southerly aspect exposed to the west winds: it contains many crooked trunks and stems straggling and bent over.

BLACK-BRIDGE PLANTATION.

Eucalyptus Globulus.

29. This is, of the Eucalypt plantations measured, that at the lowest elevation. The sample area had an elevation of 6,025 feet: the elevation of the plantation generally is not above that of Coonoor church, or only 5,954 feet. The growth in this plantation, whether from differences in soil, elevation, or rainfall, is markedly inferior to that at *Bathri.* They were both planted in the years of drought—1876 and 1877. There appeared to me in this plantation to be symptoms of that tendency to straggle—to send up long thin stems bearing only a tuft of the early sessile leaves—which is noticeable in the Blue-gum as it approaches its lower limit of elevation in the latitude of Southern India. In June 1876 Colonel Beddome writes of this plantation: "Forty-eight acres, in the immediate vicinity of Wellington, planted with *Eucalyptus globulus* two years ago; there have been many failures, and there are large gaps which are to be planted up this year." Again in April 1878: "*Black-bridge*, 48 acres, Eucalyptus, 6′ × 6′. Many of the casualties have been replaced, and 17,000 trees put down in 1876-77." Again in June 1881 Colonel Beddome reports: "The growth of this plantation is fair, and in a few years time it will be cut down for coppice."

The sample area chosen had a north-easterly aspect and a gradient of 1 in 7. There were places in this plantation where it would have been right to have allowed for blanks, were it not that the trees originally planted were still there but straggling and of no growth. The "covert" or "leaf-canopy" was generally too broken and scanty to estimate blanks from it. Small patches, but under an acre in area, showed here and there a better growth. The usual undergrowth of *Rubus* and succulent plants was replaced by a growth composed mainly of *Dodonea viscosa* and plants indicating a drier, warmer climate.

BLEAK-HOUSE PLANTATION.

Acacia Melanoxylon and Acacia Dealbata.

30. Composed mainly of *Acacia melanoxylon* with *Acacia dealbata* (Wattle) in parts, and a few Blue-gums and Casuarinas. Colonel Beddome writes in 1876: "About 235 acres; 150 of this was planted nearly twenty years ago chiefly with *Acacia melanoxylon;* this must stand for High-timber, but requires a good deal of thinning: there is some *Acacia dealbata* which has mostly been felled over for fuel, and it must regularly be cut over for this purpose on its attaining sufficient size. Seventy-five acres are young, having been planted during the last few years, and are composed almost entirely of *Acacia dealbata* (the Wattle), and must be treated as a coppice fuel plantation." In his report, dated 1878, Colonel Beddome says that "150 acres were planted about 1856-57 at 4′ × 4′ and 75 acres between 1864 and 1873 at 6′ × 6′. All the Wattle has been cut out for fuel, and the *Acacia melanoxylon* has been thinned, all the trees suffering from parasites being taken out. The growth here is very poor for its age and this plantation proves how very inferior the *Acacia melanoxylon* is to *Eucalyptus globulus* either as timber or firewood: the older portions were originally planted too close, and for many years little or no attention was paid to thinning: but beside this nearly all the Melanoxylon trees suffer terribly from the loranth parasite, which soon renders them sickly and retards their growth, and unless they are cut down they eventually die; the largest tree that I could find was only 5′ 8″ in circumference at 6 feet from the ground, which is very poor growth for twenty-one or twenty-two years, compared to Eucalyptus. The average girth in the older portion of this plantation, taken from the measurement of 30 trees as they came, is 2′ 11″. It is no use attempting to keep this plantation for timber, as the trees will continue to suffer from parasites and must be thinned when badly attacked; it should therefore all come down shortly and when cleared must be replanted with *Eucalyptus globulus.*" Again, in a report written last year: "A portion of this contains the oldest and largest *Acacia melanoxylon* trees we have on the hills, but unfortunately they are so subject to attacks of the parasite (Loranthus) that I fear eventually the whole plantation will have to be cut down. As this site is a suitable one for a plantation it should be replanted with Blue-gum when cleared."

31. At the present da[y] the *Acacia melanoxylon* in this plantation presents a far more encouraging appearance than when the above was written. There are now but few trees suffering from loranths: three attacked and three dead out of 289 trees in the sample area, or 2·07 per cent. As a show of timber there is nothing finer on the hills than the straight clean stems of these beautiful Acacias, crowned with their ample heads of foliage. Felled, the timber shows a rich black heartwood occasionally mottled brown, equal to the description of the tree as it occurs in Australia where it is used for furniture, ornamental panelling and the variety of uses to which a light tough ornamental wood can be put. The advantage of *Acacia melanoxylon* wood is that while very dark and often richly marked and while tough and close in the grain, it is at the same time light, weighing when dry only from 36 lb. (young Nilgiri wood) to 44 lb. (Australia) per cubic foot. The heartwood appears as a black streak when the tree is under ten

years old, as at *Norwood*, and in large old trees there is comparatively little waste from the whitewood. Rings can be traced in the whitewood, but in the heartwood, as is sometimes the case with other trees, they become indistinct. On account of the fine shade afforded by Acacias, the soil under them is free from the tangled undergrowth which characterises the Eucalypt plantations; there is a fair show of humus under the *Acacia melanoxylon* tree and usually some natural reproduction. In the *Bleak-house* plantation the trees from self-sown seedlings are numerous enough and large enough to require a table apart. A gully near the sample area, but not included in it, had a very fair show of self-sown seedlings of all ages. Left quite alone, this plantation would possibly resolve itself into a few scattered trees, and into sholas of *Acacia melanoxylon* filling up the hollows and ravines. Natural reproduction of *Acacia melanoxylon* from seed and root shoots may be observed in many situations near Ootacamund and Coonoor; the tree is not intolerant of shade like the Eucalypts, and seems well fitted for sowings and plantings in impoverished sholas, or wherever the natural forest is worked systematically for its improvement or for a revenue. It may be mentioned here that nowhere in the Eucalypt plantations is there any evidence of natural reproduction from seedlings, while natural reproduction from coppice shoots is equally at fault in the Melanoxylon plantations.

32. A quarter of an acre of Wattle coppice was felled clean, and the Acre-increment calculated will be found in its place among the tables of Acre-increments. The sample area of *Acacia melanoxylon* had a gradient of about 1 in 8 and a southerly aspect: elevation 6,384 feet. Though the trees as they now stand in the ground are irregularly placed, being I suppose, those spared by the Loranths; their crowns form a fairly even "covert" or "leaf-canopy" overhead, leaving less room for interpolating blanks than would be at first supposed.

CHAUGHATKALLI.

EUCALYPTUS GLOBULUS.

33. In this plantation the only work done was the measuring of 23 trees which had been originally selected and felled as Factor trees when it was proposed to take a sample area in the plantation. On account of the irregularity of the stock, which has suffered from fire and wind, and has been felled to some extent, and the uncertainty with regard to the age of the trees in different parts of the plantation, it is not well adapted to furnishing figures of growth. The Individual increment obtained from these 23 trees, 1·3659 cubic feet, indicates a fair growth, but the figure has only a relative value on account of the few trees measured and the uncertainty with regard to their age. Of the 23 trees, five were average margin trees. These margin trees have naturally a higher Individual-increment than the others, namely, 2·457 cubic feet.

EXPLANATION OF TABLES.

TABLE OF REDUCING-FACTORS.

34. The results of my work are embodied in two series of tables: (1) The table of calculation of Reducing-factors, (2) The table of stock on the sample area. The former I now proceed to discuss, taking as an example the table of calculation of the Reducing-factor for *Arambi* plantation (the first 21 trees). This table is the first of the series and is fuller than those which follow.

35. As the table for the *Arambi* plantation was at first prepared, the Reducing-factor or Form-figure was worked out in terms of the length of bole of each tree. But it was found that the length of bole was not sufficiently fixed for the purpose of these tables. The total height of the tree was therefore substituted for the length of bole as will be noticed in the Factor-table for the second 20 trees at *Arambi*.

As now worked out the Reducing-factor includes the whole tree—branches and bole. Economically this arrangement is the most useful and simple, as the Australian trees, at present, are used exclusively for firewood, for which purpose the stem, branches and twigs are all sold. Thus the total cubic content of a tree equals the sectional area (corresponding to the girth taken at 5 feet from the ground) multiplied by the height, multiplied by the Reducing-factor for a tree of that age and class.

36. Column (1) of the table of calculation of the Reducing-factor shows the number of trees felled and measured in each plantation for the purpose of ascertaining the Reducing-factor.

37. Column (2). The girth is taken at 5 feet from the ground with an ordinary measuring tape. The system of measuring the circumferences with a tape, instead of the diameter with a "diameter gauge" or "forest compass" was adopted at

the outset, as it is slightly more accurate, and there were no diameter gauges available; but owing to the continuous wet weather, during which most of my field work was done, the event proved that it would have been better to have waited and had a set of diameter gauges made. The tapes employed, both metallic and plain, shrank continually. In the *Arambi* and *Brooklands* figures a special correction will be noticed for error of tape. This error was detected by Dr. Brandis in the course of the field work. The tapes were afterwards kept correct by continual testing, comparing and stretching; some time was lost in doing this.

38. I should strongly advocate the use of the diameter gauge when cubages have to be done in wet weather, but otherwise a tape would be the more correct, especially for large trees. I should prefer a diameter gauge with the scale made of brass, with a fixed and a sliding socket of the same material. The sockets would be provided with a short arm of brass truly at right angles with the scale. For measuring large trees the small brass arms could be lengthened with pieces of straight bamboo. I have found ordinary European diameter gauges made entirely of wood liable to stick and warp, though I learn that those used in Northern India are made only of wood. If the table of cubic contents of cylinders to be used is a decimal one, as are most of the modern European tables, the scale of the diameter-gauge should of course be graduated in tenths of a foot; if a duodecimal table, in inches. But, both for use without a table of cubic contents, and for accurate and easy work in the field, I should prefer a diameter gauge graduated in square tenths of a foot so as to read the sectional area at a glance. The cubic content of a tree would then equal simply the diameter gauge reading × height of the tree × the Reducing-factor. This graduation in square tenths of a foot of sectional area would have the advantage that there would be no fractions to work with. One square tenth of a foot of sectional area corresponds to 1″·36 of diameter which is a very fair starting point for the scale: one thousand square tenths correspond to a diameter of 42·9 inches which is a convenient point for finishing the scale of a small instrument. For larger trees the diameter gauge would read up to 1,500 square tenths of a foot of sectional area which corresponds to a diameter of 52·4 inches: for still larger trees up to 2,000 square tenths, which corresponds to a diameter of 60·6 inches. A scale graduated in square tenths of a foot of sectional area would be more accurate to work with than the equally-divided scale for this reason, that the figures shown on it from 1 to 2,000 would have an equal value all through the scale. In working with an ordinary equally-divided scale we are landed in a series of fractions as soon as the cubic content is worked out, and further, as regards the cubic contents of a tree, each division on the equally-divided scale has a different value. For instance, the first inch on an equally-divided diameter gauge represents a difference of sectional area of only two square tenths of a foot. The last inch on the equally-divided scale reading to 60 inches represents a difference of as much as 64·904 square tenths of a foot of sectional area. From this it appears that the ordinary diameter gauge, with an equally-divided scale, reads with superfluous exactness at the bottom of the scale, and with lamentable laxness at the top.

In addition to the advantage of being more accurate to read from, a diameter gauge graduated in square tenths of a foot of sectional area does away, as has been mentioned, with fractions of cubic feet. A glance at any table of cubic contents of trees will show that this means; 1st, shortening the table by about one-half, since all the decimals are got rid of, 2ndly, increased accuracy, since there are no neglected places of decimals. An ordinary table of cubic contents constructed to read with the equally-divided scale begins with minute fractions of a cubic foot, and at the end proceeds by bounds of several cubic feet. This inequality is multiplied by the length of the tree, if the length is 100 feet by 100, and so on: the larger the tree in circumference, the greater is the chance of error with the equally-divided diameter scale, and it follows that the larger the tree in height by so much the more is this error magnified.

The diameter gauge here described I shall have constructed and graduated in square tenths of a foot of sectional area as early as possible. To a great extent a diameter gauge so graduated would do away with the necessity of a table of cubic contents. A scale graduated in square tenths of a foot of sectional area gives whole numbers from 1 to 1,000, to 1,500 or to 2,000, and the cubic content of the cylinder will equal one of these whole numbers multiplied by the height of the tree. The result is in whole hundredths of a cubic foot. To convert this into cubic feet it is only necessary to perform the nominal calculation of multiplying by 100.

Example.—Diameter gauge reads 121. Height of tree = 60 feet. Then cubic contents of cylinder = 121 × 60 ÷ 100 = 72·60 cubic feet.

For use with a diameter gauge graduated thus in square tenths of a foot of sectional area the table of cubic contents becomes one of simple multiplication, with which it would be easy to combine the Reducing-factor, or, if figures were available, the average height. In India where there are no old-established tables of Reducing-factors, and average heights for corresponding diameters, and where for each "cubage," or measurement of standing stock per acre, it is necessary to take a Reducing-factor and work out the cubic content from that of the ideal cylinder, a diameter gauge graduated, as I have described above, in square tenths* of a foot of sectional area would lighten and simplify the whole work. In the same manner, a girthing tape graduated in square tenths of a foot of sectional area, would render the subsequent calculations of cubic contents more easy and more accurate.

39. Column (4) in the table of "Calculation of Reducing-factor" for *Arambi* shows the height of the trees. This is the height taken from the ground level to the topmost twig with a tape, after the trees have been felled for the purpose.

40. Column (5) gives the cubic content of the ideal cylinder obtained by multiplying the sectional area at 5 feet from the ground by the height of the tree. The first part of the table ends with the cubic content of the ideal cylinder; the second part of the table gives measurements and the calculation of the true cubic content of the tree; the last column shows the relation between the ideal cylinder and the true cubic content, *i.e.*, the Reducing-factor. The first four columns give all the figures which are available in measuring a standing tree. The "Reducing-factor" or "Form-factor" is the fraction which expresses the relation between the true cubic content and the cubic content of the ideal cylinder. To obtain the true cubic content of the tree it is necessary to fell it. The trunk is then measured in sections as small as may appear necessary from the shape of the bole; the branches, always too irregular to measure, are weighed, and the twigs and the leaves, if they are worth taking into account, should be weighed too.

41. Column (7) shows the cubic contents of the boles, or trunks of the trees, obtained by measuring them in 10-foot sections. In the table of the first Reducing-factor taken, that for the first 20 trees at *Arambi*, will be found two columns, one No. (7) showing the cubic content of the bole as measured in 10-foot sections, the other No. (6) as measured in 5-foot sections. The difference between these figures was considered small enough to allow of measurement by 10-foot sections only in subsequent work. There is naturally some difference in the first or lowest sections measured. The bole of a regular plantation tree slopes fairly evenly from the top to within 2 or 3 feet of the base, but there, we meet a rapid increase in diameter, and were it not for another cause, this bulging which occurs at the base of all trees would tend to make a cubage from 5-foot sections read higher than a cubage from 10-foot sections, since the 5-foot sections would measure the bulge at the base more closely.

Looking, however, at the *Arambi* Factor-table, it will be observed that the cubic contents derived from 10-foot sections are usually slightly higher than those from 5-foot sections; it is evident, therefore, that the 10-foot sections give an excess somewhere which more than compensates for the loss in measuring the bulge at the base of the trunk. It is perhaps not easy to account for this: it may, however, be explained thus:—Imagine a tree sawn longitudinally down the middle and that we stand facing the section. The line of section above and below through the bark shows near the base end of the tree a short concave curve, then, following the trunk towards the apex, are convex curves which are nearly straight lines on a 10-foot section; then appear sharper convex curves to the top of the trunk. In measuring the trunk of a tree as it lies on the ground, it is necessary to take sections so small that these curves are practically straight lines. But however small the sections, some error remains, and,

* This unit, which is a little more than a square inch, might perhaps be conveniently distinguished by the word doigt or square doigt: a doigt would then be the decimal of a foot, and one cubic doigt would be the hundredth of a cubic foot.

where the girth of a section is measured in the middle, the error is one of excess for convex surfaces, of loss for concave surfaces. To repeat; the lower central portion of the trunk of a tree is often nearly cylindrical, below is the bulge at the base, above towards the crown the trunk tapers more rapidly. Sections taken where the taper becomes more rapid are in fact on a convex surface: this would affect several sections, and more than balance the loss on the one or perhaps two sections taken on a concave surface at the base. Thus the final result is an excess error, this excess error being greater the larger the sections: hence comparing the cubic contents of the trees measured at *Arambi*, both in 5-foot and in 10-foot sections, we have the result that on an average the 10-foot sections give a slightly higher result. It follows also, that, since in measuring the trunk of a tree in sections, the gain at the top end of the trunk more than compensates the loss in measuring the bulge at the base, there is no advantage in taking two or three smaller sections at the base of a tree with the idea of measuring the trunk more closely. It is here assumed that the mean girth of each 5-foot or 10-foot section is the girth measured at the middle of the section. This is the simplest plan of working, and (even in the case of sections of a trunk with an irregular taper) is as near the truth as measuring the section at each end and taking the mean of the figures obtained. With the latter plan the error is reversed being one, of excess with concave tapers and, of deficiency with convex tapers. From the *Arambi* table it will be seen that in the 16 regular trees first measured the average difference between the cubical contents of a tree when measured in 10-foot and in 5-foot sections is an excess in the 10-foot sections of one-fifth of a cubic foot per tree.

42. Column (8) gives the contents of the top and branches obtained by cutting up and weighing the head of each tree. To convert the weight of the branch-wood thus obtained in pounds into cubic feet, it was necessary to know the weight of a cubic foot of green branch-wood measured over the bark. At first such data as existed were taken—see the *Arambi* table. Afterwards a series of weighings was made of billets of *Eucalyptus globulus* and *Acacia melanoxylon*. The billets so weighed were selected out of the heaps of branch-wood which had been weighed in determining the various factors. Billets straight and of regular taper were chosen, cut off clean at each end (usually to some convenient length) and then carefully measured and weighed. Full particulars of these weighings are given in separate statements. The twigs and leaves of the factor trees were estimated in head loads, this being the only form in which they have any value. It would have been interesting to have found out the dry weight of a head load of green twigs, but in the weather which prevailed during my field work this was impossible. A head load is reckoned at 60 lb.: it would dry down to 20 or 25 lb., and a cubic foot of dry wood of *Eucalyptus globulus* with bark weighs about 40 lb. Half a cubic foot was therefore assigned as the value of a head load of twigs, and all the figures in column (8) are calculated at this rate.

43. Column (9) gives the true cubic contents of the tree obtained by adding together columns (7) and (8). The Reducing-factor then follows in column (10) obtained by dividing, the true cubic contents, by the ideal cylinders. This can be done in two ways: 1st, by taking the average of the individual factors obtained from each tree; 2ndly, by dividing the total cubic feet in column (9) by the total cubic feet in column (5). It would appear at first sight that the first method is the more correct. We have Form-factors for 20 trees and the mean of these 20 factors represents the average form. But as regards the figures of cubic contents this average is not a true one. Take the extreme case of two trees—one containing, say, 50 cubic feet, and one containing 1 cubic foot; it would be practically correct to employ the factor of the larger tree for trees of both classes, but very erroneous to employ the factor of the smaller tree for trees of both classes. The true average is one in which the factor from each tree influences the general Form-factor in proportion to the cubic contents of the tree. This average is obtained by dividing the total figures in each column (of ideal cylinders, and of true cubic contents) the one by the other. In the following statement both values of the factor are given. It will be seen that they differ but slightly. This is because of the very uniform growth in close plantations of the *Eucalyptus globulus* and *Acacia melanoxylon* which causes the factors for plantations of different ages and trees of different sizes to be nearly identical.

Plantation.	Age.	Factor. First Value.	Factor. Second Value.	Species of Tree.
	YEARS.			
Arambi	19	0·460	0·450	Eucalyptus globulus.
Norwood	10	0·446	0·445	
Bathri	5	0·496	0·472	
Ralia	10	0·460	0·457	
Brooklands	20	0·401	0·393	
Norwood	10	0·558	0·546	Acacia melanoxylon.
Ralia	10	0·558	0·547	
Bleak-house	26	0·539	0·536	
Total ...	...	3·918	3·846	
Difference ...	...	0·072		
Mean Difference ...	...	0·009		

The second value of the Reducing-factor is the one used in these tables of growth. In the same plantation amongst trees of about the same height the larger trees taper more and have the lowest factors: hence the second value is rather less because it is duly influenced by the larger trees, this influence being in proportion to their cubic contents. The smallest difference in the values is seen in the *Norwood* Eucalypts, probably because there happened to be among the trees felled and measured for the factor two small dominated trees with abnormally low factors. The mean difference between the two values for the Reducing-factor is ·009.

Factor Trees how chosen.

44. In *Arambi* the factor trees were a group of 20, standing in one corner of the sample area. The trees are of very regular growth in *Arambi*, and these trees doubtless gave a very fair average. In the other plantations the best possible average was obtained by felling every tree which came within a band, a yard broad, taken round the sample area on its outside edge, till 20 trees were obtained. In this manner trees of every form were included and made to influence the general factor for the plantation in proportion to their cubic contents. To instance two opposite forms:—There were two Eucalypts partially dominated and with scarcely any head remaining among the *Norwood* factor trees; there was a large Acacia among the factor trees at *Bleak-house* forking and reforking from the base, the whole tree composed entirely of branch-wood.

Factors for various classes of Trees.

45. Comparing the factors obtained, we see that, as regards age, *Bathri*, the youngest plantation measured, has a very slightly higher factor than the other Eucalypt plantations. Here the trees, quite young, furnished with branches to the base and with ample bushy heads, would tend to have a slightly higher factor. Their form approaches that of a bush. In the *Norwood*, *Acacia melanoxylon*, Factor table is a small tree noted as being little better than a bush, with a factor as high as ·75, and there is a similar curiosity on a large scale among the *Bleak-house*, *Acacia melanoxylon* trees, namely, tree No. 2, with a factor of ·64.

In Brooklands some of the trees have a form of trunk which (without the branches) would be expressed by a figure a little below ·33 (a cone), because the shape of these trunks approaches that of a cone bulging at the base. But the large quantity of branch-wood brings the factor for these trees up to ·39. Turning to the *Acacia melanoxylon* plantations, it will be observed that *Norwood* and *Ralia* have factors which are the same. The Acacia factor at *Bleak-house* is slightly lower, the trees being further apart and hence with more tapering trunks. Here, again, though there is much

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branch-wood, its abundance does not make up for the extra taper of the trunk in trees grown far apart.

Trees on the margin of a close high plantation have a form which differs both from that of the ordinary plantation tree and from that of trees grown quite isolated.

The Form-factor used for each plantation will be found in the statement of Acre-increments (page 20) and again in the tables of stock per acre. The factors for five margin trees at *Arambi* will be found at the foot of the table of the first 21 trees taken. As has been explained, the figures in this table are not absolutely correct, the length of bole having been taken in the first instance instead of the total length of tree. Relatively, however, the comparison between the margin trees and the others stands good. The first two of these margin trees, with a cubic content rather above the average, have a height not much above half the average. The last margin tree with a cubic content of 96 cubic feet was the largest tree measured by me in the *Arambi* plantation. It was nearly isolated, standing by itself outside the plantation: its Form-factor is lower than the average of the trees inside the plantation, just as the *Brooklands* trees with their gnarled squat trunks have lower Form-factors than the straight nearly cylindrical trunks of a close plantation tree.

46. The following table shows the Reducing-factors which have been obtained and the class of trees to which they are applicable:—

Plantation.	Age.	Form-factor.	Remarks.
	YEARS.		
Bathri	5	0·47	The Form-factor for a young close Eucalypt plantation: it was used by me for this, and for the Black-bridge plantations.
Norwood	10	0·45	The general Form-factor for a closely-grown Eucalypt from 5 to 20 years old is 0·450.
Ralia	10	0·46	
Arambi	19	0·45	
Brooklands	20	0·39	The Form-factor for a Eucalypt grown isolated and in an exposed situation.
Norwood	10	0·55	The Form-factor for young trees in a close plantation of *Acacia melanoxylon*.
Ralia	10	0·55	
Bleak-house	26	0·54	The same in an older plantation where the trees are farther apart.

Table of Stock on the Sample Area.

47. The following remarks will serve to explain the nature of the entries in the tables of stock on the sample area.

Column (1) shows the trees which were measured, numbered consecutively.

48. Column (2) shows the girth at 5 feet above the ground, which is the most convenient height for measuring. These girths were all measured with a tape as has been already described in speaking of the girth measurements of the trees measured for the Reducing-factor.

49. Column (3). At first when the older plantations with the tallest trees were being measured, the heights were taken in the following manner:—A sample tree of straight and vertical growth was selected and measured with the dendrometer (Nancy pattern), and then the heights of the trees immediately around this were estimated by eye: this plan is more accurate than that of measuring each tree, more or less hurriedly, with the dendrometer. For trees of irregular growth, especially if not vertical, or in the case of trees with the top bent by a high wind, the dendrometer is not to be relied on for direct measurement. In the younger plantations, a 30-feet pole was employed: this pole, with a red flag on the top, was carried by two coolies and placed against each tree in succession, the height of each tree being estimated by eye from the 30-feet pole.

50. Column (4) shows the cubic contents of the ideal cylinders obtained by multiplying the sectional area corresponding to the girth at 5 feet by the total height

of the tree. The girth at 5 feet being expressed in inches and the height of the tree in feet, the cubic content of the ideal cylinder in cubic feet was entered from a German table of cubic contents belonging to Mr. Gass. This table is by G. Koenig of Gotha. It gives the cubic contents in feet direct from the girth in inches and the height in feet, and for working with a tape nothing could be more convenient. It however does not deal with trees above 100 feet in height, and when decimal places are rejected the usual correction has been omitted. With these two faults supplied the table being one of simple cubic contents from girths and heights is one which ought to be in the hands of every Indian Forester and it is the kind which is most likely to be generally useful. For, one can hardly look forward to tables of cubic contents combined with Form-factors and average heights for the many species in the mixed and irregular forests of this country; and a tape as compared with a diameter gauge has the advantage of being always at hand. If a diameter gauge were used I should prefer it graduated, as I have explained, in square tenths of a foot of sectional area, and a table to accompany it would be one of simple multiplication of integers. This table and an English reprint of Koenig's table might be easily prepared and printed at little cost, and they would be the most generally useful for "cubages" or measurements of standing stock in various descriptions of forests.

51. Column (5). To save the labour of repeated multiplications the Reducing factor is, in the table, applied to the totals of ideal cylinders instead of to the ideal cylinder of each tree.

Column (6) could be filled up at any time if it were thought desirable to show the true cubic content of each tree separately: for comparison between trees the cubic contents of the ideal cylinders serve every purpose, it being remembered that the ideal cylinders are always about double the true cubic content of each tree.

EXPLANATION OF THE SUMMARY AT THE HEAD OF THE TABLES OF STOCK PER ACRE.

52. The ages of the plantations measured have been taken from the records in the office of the Deputy Conservator of Forests, Nílgiri Division. The "cubages" being taken during the first half of the monsoon, it was convenient to reckon in whole years from the date of planting. To obtain the age from seed six months must be added to the figures given in these tables.

Sample Areas.

53. With one exception, the *Old Forest* plantation, the sample areas were taken in the oldest portion of each plantation. In the *Old Forest* plantation the sample area was taken in the second year of planting in order to keep clear of thinnings. The area of the sample areas varied from 1·7 acres in *Bathri* and *Bleak-house* plantations to ·932 of an acre in *Newman* plantation: the large areas in *Bathri* and *Bleak-house* were taken because they were rather irregularly stocked and a true average was very important for plantations of that age. In most cases the area of the sample area was an acre and a fraction. The sample area at *Newman* was restricted by the nature of the ground: had we taken the sample area elsewhere, it would have involved heavy unrecorded thinnings. The form of the sample area was always that of a band, usually one, or one and a half, chains broad, so as to get a good average from the trees measured. At *Ralia* it was necessary to make the sample area conform to the mixed planting which is in alternate strips of *Acacia melanoxylon* and of Eucalypts. This area was surveyed with the plane table. In all the other High-timber plantations the sample area was taken rectangular and measured with a chain.

Stock per Acre.

54. The figures which will be found against the entry "Sample area carries per acre" are the record of the actual stock now standing per acre. The increment per acre per annum is a calculated figure allowing for—1st, previous thinnings; 2ndly, for present blanks in the covert or leafy canopy. A blank in the covert, unless it is the result of recent thinnings, when a double reckoning must be guarded against, means simply the loss of so much space which must of course be allowed for in calculating the Acre-increment. Thinnings, representing what has been already produced, are naturally, in every case, included in the calculation of the Acre-increment. Where

any portion of the Acre-increment is derived from blanks or thinnings, there is an entry at the head of each table of stock showing how much of the Acre-increment comes from these sources.

55. For ready reference the Acre-increment is expressed both in tons and in cubic feet, the weight of a cubic foot of wood of *Eucalyptus globulus* (dry wood with bark) being taken at 40 lb.; this equals 56 cubic feet per ton. The weight of a cubic foot of dry wood of *Acacia melanoxylon*, measured over bark, is taken at 35 lb.; without bark it is 36 lb. (Nílgiri, and probably young, wood—see Manual of Indian Timbers by J. S. Gamble). The wood of *Eucalyptus obliqua* when dry is slightly lighter than that of *Eucalyptus globulus*, and the bark is thicker, thus—

	Age.	Mean thickness of Bark at 5 feet from ground.
	YRS.	INCHES.
Eucalyptus obliqua	10	0·525
Do. globulus	10	0·370

The weight of the wood of *Eucalyptus obliqua*, dry and measured over bark, is taken therefore at 38 lb. the cubic foot, *Eucalyptus globulus* being 40 lb. per cubic foot.

There are not sufficient trees of *Eucalyptus obliqua* to fell and determine the factor. Stringy-barks are usually rather shorter than trees of the same girth of *Eucalyptus globulus*. The factor for *Eucalyptus globulus* at 10 years is 0·45, that for *Eucalyptus obliqua* is assumed at 0·02 less, namely, 0·43—*vide* table showing the growth of *Eucalyptus obliqua* at *Ralia*.

There are a few trees of *Eucalyptus calophylla* in *Norwood* and *Ralia*: they show a very poor growth and are not worth while considering separately.

INCREMENTS.

Acre-increment.

56. We come now to the consideration of the figures of growth (Increments) which have been obtained. Increments referred to in this report are of two kinds:

1*st.*—The yearly Increment of stock per acre per annum or the *Acre-increment.*

2*ndly.*—The yearly Increment of average individual trees, or the *Individual-increment.*

Of these, the first is the most important; it gives tangible expression to the growth of trees in masses, where only they attain their best form and largest size, and where the light, and the space which they occupy, are utilized to the fullest possible extent. It is rarely a figure which can be obtained simply from actual measurement of stock on the ground. Irregularities in the wooding, and blank places have to be allowed for. Many of the plantations on these hills are models of regular growth, but a plantation must necessarily be thinned if it is to be kept at the maximum of production, and thinnings must be very carefully registered in order that they may be valued correctly in subsequent years. This cannot, in fact, be done without working plans, of which none have been prepared for the Nílgiri plantations. In the absence of working plans the thinnings have been estimated, as has been explained in the individual histories of the plantations, from the best data available. The following *Table of Acre-increments* shows at a glance how far thinnings and blanks enter into the calculation of each Acre-increment and brings together other information bearing on this important figure:—

TABLE OF ACRE-INCREMENTS.

Plantations.	Area of Plantation in Acres.	Age of Sample Area in Years.	Elevation in Feet.	Area of Sample Area in Acres.	Number of Trees per Acre now on the ground.	Reducing Factor used.	Actual Stock now on the ground per Acre, Cubic Feet.	Yearly Individual-increment (Actual), Cubic Feet.	Yearly Acre-increment (calculated), Tons * of Dry Wood.	Details of Acre-increments: From Standing Stock. Tons Dry Wood.	From Blanks in Canopy. Tons Dry Wood.	From previous Thinnings. Tons Dry Wood.
Eucalyptus globulus or Blue-gum.												
Bathri	60	5	7,235	1·708	847·19	0·4717	2,966	0·70021	13·067	10·593	2·474	...
Blackbridge ...	48	6	5,954	1·000	980·00	0·47	2,151	0·36583	6·682	6·395	(a) 0·287	...
Old Forest	200	9	6,694	1·057	1045·41	0·457	5,963	0·63383	11·993	11·832	0·161	...
Norwood	26	10	7,550	1·221	416·00	0·447	6,829	1·64171	13·434	12·196	(b) 0·263	0·975
Ralia	60	10	7,215	(c) 0·269	523·19	0·45	6,960	1·33025	12·428	12·428	...	...
Newman	35	12	7,185	0·932	1323·50	0·455	6,792	0·42766	11·039	10·107	0·015	(d) 0·917
Arambi	58	19	7,460	1·406	498·58	0·4503	9,031	0·95338	12·063	8·488	...	(e) 3·575
Brooklands ...	10	20	7,300	(f) 0·326	(f) 100·00	0·3926	8,636	4·31800	(g) 7·710	7·710	...	Unknown.
Marlimund ...	11	22	7,550	0·599	65·11	0·43	5,997	4·18661	(g) 9·485	4·867	4·618	Do.
Acacia melanoxylon or Australian Black-wood.												
Ralia	60	10	7,215	0·5493	592·00	0·547	3,845	0·64952	5·858	5·858	...	...
Bleak-house ...	235	26	6,384	1·778	162·54	0·5357	7,336	1·7351	(g) 5·751	4·408	1·343	Unknown.
Acacia dealbata or Wattle tree.												
Bleak-house ...	235	4	6,384	0·2575	Indefinite.	...	...		(h) 3·00	3·00	...	...

(a) Approximate, the plantation being irregular and the covert not properly established.
(b) From nine blanks.
(c) This is the area of the two bands of *Eucalyptus globulus*.
(d) The thinning was estimated by counting the stumps which are quite recent.
(e) This is an approximate estimate—*vide* the history of the Arambi plantation.
(f) *Vide* Table of Spread of Branches. The Acre-increment here is only an approximation.
(g) The Acre-increment is deficient by the amount of previous thinnings which cannot be estimated.
(h) 8·154 tons is the weight of Wattle brushwood, *green*; for comparison with the other Acre-increments it may be taken as about equal to 3 tons of dry wood.
* *Vide* page 29 for weight of dry wood with bark, per cubic foot .. { Eucalyptus globulus, one ton = 56 cubic feet. Acacia melanoxylon, one ton = 64 ,,

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57. Comparing together the Acre-increments of the several plantations as exhibited in this table, the most striking feature is, that although in the case of the Blue-gum we have ages from 5 up to 22 years, there is no marked rise or decline in the Acre-increments. *Bathri*, 5 years old, has an Acre-increment of 13 tons; *Norwood*, at double that age, 13·4 tons; *Arambi*, at nearly double the age of *Norwood*, shows a decline to 12 tons; but *Arambi* has certainly suffered from not having been properly thinned. The increments calculated for *Brooklands* and *Marlimund*, 7·7 tons and 9·5 tons, respectively, take no account of previous thinnings (for which there are no data): if the thinnings could be included it is probable that the Acre-increment would be 12 or 13 tons. What appears established beyond a doubt from this table of Acre-increments is that *a Blue-gum plantation, whether planted 6′ × 6′ or 9′ × 9′, will, if fully stocked, at 10 years show a growth of 12 tons per acre per annum.* The *Bathri* figure indicates that the Acre-increment may reach 12 tons as early as 5 years in the case of a plantation planted 6′ × 6′. *Black-bridge* however, the next in point of age, whether owing to a poorer soil or a lower elevation, has an Acre-increment of a little under 7 tons at 6 years. The next plantation on the list, *Old Forest*, is one of the best on the hills. Its Acre-increment of just under 12 tons at 9 years is from a piece of planting *not above the average* in appearance, and selected, as has been explained, because it was free from unrecorded thinnings. It may be asserted positively that the whole of the 200 acres of the *Old Forest* plantation is now making wood at a rate of not less than 12 tons per acre per annum.

Norwood plantation, the next on the list, has the highest Acre-increment obtained, namely, 13·4 tons. Of this figure just under a ton comes from thinnings. It may be, to some extent, to careful thinning that this plantation owes its high increments. The next plantation, *Ralia*, planted at the same distance 9′ × 9′, and at practically the same elevation, has within a very small fraction the same Acre-increment as *Norwood*, if we subtract the thinnings at *Norwood*. The figures of standing stock per acre, as has been mentioned, show a close correspondence, *Norwood* having 6,829 cubic feet per acre of actual stock now on the ground, while *Ralia* has 6,960 cubic feet. *Newman*, two years older, shows a falling off of $1\frac{1}{2}$ tons from Ralia and of $2\frac{1}{2}$ tons from Norwood, but it is possible that this decrease appears greater than it really is for the reason that there is some doubt whether the age of the sample area in Newman is 12 or 11 years. The planting of *Newman* plantation was two years in progress, and the appearance of the stock on the sample area would rather indicate that it was planted during the second year of planting. The distance of the sample area from the nursery would support the same view, the portion of a plantation nearest the nursery being usually that which is first planted. But, on the other hand, such evidence as could be gathered from the memory of forest officials and Badagas who had done the planting, was to the effect that the sample area was planted during the first year of planting: it was safest to accept the higher figure and the age was accordingly taken as 12 years. Nothing but a working plan could be conclusive on such a question: it is especially unfortunate that working plans have not been made for plantations which, if only for their remarkable growth, must ever present features of exceptional interest in Indian Forestry. The *Arambi* Acre-increment has already been referred to; the figures might be taken as showing a falling off in the Acre-increment of a Blue-gum plantation at 19 years, but if the plantation had been properly thinned, if a register of thinnings had been kept, and interest allowed on these thinnings in making the calculation, it might be expected that *Arambi* would show a firm Acre-increment of 12 tons at 19 years. As the figures now stand *Arambi* at 19 is a ton above *Newman* at 12 years of age.

The Acre-increments at *Marlimund* and *Brooklands* are but approximations, but could the thinnings be estimated, there is little doubt that these plantations would show Acre-increments equal to any that have been obtained. These plantations have been thinned to the point of isolating the trees, which are now in the position of standards, at *Brooklands* over Wattle, and at *Marlimund* over young Blue-gum planting.

Influence of Climate on the Growth of the Blue-gum.

58. The figures of Acre-increments that have been obtained afford no support to the opinion that the Blue-gum has a higher Acre-increment in the plantations to the east of the Dodabetta range than in those plantations lying on the western or

Ootacamund side. As will be noticed from the table of Acre-increments, where there are two plantations of the same age and planted at the same distance apart, the comparison is in favor of the plantation near Ootacamund :—

Age.	Distance of Planting.	Near Ootacamund.		Near Coonoor.	
		Plantation.	Acre-increment.	Plantation.	Acre-increment.
			TONS.		TONS.
5 years	6′ × 6′	Bathri ...	13·0	Black-bridge...	6·9
10 „	9′ × 9′	Norwood ...	13·4	Ralia	12·4

There is little difference in the elevation of these plantations, except that *Black-bridge* is decidedly lower, and here the Acre-increment is markedly lower than in the other plantations. Comparing *Norwood* and *Ralia*, where the age and distance apart are the same and the elevation very similar, *Norwood* near Ootacamund has an Acre-increment better by a ton than *Ralia* on the eastern side of Dodabetta.

During the past unusually violent monsoon there is no doubt, however, that some of the plantations to the west of Ootacamund have suffered severely. Large portions of the Governor's shola group of Eucalypt plantations have had their foliage nipped and scathed as if fire or frost had passed over them. The Acre-increment for the present year in these plantations cannot but be lowered and the trees must suffer in health. The past severe monsoon has in no marked way affected the plantations to the east of the Dodabetta range. I have nowhere observed that peculiar action of the monsoon by which the young foliage of the Blue-gum is withered, shrivelled and killed. This action is not analogous to a wintering or fall of the leaf: it is the young foliage and tender shoots at the top of the trees which are attacked first. Probably in ordinary years, or always where the situation is sheltered, in the cooler and damper climate of the west side of the Dodabetta range, the Ootacamund plantations (other circumstances being equal) have a higher Acre-increment than the plantations near Coonoor and Wellington. It must be borne in mind that in Australia it is most markedly in the cold, damp climate of the south-eastern mountains that the Eucalypts attain that wonderful development and rapid growth which has caused the Blue-gum to be planted all over the civilized world and especially in cool mountainous regions in low latitudes, such as California, South Africa and Southern India.

59. Where the effect of the monsoon is most to be considered in the Ootacamund plantations is when we come to compare the stock on the total area with that on the sample area. In plantations in exposed situations to the west of Ootacamund the stock is in places deficient and irregular; here and there are areas where planting has been a failure. In the Coonoor plantations the stock is generally more regular and more equal throughout to that on the sample area. Doubtless the question of planting shelter bands of dense growing trees to the windward of plantations in exposed tracts will receive attention. The Blue-gum with its slender branches and scanty foliage is itself singularly unfitted for planting as a barrier against wind. A dense band of *Acacia melanoxylon* would be more serviceable in this respect. The following trees are of rapid growth at Ootacamund as may be noticed in the case of the fine specimens of them in the Government gardens, and they appear well fitted for planting as barriers against the wind and for forest purposes generally :—

> *Frenela rhomboidea* or Oyster-bay pine,* seeds and reproduces itself readily from seed. There is a thicket of self-sown seedlings of these trees near Bishops-down.
>
> *Pinus insignis*, probably the fastest-growing Conifer on the Nilgiris.
>
> *Cupressus torulosa* reproduces itself from self-sown seedlings.

They are all of a dense sturdy habit of growth, and appear to be sufficiently hardy for planting on a large scale.

* Stated to be an important forest tree in the Colony of South Australia—*vide* Conservator's 1st Annual Report, "Indian Forester," 1880.

Acre-increment of Acacia Melanoxylon.

60. For the determination of this instructive figure only two plantations were available for measurement, and of these two plantations, only the figure from the *Ralia* plantation is complete.

The *Ralia* Acre-increment, it will be seen, is just under 6 tons at ten years. The Acre-increment is 12·43 tons from the Blue-gum growing in bands side by side with the Melanoxylon, the two species being thus placed in every respect under identical conditions. Thus in *Ralia* plantation the growth of the *Acacia melanoxylon* is as nearly as possible one-half that of the Blue-gum tree. From the figures before us of the Acre-increment at *Bleak-house*, which is 26 years of age, it would appear that the Acre-increment rises after ten years. The thinnings at *Bleak-house* plantation have been severe and continued: it was necessary to take out the Melanoxylons as they were successively attacked by Loranths. No record of these heavy thinnings has been kept; but, leaving them entirely out of consideration, there is still left an Acre-increment of 5·76 tons. Now at *Ralia*, where there have been no thinnings the Acre-increment at ten years is 5·86 tons. It appears therefore that the *Bleak-house* Acre-increment exceeds the *Ralia* Acre-increment to the extent of all the stock removed in the heavy thinnings at the former plantation. To summarize; the Acre-increment of *Acacia melanoxylon* at ten years is one-half that of *Eucalyptus globulus* at the same age; and there is reason to believe that afterwards the Melanoxylon Acre-increment rises slowly while the Blue-gum Acre-increment remains stationary, or possibly declines gradually.

Acre-increment of Acacia Dealbata or Wattle.

61. A quarter of an acre of Wattle coppice 4 years old at *Bleak-house* plantation was felled clean, the firewood weighed, and the area which was irregular surveyed with a plane table. The figure obtained, 8·154 tons, it must be remembered, represents green-wood twigs and leaves, and to be compared with other Acre-increments which refer to dry wood it must be reduced to about 3 tons. All coppice (and Wattle is no exception to the rule) grows very rapidly at first, but after a few years its Acre-increment is exceeded by that of high forest. It is probable that the Acre-increment from Wattle coppice never rises beyond 3 tons per annum, and that at ten years it is about $\frac{1}{4}$ that of the Blue-gum.

Individual-increments.

62. When the Acre-increment cannot be obtained, much may be learnt from a consideration of average increments per annum of individual trees. Where the stock in a plantation is irregular, or where trees are scattered and isolated, the Individual-increment is the only certain figure of growth which can be obtained. The figures below are consequently rather more complete than the corresponding Acre-increment figures :—

Table of Individual-increments.

Plantation.	Age in Years.	Number of Trees per Acre.	Individual-increment in Cubic Feet.	Number of Trees from which the average is taken.
Eucalyptus globulus or Blue-gum.				
Bathri	5	847·19	0·70021	From 1,447 trees.
Black-bridge	6	980·00	0·36583	„ 980 „
Old Forest	9	1045·41	0·63383	„ 1,105 „
Norwood	10	416·00	1·64171	„ 508 „
Ralia	10	523·19	1·33025	„ 141 „
Chaughátkalli	11	...	1·36590	„ 23 „
Newman	12	1323·50	0·42766	„ 1,234 „
Arambi	19	498·58	0·95338	„ 701 „
Brooklands	20	100·00	4·31800	„ 31 „
Marlimund	22	65·11	4·18661	„ 39 „

Plantation.	Age in Years.	Number of Trees per Acre.	Individual-increment in Cubic Feet.	Number of Trees from which the average is taken.
Eucalyptus obliqua or Stringy-bark.				
Ralia	10	...	1·52438	From 18 trees.
Eucalyptus calophylla.				
Ralia	10	...	0·17000	From 11 trees.
Acacia melanoxylon or Australian Blackwood.				
Ralia	10	592·00	0·64952	From 314 trees.
Bleak-house	26	162·54	1·7377	„ 289 „
Norwood	10(?)	...	0·266 (?)	„ 72 „
Blue-gum Coppice.				
Newman	2	...	0·35945	From 147 trees.

These figures, it will be observed, vary between sufficiently wide limits, from an Individual-increment of a little above $\frac{1}{3}$ of a cubic foot per annum at Black-bridge to the $4\frac{1}{2}$ cubic feet per annum of the *Brooklands* standards. These Individual-increments demonstrate what would have been expected, namely, that provided the soil is covered with foliage,—provided the "couvert" remains unbroken, it matters little, as regards the production of wood per acre, how many trees go to the acre. The *Old Forest* and *Ralia* of nearly the same age and Acre-increments, have very different Individual-increments. In the *Old Forest* (planted 7′ × 6′ in the sample area) an average tree makes only 0·63 of a cubic foot per annum. In *Ralia* planted 9′ × 9′ the average tree makes 1·33 cubic feet per annum. Thus an average tree in *Ralia* does more than double the work of an average tree in the *Old Forest*.

In *Norwood* (planted 9′ × 9′ and now ten years old), which has been thinned down to only 416 trees per acre, the average tree makes 1·64 cubic feet per annum. The highest Individual-increments are those from the *Brooklands* and *Marlimund* standards. The contrast between the Individual-increments of these trees and of those of about the same age in the *Arambi* plantation is very remarkable, and has been described already in the history of these plantations. It is an extreme case, where, with similar ages and Acre-increments, the "couvert" being complete in both cases, the same work is performed by 100 trees in one plantation (*Brooklands*) and by 500 trees in another (*Arambi*).

The Individual-increment from *Chaughattkalli* refers only to 22 trees which were felled to obtain a Reducing-factor and not used for this purpose. The Individual-increment from the Stringy-barks at *Ralia* refers only to 18 trees which is all that were available for measurement.

Among the Acacias, the rise in the Individual-increments from the 0·65 cubic foot of *Ralia* plantation at ten years to the 1·74 cubic feet of *Bleak-house* plantation at 26 years of age indicates a satisfactory and healthy development of the *Acacia melanoxylon*, exactly as the reverse is indicated for *Eucalyptus globulus* by the fall in the Individual-increments from the 1·64 cubic feet of *Norwood* plantation at ten years to the 0·95 cubic foot of *Arambi* plantation at nineteen years. The last entry in the table of Individual-increments refers to the Acacias at *Norwood*. It was assumed that these Acacias growing amongst and dominated by the Eucalypts were the same age as the Eucalypts, an assumption which appeared afterwards to be doubtfully true. The situation of these Melanoxylons is interesting; they utilize light which the Blue-gums could not, and improve the covert of the plantation. Measurements were therefore taken to establish their Individual-increment compared to the Blue-gums. The Individual-increment appears in the table as only 0·266 cubic foot. That it is so very low is probably due to a mistake with regard to the age of these Acacias though from being dominated

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their increment naturally would be low: the Individual-increment of these trees is entered in the table, but with a mark of interrogation against it.

63. Looking at a mass of trees the distance at which they can be most economically spaced is decided by a study of their increments, and here two questions arise—

1st.—What is the best distance to plant at.

2ndly.—To what distance apart to thin to afterwards.

Planting 9′ × 9′ or 6′ × 6′.

The planting hitherto has been done rectangular at 9′ × 9′ = 537 plants to the acre, or at 6′ × 6′ = 1,220 plants to the acre. Roughly, the cost of planting 9′ × 9′ is one-half the cost of planting 6′ × 6′. The total cost of planting the 1,226 acres of fuel and timber plantations on the Nîlgiris has been Rs. 39,151, or at an average rate of Rs. 31-8-0 per acre. But planting is now done at the rate of Rs. 30 in shola, and Rs. 25 in grass land, per acre of 1,220 trees, or, allowing for failures, let us say, at the mean rate of Rs. 25 per 1,000 trees. Thus planting 9′ × 9′ would bring the cost of planting down to the satisfactory figure of Rs. 13 per acre, exclusive of the cost of supervision. Planting done 9′ × 9′ has been considered inferior to planting done 6′ × 6′. But, as has been mentioned in the history of the various plantations measured, at ten years of age plantations planted 9′ × 9′ look equally well with those planted 6′ × 6′; and putting the matter to the test of figures, we see that *Norwood* and *Ralia* planted 9′ × 9′ have slightly higher Acre-increments than *Newman* and *Old Forest* planted 6′ × 6′ and 6′ × 7′, respectively, the ages of all four being similar. Looking at the Individual-increments of the four plantations, we see that the trees in the plantations planted 9′ × 9′ have three times the development, and are growing on an average three times as fast as those trees planted 6′ × 6′. In *Norwood* and *Ralia* the average height of the trees is 78 feet in *Newman* and *Old Forest* it is 58 feet. The average yearly Individual-increment of the two plantations planted 6′ × 7′ and 6′ × 6′ (*Old Forest* and *Newman*) is ·530 of a cubic foot; the same figure for the two plantations (*Norwood* and *Ralia*) planted 9′ × 9′ is 1·49 cubic feet.

The two younger plantations—*Bathri* and *Black-bridge*—are unfortunately both planted 6′ × 6′, so that we have no comparison of the Individual-increments of trees planted 6′ × 6′ and of trees planted 9′ × 9′ at 5 years of age. Probably, at 5 years of age, with close planting, the Acre-increment would be slightly higher, but the Individual-increment lower.

64. In the large Government Casuarina plantations in Mysore, the planting is now done uniformly 9′ × 9′; it was formerly done 15′ × 15′. On account of the difficulty in keeping down the grass and the slower growth of Casuarina as compared with Blue-gum, even closer planting than 9′ × 9′ would be advisable there, if it could be done economically. Planting 6′ × 6′ would be considered extravagant. Planting 6′ × 6′ on the Nîlgiris is stated to counteract the effect of wind, and this is doubtless the case in some situations: but, apart from wind, planting 9′ × 9′ is certainly more economical, and appears to produce better trees than planting 6′ × 6′. Wind could probably be resisted most effectually by regular shelter bands, as has been mentioned above. The *Eucalyptus globulus* is a tree which appears on the Nîlgiris to require plenty of light. It is the same in the temperate climate of Australia where the Eucalypt forests are described by Darwin as strikingly sparse and open. At low elevations in South India the Blue-gum appears to be less intolerant of shade.

Thinnings.

65. After 8 or 10 years (or even sooner when the planting has been done 6′ × 6′ or the growth is very rapid) the question of wide or close planting resolves itself into one of more or less thinning. Now, in thinning, three things have to be observed:

1st.—The Acre-increment.

2ndly.—The Individual-increment, as the index of the development of each tree.

3rdly.—The average height of the trees. If the plantation is for timber, nothing but keeping trees close together will ensure straight clean stems.

Looking at the table of Acre-increments, among the High-timber plantations of *Eucalyptus globulus*, what first strikes the eye, is, that *Norwood*, with the least number of trees per acre of any plantation, has the highest Acre-increment and by far the highest Individual-increment. It has been thinned down to only 416 trees per acre, and it is evident that, comparing it to the three other plantations of the same age, the yield per acre and the individual growth of the trees at *Norwood* have profited by the thinning. Indeed the Acre-increment at *Norwood* is above the general Acre-increment of the other plantations of the same age by just the amount of the thinning. *Bathri*, 5 years old, and planted 6′ × 6′ has now the satisfactory Acre-increment of 13 tons, but this figure is weak, inasmuch as 2·47 tons come from blanks. To keep the Acre-increment at its present figure and improve the Individual-increment, it will be necessary, in a few years, to thin the crowded portions of the *Bathri* plantation.

66. It is probable, that all the *Eucalyptus* plantations of average growth would be improved by being thinned down to 400 trees per acre, when 10 years old, that is to say, about 100 trees per acre would be removable at 10 years from plantations planted 9′ × 9′. One thinning carefully performed would be more economical and allow of a better selection of trees than several light thinnings. The one specimen we have of an older High-timber plantation, *Arambi*, is a deplorable example of the want of thinning. The comparison between *Arambi* and *Norwood* or *Ralia* is instructive thus:—

Arambi, 19 years old, with 498 trees per acre, has an Individual-increment of 0·953 cubic foot and an Acre-increment of 12·06 tons.

Norwood, 10 years old, with 416 trees per acre, has an Individual-increment of 1·64 cubic feet, and an Acre-increment of 13·43 tons.

Ralia, 10 years old, with 523 trees per acre, has an Individual-increment of 1·33 cubic feet, and an Acre-increment of 12·43 tons.

Of the increments at *Arambi*, the Individual-increment is the worse: it is about half that of the younger plantations, when it might probably have been double without sacrificing the height of the trees. The opinion has been already expressed that a careful thinning would have maintained the Acre-increment at *Arambi* at 13 or 14 tons.

Thinning, instead of Coppicing, the Blue-gum.

67. With such a growth, it is evident that there is nothing to be gained, economically, as regards the production of wood, by sacrificing these fine plantations for coppice. There is as yet no good Eucalypt coppice in Government plantations old enough to be measured, and allow of a comparison of its increment with that of the increments which have been obtained from Eucalypt High-timber forest. Speaking broadly, the gross yield of wood is greater over a term of years from High-timber than from coppice forest, but the revenue from coppice is the greater, if the interest on the money value of the early cuttings from the coppice is reckoned. At the present moment, on the Nílgiris, the market for Blue-gum wood is restricted to a comparatively small demand for firewood which could be met from the regular thinnings of the High-timber plantations, supposing them to be preserved as high forest: and the market-rate of interest on money having within the last few years fallen from 5 to 4 per cent., there is less to be gained by realizing at once. To coppice some of the Blue-gum plantations and to leave others unthinned, as has been the case, is evidently to grasp at the shadow of a higher revenue (in the coppiced plantations) and to lose the substance of an increased Acre-increment (or yield of wood per acre) in them all. As a conclusion from the figures which have been now obtained, I would put forward the suggestion, that coppicing the *Eucalyptus* plantations be suspended until there is a better market for Blue-gum firewood on the Nílgiris, or until we are in possession of figures of the yield of coppice showing that a really larger revenue could be realized from coppice, than from High-timber forest. It must be remembered, too, that the coppice reproduction of the *Eucalyptus globulus* is not always certain. At the *Old Forest* the coppice reproduction is magnificent: at several places, among the Governor's shola group of plantations, it is poor, or has failed altogether. None of the Blue-gum plantations are fenced and cattle do great damage to young Blue-gum coppice, by treading and breaking off the young shoots. If it is decided to continue coppicing the Blue-gum plantations it should be remembered that the increments from the *Brooklands* and *Marlimund* standards are such as to suggest the advisability of

leaving as many standards as possible, consistent with the amount of light necessary for the growth of the coppice.

68. There is, indeed, much to be said in favor of converting the Blue-gum plantations permanently to the form of forest known as Coppice-under-standard forest. As pure High-timber forest there is the difficulty that at the end of the rotation it would probably be necessary to replant. It is not yet established that an old forest of Blue-gums on the Nílgiris would present no self-sown seedlings. Self-sown seedlings are reported to have been observed at Shillong in the Khasia hills under old Blue-gum trees.—(Gamble's Indian Timbers, page 189.) An old High-timber forest will reproduce itself from seed when a young forest will not. A high covert throwing a broken half shade, and an old forest soil, are the best conditions for good natural reproduction from seed, and there is as yet no Blue-gum forest of this class on the Nílgiris. Still the fact remains, that there is no authenticated case of self-sown seedlings of Blue-gum on the Nílgiris. In the Government plantations and under single old trees there is no sign even of the germination of self-sown seed. Indigenous Blue-gum seed is not used by the Forest Department, and it is stated, that when tried in the nurseries, it proved to be inferior to Australian seed. We must therefore accept the fact, for the present, that there is no natural reproduction from seed of the Blue-gum tree on the Nílgiris. Now a Coppice-under-standard forest could be made to reproduce itself almost entirely from coppice shoots. It would afford a steady supply of small wood for firewood, while the standards would furnish a limited supply of large timber suited to the limited demand. The two drawbacks to Coppice-under-standard forest in Europe, namely, that the shade thrown by the standards lowers the growth of the coppice, and that the standards, which are usually of Oak, take a low branching form, would probably apply, in a limited degree, to Blue-gum Coppice-under-standard forest on the *Nílgiris*, because, 1st, the supply of light in a mountainous region within 11 degrees of the tropics is in excess of that in many temperate countries where the *Eucalyptus globulus* flourishes; and, 2ndly, the *Eucalyptus globulus* grown isolated, takes naturally a better form than Oak under the same circumstances.

69. The third point to be considered in thinning is the height, *vide* statement of average heights, page 26. Thinning almost necessarily involves a loss of height: but, as long as the Blue-gum on the Nílgiris is grown almost exclusively for fuel, the form of the tree is of secondary importance to the maximum yield of wood; in other words, the thinnings and final cuttings must be regulated strictly by the Acre-increment. Then, with a High-timber plantation grown simply for the maximum yield of wood, a thinning is demanded as soon as there is any certain decline in the Acre-increment, or also, if the Individual-increment becomes stationary. For the Individual-increment being the index of the growth and development of the individual trees, it is evident that, unless this figure rises steadily with the age of the trees, the trees themselves are cramped in their development (if they are not in an unhealthy state from some other cause). With our limited knowledge of the figures of growth of the Blue-gum on the Nílgiris, it may happen for some years, that the average Individual-increment in a plantation may be a better index of when to thin, than the Acre-increment. Only long experience will show how the Acre-increment in a properly-thinned Blue-gum plantation should rise up to a certain age, remain at a maximum, and finally begin to decline. In the oldest High-timber plantation (*Arambi*), it is exceedingly probable, looking at the Acre-increment in other plantations, that the Acre-increment has remained stationary for the last ten years, and this is as good a result as most people would have anticipated at the age of nineteen years. But, as has been pointed out, the Individual-increment demonstrates clearly that the *Arambi* plantation has not been maintained at its maximum of production, owing to a want of thinning. We must therefore look for better figures than are now afforded by *Arambi* and await fuller information on the interesting question of what is the maximum growth of the Blue-gum on the Nílgiris. The subject has a wide interest and it is well worth while devoting more attention to it than the value of the plantations themselves would warrant. Working plans embracing a register of thinnings are indispensable. A register of thinnings is of course absolutely necessary in plantations where it is intended to observe the rates of growth, so that subsequently in calculating

the Acre-increment these thinnings may be allowed for, increased by compound interest at 4 per cent. Briefly, thinning tends to raise the Acre-increment by—

1*st.*—Realizing the idle capital represented by the value of the thinnings.

2*ndly.*—By stimulating the individual growth of the trees or raising the Individual-increment.

Averages for the Plantations measured.

Plantations.	Age in Years.	Girth at 5 Feet in Inches.	Height of Tree in Feet.	Cubic Contents in Cubic Feet.	Remarks.
			Eucalyptus globulus or Blue-gum.		
Bathri	5	14·38	50·97	3·50	From 1,447 trees in the sample area.
Black-bridge ...	6	10·61	37·46	2·19	„ 980 „ „
Old Forest ...	9	16·43	57·23	5·70	„ 1,105 „ „
Norwood	10	23·30	84·87	16·42	„ 508 „ „
Ralia	10	24·60	70·72	13·31	„ 141 „ „
Chaughátkalli ...	11	..	...	15·08	„ 23 „ „
Newman	12	15·98*	58·76*	5·73*	„ 1,087* „ „
Arambi	19	26·62	97·00	18·11	„ 701 „ „
Brooklands ...	20	73·90	75·61	86·36	„ 31 „ „
Marlimund ...	22	58·71	108·49	92·11	„ 39 „ „
			Eucalyptus obliqua or Stringy-bark.		
Ralia	10	28·14	63·57	15·24	From 18 trees in the sample area.
			Eucalyptus calophylla.		
Ralia	10	13·36	25·45	1·70	From 11 trees in the sample area.
			Acacia melanoxylon or Australian Blackwood.		
Rália	10	18·32	43·91	6·50	From 314 trees in the sample area.
Bleak-house ...	26	40·32	83·65	45·14	„ 289 „ „
			Blue-gum Coppice.		
Newman	2	5·34	16·21	6·72	From 147 trees in the sample area.

70. Though the average height at different ages is of secondary importance in plantations grown for fuel, the above statement of average heights, girths, and cubic contents, in each of the plantations measured, will be read with interest. It has been noticed that among the Blue-gum plantations the Acre-increments were best where the trees were least crowded. Turning to the column of average heights, it appears that the average heights also are better in those plantations, where the number of trees per acre is least, though it must be remembered that the sample areas in *Old Forest* and

Name of Plantation.	Age in Years.	Number of Trees per Acre.	Average Height in Feet.
Norwood	10	416	85
Rália	10	523	71
Old Forest	9	1,045	57
Newman	12	1,324	59 †

Newman plantations do not represent the best stock on the ground. Quite contrary to what might have been expected, we see in the above four plantations, of about the same

* The coppice shoots are excluded from these figures.
† In this average the coppice shoots are excluded: this is the only plantation where coppiced Blue-gum occurs.

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age, that the average height varies *inversely* with the number of trees per acre, and in *Newman* this holds good in the face of two years more of age. I had, however, suspected that this might be the case, after seeing the plantations, not because the average of the better trees is low, but that, in those plantations where thinnings have been neglected, the general average is lowered by the quantity of dominated and under-sized trees which ought to have been removed. Many observers have been struck with the great difference in the sizes of the trees in the Nílgiri Eucalypt plantations. (*Vide* Colonel Beddome's various reports on the Nílgiri plantations.) *Arambi* is mentioned by him as showing this. Neglecting dominated trees the average height at *Arambi* is without doubt considerably above 97 feet, which is the average of the stock now on the ground. And, as the same thing occurs in other plantations, too much importance must not be attached to the low figures of height given in the statement of averages. *Bathri*, which is not too crowded for a young plantation, has an average growth of 10 feet per year up to five years, and likewise *Norwood* of 8½ feet per year up to ten years. General Morgan considers that during the time that the *Eucalyptus globulus* grows rapidly in height the average is about 8 feet per year. It may be concluded, therefore, that in those plantations which, owing to a neglect of thinning, are now suffering from over-crowding, not only has there been a direct loss, as has been seen, in the production of wood per acre, but the individual trees, so far from having been drawn up and put into a good shape for timber, have suffered in their growth to an extent that *their average height is now less than if they had been grown less crowded.* It is possible that the inequalities in growth observable in the Blue-gum plantations on the Nílgiris may be due in part to changed conditions, Australian seed being exclusively used; but in any case the value of thinning as a means of getting rid of trees of poor growth remains. The fact of the natural forests of Gum trees being strikingly sparse and open has been already noticed.

ALLOWANCE FOR BARK.

71. As has been mentioned in the course of this report, all the measurements taken are on green wood and over bark. The original figures for green wood have been converted into those for seasoned wood, in the manner explained from existing data of the specific gravity of the dry wood, making an allowance for the weight of bark being less than the weight of wood. The figures in all the tables therefore refer to *dry wood with bark on,* the state in which the wood should be sold for fire-wood. Thus the weight of a cubic foot of seasoned Blue-gum wood which in Mr. Gamble's "Indian Timbers" and in Baron von Müller's "Eucalyptographia" is given at 44 lb. and above, is reckoned, with the bark on, at only 40 lb. per cubic foot. And, on the other hand, in the Factor tables, where green branch-wood has to be converted into cubic feet the safe figure of 72 lb. for the cubic foot is employed, this figure having been obtained by me from experimental weighings, as explained at page 108. Blue-gum is eminently a sappy wood. Blue-gum wood in Ootacamund is usually sold nearly green, so that for saleable wood in the Ooty market, the Acre-increments as expressed in these tables in tons of dry wood may be nearly doubled, or, more exactly, the Acre-increments expressed in cubic feet must be multiplied by about 70 instead of 40 to give the weight of green wood in pounds, during the monsoon when the wood is full of sap. Again, the weight of seasoned wood of *Acacia melanoxylon* which is 36 lb. and above, (page 18) is reckoned at 35 lb. in these tables, so as to allow for the bark which is thin in this tree. Green branch-wood with bark weighs 48 lb. per cubic foot—*vide* table of weighings and measurements of thickness of bark at the *Bleak-house* plantation. The deduction in measuring for saleable timber is empiric and varies with the locality and the market: but inquiries might arise in which it would be desirable to know the thickness of bark included in my figures. Measurements have therefore been taken of *Eucalyptus globulus* bark at *Arambi* and at *Ralia*, of *Eucalyptus obliqua* bark at *Ralia*, and of *Acacia melanoxylon* bark at *Bleak-house.* The measurements of the thickness of bark were obtained by cutting through the bark of living trees with a sharp chisel and inserting a steel foot-rule. The detail of these measurements are given with the other tables of the plantations in which they occur and the following is a summary of the results obtained :—

Thickness of Bark—Averages.

Plantation.	Age.	Average Girth.	Mean Thickness of Bark on the Trunk at 5 feet from the ground.	Mean Thickness of Bark on the Branch-wood.	Number of Trees measured.
Eucalyptus globulus or Blue-gum.					
	YRS.	INCHES.	INCHES.	INCHES.	
Arambi	19	26·4	0·525*	0·156	10
Ralia	10	24·1	0·369	0·125	10
Eucalyptus obliqua or Stringy bark.					
Ralia	10	29·7	0·525	...	11†
Acacia melanoxylon or Australian Blackwood.					
Bleak-house	26	...	...	0·06	10

* On the big margin tree, the largest tree in the sample area, the bark was 0·88 of an inch thick at 5 feet from the ground.

† These 11 trees had 15 stems which were measured separately: the average is that of the 15 trunks.

Calculation of Reducing-factor.

Eucalyptus globulus—Bathri Plantation.

Number of Tree.	Girth at 5 feet.	Height of Tree.	Ideal Cylinder from Girth at 5 feet.	Cubic Contents from 10-feet Sections of Stem.	Cubic Contents of Top and Branches.	Cubic Contents of Tree (5 + 6).	Reducing-factor (7 ÷ 4).	Remarks.
1	2	3	4	5	6	7	8	9
1	16	60	8·48	4·01	0·55	4·56	0·5387	
2	20	67	14·31	6·14	0·68	6·82	0·4605	
3	11	47	3·14	1·39	0·17	1·56	0·4968	
4 .. .. {	20 13	64 64	14·14 5·97	6·25 3·91	1·30	11·46	0·5698	A double tree forking from the ground.
5	28	71	30·76	11·56	0·81	12·37	0·4021	
6	18	62	11·10	4·38	0·75	5·13	0·4622	
7	16	61	8·62	4·32	0·44	4·76	0·5522	
8	25	69	23·83	10·40	0·58	10·98	0·4607	
9	20	65	14·36	6·11	0·55	6·66	0·4638	
10	17	63	10·06	4·30	0·33	4·63	0·4602	
11	6	34	0·67	0·34	0·10	0·44	0·6567	
12	15	48	5·96	2·59	0·30	2·89	0·4849	
13	13	41	3·82	1·75	0·17	1·92	0·5026	
14	10	40	2·21	1·17	0·10	1·27	0·5747	
15	26	67	25·02	9·64	0·99	10·63	0·4219	
16	15	52	6·46	2·59	0·57	3·16	0·4892	
17	19	55	10·97	4·65	0·41	5·06	0·4613	
18	21	60	14·62	5·71	0·50	6·21	0·4248	
19	15	48	5·96	2·49	0·33	2·82	0·4732	
20	18	51	9·13	4·14	1·07	5·21	0·5706	
Total ..	362	1189	230·09	97·84	10·70	108·54	9·9299	
Average ..	18·1	59·45	11·505	4·892	0·535	5·427	0·49649	
Reducing-factor ..			108·54 ÷ 230·09 = 0·4717.					

NOTE.—Branch-wood 72 lb. per cubic foot.—*vide* table of experimental weighings in this plantation. Twigs and eaves one head-load = ½ cubic foot.

Calculation of Reducing-factor.

Eucalyptus globulus—Norwood Plantation.

Number of Tree.	Girth at 5 feet.	Height of Tree.	Ideal Cylinder from Girth at 5 feet.	Cubic Contents of Stem from 10-feet Sections.	Cubic Contents of Top and Branches.	Cubic Contents of Tree (5 + 6).	Reducing-factor (7 ÷ 4).	Remarks.
1	2	3	4	5	6	7	8	9
1	31	100	53·10	23·48	1·56	25·04	0·4716	From experimental weighings at *Bathri* plantation, the weight of a cubic foot of freshly-cut wood of *Eucalyptus globulus* with bark is 72 lb. A head-load of twigs is taken as equal to half a cubic foot.
2	39	109	91·61	34·18	2·70	36·88	0·4026	
3	27	83	33·43	11·86	0·91	12·77	0·3820*	
4	50	105	145·05	63·65	5·80	69·45	0·4798	
5	13	60	5·60	2·29	0·39	2·68	0·4786	
6	31	100	53·10	20·02	1·26	21·28	0·4007	
7	41	108	100·32	37·70	4·00	41·70	0·4157	
8	25	91	31·43	11·53	0·39	11·92	0·3793*	
9	35	102	69·04	28·47	2·01	30·18	0·4415	
10	28	88	38·12	15·71	2·93	18·64	0·4890	
11	24	98	31·19	15·04	0·53	15·57	0·4992	
12	26	91	33·99	14·84	1·82	15·66	0·4606	
13	16	62	8·77	3·63	0·19	3·82	0·4356	
14	14	64	6·93	2·98	0·23	3·21	0·4632	
15	35	101	68·36	27·40	2·14	29·54	0·4321	
16	23	92	26·89	11·15	1·33	12·48	0·4641	
17	41	100	92·89	38·59	4·12	42·71	0·4598	
18	37	103	77·91	35·77	0·69	36·46	0·4680	
19	24	84	29·92	12·78	1·29	14·07	0·4703	
20	21	89	28·32	12·18	0·46	12·64	0·4462	
Total ..	584	1830	1,025·97	423·25	34·75	457·0[illegible]	8·9399	
Average ..	29·2	91·5	51·2985	21·163	1·738	22·85	0·44699	
	Reducing-factor 457·00 ÷ 1,025 ·97=0 ·44544							

* Dominated trees with little head; their form approaches a cone.

Calculation of Reducing-factor.

Eucalyptus globulus—Ralia Plantation.

Number of Tree.	Girth at 5 feet.	Height of Tree.	Ideal Cylinder from Girth at 5 feet.	Cubic Contents from 10-feet Sections of Stem.	Cubic Contents of Top and Branches.	Cubic Contents of Tree (5 + 6).	Reducing-factor (7 ÷ 4).	Remarks.
1	2	3	4	5	6	7	8	9
1	30	77	38·29	16·292	0·911	17·203	0·44928	
2	19	54	19·77	4·491	0·494	4·985	0·46179	
3	29	84	29·03	16·065	1·514	17·579	0·45040	Double tree with 2 trunks.
4 .. .. {	22 12	70 58	18·72 4·61	7·787 2·405	0·453	10·845	0·45523	
5	16	59	8·34	4·007	0·384	4·391	0·52650	
6	30	85	42·[illegible]7	17·186	1·403	18·589	0·43977	
7	23	74	21·6[illegible]	10·256	0·486	10·742	0·49663	
8	29	76	35·32	15·064	0·793	15·857	0·44595	
9 .. .. {	22 20	77 59	20·59 13·04	8·019 5·443	0·764	14·226	0·42204	Do. do. ..
10	23	85	24·84	10·057	0·944	11·001	0·44288	
11	19	63	12·56	5·698	0·342	6·040	0·48089	
12	21	72	17·54	7·277	0·634	7·911	0·45103	
13	36	94	67·32	29·570	1·541	31·111	0·46213	
14	23	78	22·80	9·477	1·375	10·852	0·47597	
15	27	77	31·02	12·964	1·505	14·469	0·46649	
16	28	82	35·52	13·892	2·000	15·892	0·44741	
17 .. .. {	31 21	93 82	49·38 19·98	20·811 9·373	1·998	32·182	0·46399	Do. do. ..
18	27	80	32·22	12·445	0·917	13·362	0·41471	
19	33	77	46·33	18·762	4·194	22·956	0·49549	
20	21	68	21·64	8·051	1·847	9·898	0·45740	
Total ..	565	1,724	633·76	265·392	24·499	289·891	9·20898	
Average ..	28·25	86·2	31·688	13·2696	1·22495	14·4945	0·460449	
	Reducing-factor 289·891 ÷ 633·76 = 0·45741.							

NOTE.—Weight of a cubic foot of green branch-wood of *Eucalyptus globulus* with bark is 72 lb.—*vide* table of experimental weighings in Bathri plantation.

Calculation of Reducing-factor.

Arambi Plantation—Blue-gum—19 years old.

The first 21 trees—taking a mean length of head = 18 feet.

Number of Tree.	Girth at 5 feet.	Sectional Area at 5 feet.	Height of Tree.	Ideal Cylinder from Girth at 5 feet.	Cubic Contents of Stem. From 5-feet Sections.	Cubic Contents of Stem. From 10-feet Sections.	Cubic Contents of Top and Branches.	Cubic Contents of Tree (7 + 8).	Reducing-factor (9 ÷ 5).	Remarks.
1	2	3	4	5	6	7	8	9	10	11
1	36	0·72	113	80·93	40·86	41·09	3·00	44·09	0·54	Weight of wood of *Eucalyptus globulus* dry = 44 lb., or with bark 40 lb. Loss of weight on driage is 10 per cent., therefore 66 lb. of fresh cut branch-wood = 1 cubic foot. A head-load of fresh twigs and leaves is taken as weighing 20 lb., when dry = ½ a cubic foot.
2	27	0·40	88	35·45	18·03	17·16	1·75	18·91	0·53	
3	25	0·35	103	35·56	17·58	16·61	1·25	17·86	0·50	
4	28	0·43	98	42·45	20·79	21·12	1·60	22·72	0·54	
5	24	0·32	93	29·60	15·15	16·62	1·50	17·12	0·58	
6	38	0·80	118	94·15	44·18	46·33	2·16	48·49	0·52	
7	34	0·64	103	65·79	30·79	30·07	2·08	32·15	0·49	
8	31	0·53	108	57·07	26·40	26·24	1·15	27·39	0·48	
9	26	0·37	93	34·74	17·13	17·91	1·31	19·22	0·52	
10	37	0·76	113	85·48	42·14	42·43	2·90	45·33	0·53	
11	35	0·68	108	73·10	33·90	34·46	1·76	36·22	0·50	
12	33	0·60	103	61·98	13·86	31·74	2·17	33·91	0·55	
13	30	0·50	103	51·22	25·82	25·60	1·48	27·08	0·53	
14	29	0·46	108	50·18	20·96	21·76	0·74	22·50	0·15	
15	18	0·18	73	13·07	5·88	5·81	0·21	6·02	0·46	
16	36	0·72	118	84·51	38·33	39·10	1·50	40·60	0·48	
Total ..	487	8·46	1,643	895·28	429·85	433·05	26·56	459·61	8·20	
Average ..	30·44	0·528	102·687	55·955	26·866	27·066	1·66	28·726	0·51	

Reducing-factor 28·726 ÷ 55·955 = 0·51337.

Margin trees.—The last two, nearly isolated, have tapering trunks with many branches, the first three are both cylindrical and with good heads.

1	36	0·72	53	37·95	18·78	18·99	8·32	27·31	0·74	
2	36	0·72	68	48·70	24·83	26·97	4·70	31·67	0·65	
3	27	0·40	53	21·35	9·00	9·31	2·90	12·21	0·57	
4	44	1·07	73	78·10	31·75	29·67	6·68	36·35	0·47	
5	64	2·26	104	235·40	..	78·25	18·03	96·28	0·49	
Total ..	207	5·17	351	421·50	..	163·19	40·63	203·82	2·92	
Average ..	41·4	1·034	70·2	84·3	..	32·638	8·126	40·764	0·584	

Reducing-factor 40·764 ÷ 84·3 = 0·48355.

Calculation of Reducing-factor.

Eucalyptus globulus—Second 20 trees at Arambi Plantation (from a portion of the sample area).

Number of Tree.	Girth at 5 feet.	Height of Tree.	Ideal Cylinder from Girth at 5 feet.	Cubic Contents from 10-feet Sections of Stem.	Cubic Contents of Top and Branches.	Cubic Contents of Tree (5 + 6).	Reducing-factor (7 ÷ 4).	Remarks.
1	2	3	4	5	6	7	8	9
1	32	120	67·89	29·14	0·86	30·00	0·442	Branch-wood 66 lb. per cubic foot, twigs and leaves one head-load = ½ cubic foot.
2	33	110	66·19	30·[illegible]	2·32	32·59	0·492	
3	30	114	56·69	27·10	1·01	28·11	0·494	
4	26	108	37·35	18·44	0·45	18·89	0·557	
5	45	135	151·06	64·49	2·89	67·38	0·446	
6	32	95	53·75	22·94	1·50	24·44	0·454	
7	43	136	138·96	57·18	1·79	58·97	0·424	
8	34	120	76·65	32·99	0·98	33·97	0·443	
9	19	74	14·76	6·14	0·74	6·88	0·467	
10	14	63	6·82	2·79	0·73	3·52	0·516	
11	25	110	37·98	14·31	0·89	15·20	0·400	
12	41	120	117·04	49·35	2·82	52·17	0·445	
13	47	128	156·25	65·31	4·33	69·64	0·445	
14	27	102	41·08	17·91	1·26	19·17	0·466	
15	45	135	151·06	66·66	2·94	69·60	0·467	
16	34	126	79·85	30·28	1·46	31·74	0·397	
17	27	168	43·50	18·67	0·43	19·10	0·438	
18	21	85	20·71	9·73	0·88	10·61	0·512	
19	36	122	87·37	34·52	1·75	36·27	0·415	
20	45	127	142·11	65·20	3·27	68·47	0·481	
Total ..	656	2,235	1,547·07	663·42	33·30	696·72	9·201	
Average ..	32·8	111·75	77·354	33·171	1·665	34·836	0·4600	

Reducing-factor 34·836 ÷ 77·354 = 0·45034.

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Calculation of Reducing-factor.

Brooklands—Blue-gum Standards (amongst Acacia coppice) 20 years old.

Number of Tree.	Girth at 5 feet.	Height of Tree.	Ideal Cylinder from Girth at 5 feet.	Cubic Contents from 10-feet Sections of Stem.	Cubic Contents of Top and Branches.	Cubic Contents of Tree (5 + 6).	Reducing-factor (7 ÷ 4)	Remarks.
1	2	3	4	5	6	7	8	9
1	63	91	141·26	47·04	7·30	54·34	0·3847	
2	77	80	262·11	75·80	19·64	95·44	0·3641	
3	102	97	557·69	153·90	56·61	210·51	0·3774	
4	75	97	301·52	98·70	13·17	111·87	0·3711	
5	39	90	75·64	31·13	4·53	35·66	0·4715	
6	62	98	208·17	65·74	10·14	75·88	0·3645	
7	71	94	261·86	93·33	19·13	112·46	0·4295	
8	50	87	120·19	45·64	5·59	51·23	0·4262	
9	94	73	356·45	107·69	28·44	136·13	0·3826	
10	77	90	294·88	96·59	32·71	129·30	0·4385	Forked at 63 feet.
Total ..	700	897	2,579·77	815·56	197·26	1,012·82	4·0101	
Average ..	70	89·7	257·97	81·556	19·726	101·282	0·40	

Reducing-factor 101·282 ÷ 257·97 = 0·39261.

Calculation of Reducing-factor.

Acacia melanoxylon—Ralia Plantation.

Number of Tree.	Girth at 5 feet.	Height of Tree.	Ideal Cylinder from Girth at 5 feet.	Cubic Contents from 10-feet Sections of Stem.	Cubic Contents of Top and Branches.	Cubic Contents of Tree (5 + 6).	Reducing-factor (7 ÷ 4.)	Remarks.
1	2	3	4	5	6	7	8	9
1	25	72	24·86	9·582	7·058	27·659	0·53334	Tree forking from the base.
	25	78	26·94	11·019				
2	15	54	6·71	3·122	1·457	5·967	0·59373	Do. do.
	11	50	3·34	1·388				
3	14	54	5·84	2·548	0·550	3·098	0·53047	
4	15	52	6·4[illegible]	3·122	3·138	10·067	0·56083	Do. do.
	20	52	11·49	3·897				
5	17	54	8·62	3·774	1·271	5·045	0·59890	
6	24	63	20·05	7·615	3·543	11·158	0·55651	
7	21	59	14·37	5·786	1·777	7·563	0·52631	
8	17	54	8·62	3·924	0·411	4·335	0·50290	
9	31	79	41·95	16·827	2·521	19·348	0·46122	
10	24	61	19·4[illegible]	7·853	3·963	11·816	0·60876	
11	24	62	19·75	7·184	3·553	10·737	0·54420	
12	23	64	18·70	7·598	2·101	9·699	0·51866	
13	15	51	6·34	2·846	2·447	7·918	0·62445	Do. do.
	15	51	6·34	2·625				
14	22	62	16·58	6·085	2·712	8·797	0·53058	
15	25	69	23·83	8·129	6·393	14·522	0·60940	
16	29	76	35·32	14·385	2·458	16·843	0·47687	
17	14	54	5·81	2·305	0·736	3·041	0,52071	
18	24	60	19·09	6·990	6·366	13·356	0·69964	
19	21	64	15·59	6·222	3·407	12·475	0·55813	Do. do.
	15	54	6·71	2·846				
20	17	47	7·50	2·680	1·808	4·488	0·59840	
Total ..	503	1,496	380·23	150·262	57·670	207·932	11·15101	
Average ..	25·15	74·8	19·0115	7·5131	2·8835	10·3966	0·55770	

Reducing-factor 207·932 ÷ 380·23 = 0·54686.

Note.—One cubic foot of young *Acacia melanoxylon*, wood green, and with bark, weighs on an average 47 lb. See table of weighings at *Ralia Plantation*.

Calculation of Reducing-factor.

Acacia melanoxylon—Norwood Plantation.

Number of Tree.	Girth at 5 feet.	Height of Tree.	Ideal Cylinder from Girth at 5 feet.	Cubic Contents of Stem from 10-feet Sections.	Cubic Contents of Top and Branches.	Cubic Contents of Tree (5 + 6).	Reducing-factor (7 ÷ 4).	Remarks.
1	2	3	4	5	6	7	8	9
1	13	50	4·66	2·049	0·90	2·949	0·632	Weight of green branch-wood with bark taken at 50 lb. per cubic foot. See table of some experimental weighings in this plantation. Fuller weighings show this figure to be 47 lb. for young wood. One head-load of green leaves and twigs is taken as the equivalent of ½ a cubic foot.
2	18	45	8·05	3·695	0·84	4·535	0·563	
3	7	28	0·75	0·270	0·29	0·560	0·746	
4	12	48	3·81	1·515	0·23	1·745	0·458	
5	14	58	6·28	2·785	0·51	3·295	0·524	
6	13	41	3·82	1·581	0·31	1·891	0·495	
7	15	43	5·34	2·393	0·55	2·943	0·551	
8	18	58	10·38	4·692	1·18	5·872	0·565	
9	14	55	5·95	2·703	0·38	3·083	0·517	
10	15	45	5·59	2·393	0·55	2·943	0·526	
Total ..	139	471	54·63	24·076	5·74	29·816	5·577	
Average ..	13·9	47·1	5·463	2·4076	0·574	2·9816	0·5577	

Reducing-factor 29·816 ÷ 54·63 = 0·54578.

NOTE.—The differences in the factors are due to the various shapes and sizes of the *Acacia melanoxylon* growing under *Eucalyptus globulus*. For instance, No. 3 tree, in the above table, was little better than a bush with a stem only 10 feet long; others were fairsized trees, but in getting a general factor it was necessary that all should be represented.

Calculation of Reducing-factor.

Acacia melanoxylon—Bleak-house Plantation.

Number of Tree.	Girth at 5 feet.	Height of Tree.	Ideal Cylinder from Girth at 5 feet.	Cubic Contents from 10-feet Sections of Stem.	Cubic Contents of Top and Branches by weighing.	Cubic Contents of Tree (5 + 6).	Reducing-factor (7 ÷ 4).	Remarks.
1	2	3	4	5	6	7	8	9
1	50	115	158·87	74·63	6·04	80·67	0·50895	
2	55	104	173·84	89·19	21·33	110·52	0·63576*	* This was a tree of very irregular form, branching and dividing over and over again from the ground upwards; 10-feet sections were impossible, and the tree was measured in 16 sections of different lengths; the branch-wood weighed was 832 lb., the twigs and leaves 8 head-loads. A cubic foot of freshly-cut old branch-wood of *Acacia melanoxylon* with bark weighs 48 lb. A head-load of twigs and leaves is taken as equal to ½ a cubic foot.
3	22	78	20·86	9·16	2·41	11·57	0·55465	
4	39	89	74·80	35·76	5·11	40·87	0·54639	
5	44	87	93·07	38·25	4·75	43·00	0·46201	
6	25	77	26·59	12·46	1·31	13·77	0·51786	
7	47	99	120·85	53·63	10·37	64·00	0·52957	
8	57	91	163·38	73·14	16·23	89·37	0·54827	
9	24	78	24·82	11·13	3·17	14·30	0·57615	
10	44	98	104·84	42·33	15·20	67·53	0·64412	
11	33	67	40·32	18·46	3·18	21·64	0·53671	
12	66	117	281·64	116·94	18·75	135·69	0·48179	
13	41	80	74·31	31·94	2·69	34·63	0.46602	
Total ..	547	1180	1,358·19	607·02	110·513	727·56	7·00825	
Average ..	42·076	90·769	104·476	46·693	8·503	55·966	0·53909	

Reducing-factor 727·56 ÷ 1,358·19 = 0·53568

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EUCALYPTUS GLOBULUS.

Norwood Plantation—10 *years old, planted in* 1872 *at* 9′ × 9′.

Sample area 1·2211 acres, carries per acre 416·0 trees, 6,829·54 cubic feet.
Increment per acre per annum 752·3 cubic feet (or 13·434* tons at 40 lb. per cubic foot
Average individual increment per annum 1·64171 cubic feet.

Number of Tree.	Girth at 5 Feet.	Height of Tree.	Ideal Cylinder.	Reducing Factor.	Cubic Contents of Tree.	Remarks.
1	2	3	4	5	6	7
1	33	98	58·97	...	...	
2	43	100	102·18	...	...	
3	10	45	2·48	...	...	
4	36	100	71·62	...	...	
5	18	60	10·74	...	...	
6	23	90	26·31	...	...	
7	17	90	14·37	...	...	
8	37	100	75·65	...	...	
9	13	40	3·73	...	...	
10	34	95	60·68	...	...	
11	15	55	6·83	...	...	
12	32	95	53·75	...	...	
13	23	83	24·26	..	...	
14	20	78	17·24	...	...	
15	17	70	11·17	..	...	
16	14	55	5·95	...	...	
17	43	105	107·28	...	...	
18	25	85	29·35	...	...	
19	29	100	46·47	...	...	
20	26	95	35·48	...	...	
21	31	110	58·41	...	...	
22	33	110	66·19	...	...	
23	28	95	41·15	...	...	
24	22	70	18·72	...	...	
25	24	85	27·05	...	...	
26	29	100	46·47	...	...	
27	30	100	49·73	...	...	
28	30	100	49·73	...	...	
29	18	50	8·95	...	...	
30	26	85	31·75	...	...	
31	32	100	56·58	...	...	
32	29	100	46·47	...	...	
33	29	100	46·47	...	...	
34	13	40	3·73	...	...	
35	31	90	47·79	...	...	
36	36	90	64·45	...	...	
37	27	80	32·22	...	...	
38	29	95	44·15	...	...	
39	24	92	29·28	...	...	
40	20	60	13·26	...	...	
41	24	100	31·83	...	...	
42	32	105	59·40	...	...	
43	35	110	74·45	...	...	
44	26	80	29·88	...	...	
45	13	55	5·13	...	...	
46	35	95	64·31	...	...	
47	38	105	83·77	...	...	
48	31	105	55·75	...	...	
49	28	90	38·99	...	...	
50	36	105	75·20	...	...	
Total ...	1,347	4,341	2,065·77			

* Of this figure, ·975 ton comes from previous thinnings and ·263 ton from nine blanks.

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Number of Tree.	Girth at 5 Feet.	Height of Tree.	Ideal Cylinder.	Reducing Factor.	Cubic Contents of Tree.	Remarks.
1	2	3	4	5	6	7
51	42	105	102·35	...	...	
52	30	100	49·73	...	...	
53	19	55	10·97	...	...	
54	11	50	3·34	...	...	
55	35	97	65·66	...	...	
56	30	93	46·25	...	...	
57	16	40	5·65	...	...	
58	32	105	59·40	...	...	
59	41	105	97·53	...	...	
60	45	110	123·09	...	...	
61	27	105	42·29	...	...	
62	33	107	64·39	...	...	
63	24	80	25·46	...	...	
64	24	85	27·05	...	...	
65	21	85	20·71	...	...	
66	17	80	12·77	...	...	
67	11	50	3·34	...	...	
68	36	105	75·20	...	...	
69	29	110	51·11	...	...	
70	16	30	4·24	...	...	
71	18	75	13·42	...	...	
72	27	100	40·28	...	...	
73	40	105	92·83	...	...	
74	17	60	9·58	...	...	
75	12	30	2·38	...	...	
76	25	90	31·08	...	...	
77	31	105	55·75	...	...	
78	19	80	15·95	...	...	
79	31	100	53·10	...	...	
80	20	50	11·05	...	...	
81	37	100	75·65	...	...	
82	35	100	67·69	...	...	
83	31	100	53·10	...	...	
84	29	105	48·79	...	...	
85	32	105	59·40	...	...	
86	26	96	35·86	...	...	
87	23	100	29·23	...	...	
88	19	90	17·95	...	...	
89	24	105	33·42	...	...	
90	21	95	23·15	...	...	
91	10	25	1·38	...	...	
92	37	105	79·43	...	...	
93	27	105	42·29	...	...	
94	9	30	1·34	...	...	
95	22	90	24·07	...	...	
96	25	100	34·53	...	...	
97	21	90	21·93	...	...	
98	19	60	11·96	...	...	
99	37	105	79·43	...	...	
100	13	35	3·26	...	...	
101	38	100	79·79	...	...	
102	32	109	65·59	...	...	
103	14	60	6·49	...	...	
104	33	108	64·99	...	...	
105	39	110	92·45	...	...	
106	34	110	70·26	...	...	
107	30	110	54·70	...	...	
108	26	95	35·48	...	...	
Total ...	1,522	5,035	2,429·56			

Number of Tree.	Girth at 5 Feet.	Height of Tree.	Ideal Cylinder.	Reducing Factor.	Cubic Contents of Tree.	Remarks.
1	2	3	4	5	6	7
109	20	90	19·89	...	...	
110	9	40	1·79	...	...	
111	24	100	31·83	...	...	
112	30	105	52·21	...	...	
113	18	80	14·32	...	...	
114	10	70	3·86	...	...	
115	32	110	62·23	...	...	
116	20	108	23·86	...	...	
117	17	70	11·17	...	...	
118	22	90	24·07	...	...	
119	18	65	11·63	...	...	
120	34	114	72·82	...	...	
121	13	50	4·66	...	...	
122	35	105	71·07	...	...	
123	21	80	19·49	...	...	
124	26	105	39·21	...	...	
125	34	112	71·54	...	...	
126	37	115	86·99	...	...	
127	23	100	29·23	...	...	
128	23	100	29·23	...	...	
129	12	30	2·38	...	...	
130	23	110	32·15	...	...	
131	18	80	14·32	...	...	
132	22	100	26·74	...	...	
133	27	110	44·30	...	...	
134	31	100	53·10	...	...	
135	19	70	13·96	...	...	
136	46	110	128·62	...	...	
137	29	100	46·47	...	...	
138	14	30	3·24	...	...	
139	22	90	24·07	...	...	
140	19	70	13·96	...	...	
141	20	70	15·47	...	...	
142	19	95	18·95	...	...	
143	12	65	5·17	...	...	
144	16	60	8·48	...	...	
145	15	80	9·94	...	...	
146	35	110	74·45	...	...	
147	23	105	30·69	...	...	
148	25	100	34·53	...	...	
149	19	80	15·95	...	...	
150	22	80	21·39	...	...	
151	38	115	91·75	...	...	
152	22	90	24·07	...	...	
153	24	105	33·42	...	...	
154	35	115	77·84	...	...	
155	31	115	61·06	...	...	
156	36	115	82·36	...	...	
157	34	100	63·88	...	...	
158	24	105	33·42	...	...	
159	22	88	23·53	...	...	
160	32	110	62·23	...	...	
161	32	110	62·23	...	...	
162	10	50	2·76	...	...	
163	18	70	12·53	...	...	
164	31	105	55·75	...	...	
165	30	105	52·21	...	...	
166	37	105	79·43	...	...	
Total ...	1,410	5,257	2,137·90			

Number of Tree.	Girth at 5 Feet.	Height of Tree.	Ideal Cylinder.	Reducing Factor.	Cubic Contents of Tree.	Remarks.
1	2	3	4	5	6	7
167	12	35	2·78	...	...	
168	30	105	52·21	...	...	
169	23	80	23·38	...	...	
170	18	95	17·00	...	...	
171	12	90	7·16	...	...	
172	17	95	15·17	...	...	
173	33	110	66·19	...	...	
174	22	100	26·74	...	...	
175	23	100	29·23	...	...	
176	23	100	29·23	...	...	
177	28	100	43·32	...	...	
178	37	115	86·99	...	...	
179	33	110	66·19	...	...	
180	16	85	12·02	...	...	
181	18	90	16·11	...	...	
182	30	115	57·19	...	...	
183	21	80	19·49	...	...	
184	20	100	22·10	...	...	
185	30	90	44·76	...	...	
186	23	110	32·15	...	...	
187	26	110	41·08	...	...	
188	16	50	7·07	...	...	
189	22	95	25·40	...	...	
190	37	115	86·99	...	...	
191	27	110	44·30	...	...	
192	19	100	19·94	...	...	
193	17	90	14·37	...	...	
194	26	112	41·83	...	...	
195	23	105	30·69	...	...	
196	28	110	47·65	...	...	
197	26	110	41·08	...	...	
198	20	95	20·99	...	...	
199	19	105	20·93	...	...	
200	19	110	21·93	...	...	
201	26	110	41·08	...	...	
202	23	100	29·23	...	...	
203	11	50	3·34	...	...	
204	30	110	54·70	...	...	
205	32	103	58·27	...	...	
206	27	95	38·27	...	...	
207	27	100	40·28	...	...	
208	32	100	56·58	...	...	
209	17	70	11·17	...	...	
210	33	115	69·20	...	...	
211	38	115	91·75	...	...	
212	42	115	112·10	...	...	
213	12	60	4·77	...	...	
214	36	110	78·78	...	...	
215	16	50	7·07	...	...	
216	14	50	5·41	...	...	
217	10	50	2·76	...	...	
218	9	30	1·34	...	...	
219	35	105	71·07	...	...	
220	12	25	1·98	...	...	
221	23	100	29·23	...	...	
222	32	100	56·58	...	...	
223	40	115	101·67	...	...	
224	16	60	8·48	...	...	
Total ...	1,387	5,360	2,108·77			

Number of Tree.	Girth at 5 Feet.	Height of Tree.	Ideal Cylinder.	Reducing Factor.	Cubic Contents of Tree.	Remarks.
1	2	3	4	5	6	7
225	24	70	22·28	...	...	
226	12	40	3·18	...	...	
227	36	100	71·62	...	...	
228	32	105	59·40	...	...	
229	34	105	67·07	...	...	
230	32	105	59·40	...	...	
231	42	110	107·22	...	...	
232	14	50	5·41	...	...	
233	35	105	71·07	...	...	
234	20	100	22·10	...	...	
235	13	30	2·80	...	...	
236	12	45	3·58	...	...	
237	31	108	57·34	...	...	
238	24	105	33·42	...	...	
239	35	70	47·38	...	...	
240	36	70	50·13	...	...	
241	30	80	39·78	...	...	
242	27	60	24·17	...	...	
243	35	100	67·69	...	...	
244	32	105	59·40	...	...	
245	28	105	45·48	...	...	
246	15	50	6·21	...	...	
247	34	110	70·26	...	...	
248	32	105	59·40	...	...	
249	30	105	52·21	...	...	
250	20	80	17·68	...	...	
251	15	50	6·21	...	...	
252	34	105	67·07	...	...	
253	22	60	16·04	...	...	
254	15	60	7·46	...	...	
255	25	90	31·08	...	...	
256	42	105	102·35	...	...	
257	18	85	15·21	...	...	
258	10	50	2·76	...	...	
259	18	65	11·63	...	...	
260	29	105	48·79	...	...	
261	35	95	64·31	...	...	
262	21	90	21·93	...	...	
263	11	60	4·01	...	...	
264	22	105	28·07	...	...	
265	30	105	52·21	...	...	
266	33	105	63·18	...	...	
267	34	108	68·99	...	...	
268	36	103	73·76	...	...	
269	39	110	92·45	...	...	
270	38	110	87·76	...	...	
271	20	85	18·78	...	...	
272	17	70	11·17	...	...	
273	35	105	71·07	...	...	
274	22	70	18·72	...	...	
275	13	50	4·66	...	...	
276	32	105	59·40	...	...	
277	22	90	24·07	...	...	
278	19	70	13·96	...	...	
279	18	60	10·74	...	...	
280	33	100	60·18	...	...	
281	23	70	20·46	...	...	
282	35	110	74·45	...	...	
Total ...	1,531	4,969	2,378·61			

Number of Tree.	Girth at 5 Feet.	Height of Tree.	Ideal Cylinder.	Reducing Factor.	Cubic Contents of Tree.	Remarks.
1	2	3	4	5	6	7
283	32	100	56·58	...	...	
284	38	94	75·01	...	...	
285	33	105	63·18	...	...	
286	28	95	41·15	...	...	
287	41	105	97·53	...	...	
288	19	60	11·96	...	...	
289	36	105	75·20	...	...	
290	15	70	8·70	...	...	
291	8	43	1·52	...	...	
292	24	105	33·42	...	...	
293	38	110	87·76	...	...	
294	35	110	74·45	...	...	
295	12	30	2·38	...	...	
296	31	105	55·75	...	...	
297	25	105	36·25	...	...	
298	16	40	5·65	...	...	
299	31	110	58·41	...	...	
300	19	30	5·98	...	...	
301	24	100	31·83	...	...	
302	29	105	48·79	...	...	
303	15	35	4·35	...	...	
304	10	35	1·93	...	...	
305	10	30	1·65	...	...	
306	25	75	25·90	...	...	
307	32	95	53·75	...	...	
308	19	60	11·96	...	...	
309	27	95	38·27	...	...	
310	24	93	29·60	...	...	
311	28	100	43·32	...	...	
312	34	105	67·07	...	...	
313	20	80	17·68	...	...	
314	19	85	16·95	...	...	
315	36	105	75·20	...	...	
316	26	80	29·88	...	...	
317	25	75	25·90	...	...	
318	18	75	13·42	...	...	
319	40	105	92·83	...	...	
320	44	110	117·67	...	...	
321	27	110	44·30	...	...	
322	33	100	60·18	...	...	
323	12	30	2·38	...	...	
324	14	45	4·87	...	...	
325	9	25	1·11	...	...	
326	10	40	2·21	...	...	
327	7	40	1·08	...	...	
328	24	100	31·83	...	...	
329	26	105	39·21	...	...	
330	34	110	70·26	...	...	
331	32	105	59·40	...	...	
332	34	100	63·88	...	...	
333	31	100	53·10	...	...	
334	24	95	30·23	...	...	
335	18	70	12·53	...	...	
336	21	95	23·15	...	...	
337	29	92	42·75	...	...	
338	10	30	1·65	...	...	
339	15	60	7·46	...	...	
340	28	95	41·15	...	...	
Total ...	1,424	4,712	2,131·56			

Number of Tree.	Girth at 5 Feet.	Height of Tree.	Ideal Cylinder.	Reducing Factor.	Cubic Contents of Tree.	Remarks.
1	2	3	4	5	6	7
341	42	100	97·48	...	...	
342	27	100	40·28	...	...	
343	19	30	5·98	...	...	
344	29	110	51·11	...	...	
345	24	90	28·64	...	...	
346	22	100	26·74	...	...	
347	33	105	63·18	...	...	
348	25	100	34·53	...	...	
349	26	100	37·35	...	...	
350	28	100	43·32	...	...	
351	28	100	43·32	...	...	
352	20	70	15·47	...	...	
353	16	60	8·48	...	...	
354	30	90	44·76	...	...	
355	21	90	21·93	...	...	
356	30	100	49·73	...	...	
357	31	105	55·75	...	...	
358	25	105	36·25	...	...	
359	31	105	55·75	...	...	
360	32	100	56·58	...	...	
361	30	110	54·70	...	...	
362	12	40	3·18	...	...	
363	31	105	55·75	...	...	
364	26	105	39·21	...	...	
365	33	95	57·17	...	...	
366	18	70	12·53	...	...	
367	17	80	12·77	...	...	
368	13	55	5·13	...	...	
369	25	105	36·25	...	...	
370	34	105	67·07	...	...	
371	31	100	53·10	...	...	
372	31	105	55·75	...	...	
373	14	60	6·49	...	...	
374	30	95	47·24	...	...	
375	26	90	33·62	...	...	
376	29	105	48·79	...	...	
377	23	100	29·23	...	...	
378	20	95	20·99	...	...	
379	30	105	52·21	...	...	
380	23	105	30·69	...	...	
381	10	60	3·31	...	...	
382	35	110	74·45	...	...	
383	17	85	13.57	...	...	
384	25	110	37·98	...	...	
385	21	105	25·58	...	...	
386	25	110	37·98	...	...	
387	22	95	25·40	...	...	
388	19	90	17·95	...	...	
389	22	100	26·74	...	...	
390	26	85	31·75	...	...	
391	33	110	66·19	...	...	
392	10	40	2·21	...	...	
393	12	50	3·97	...	...	
394	37	105	79·43	...	...	
395	23	100	29·23	...	...	
396	30	105	52·21	...	...	
397	28	100	43·32	...	...	
398	25	105	36·25	...	...	
Total ...	1,455	5,355	2,146·02			

Number of Tree.	Girth at 5 Feet.	Height of Tree.	Ideal Cylinder.	Reducing Factor.	Cubic Contents of Tree.	Remarks.
1	2	3	4	5	6	7
399	32	110	62·03	...	...	
400	30	110	54·70	...	...	
401	21	95	23·15	...	...	
402	23	100	29·23	...	...	
403	24	105	33·42	...	...	
404	35	110	74·45	...	...	
405	23	100	29·23	...	...	
406	24	105	33·42	...	...	
407	23	95	27·77	...	...	
408	23	95	27·77	...	...	
409	31	110	58·41	...	...	
410	39	110	92·45	...	...	
411	35	110	74·45	...	...	
412	19	90	17·95	...	...	
413	11	50	3·34	...	...	
414	24	100	31·83	...	...	
415	36	110	78·78	...	...	
416	12	55	4·37	...	...	
417	30	105	52·21	...	...	
418	35	105	71·07	...	...	
419	27	105	42·29	...	...	
420	28	105	45·48	...	...	
421	29	105	48·79	...	...	
422	21	80	19·49	...	...	
423	12	65	5·17	...	...	
424	21	100	24·37	...	...	
425	30	107	53·21	...	...	
426	9	35	1·56	...	...	
437	21	110	26·80	...	...	
438	15	50	6·21	...	...	
439	23	95	27·77	...	...	
440	16	40	5·65	...	...	
441	13	50	4·66	...	...	
442	11	30	2·00	...	...	
443	12	40	3·18	...	...	
444	30	100	49·73	...	...	
445	34	105	67·07	...	...	
446	10	30	1·65	...	...	
447	26	95	35·48	...	...	
448	14	40	4·33	...	...	
449	11	35	2·34	...	...	
450	22	70	18·72	...	...	
451	11	45	3·00	...	...	
452	11	40	2·67	...	...	
453	22	60	16·04	...	...	
454	14	40	4·33	...	...	
455	28	100	43·32	...	...	
456	32	110	62·23	...	...	
457	33	110	66·19	...	...	
458	35	110	74·45	...	...	
459	22	95	25·40	...	...	
460	20	95	20·99	...	...	
461	33	105	63·18	...	...	
462	8	35	1·23	...	...	
463	27	100	40·28	...	...	
464	23	100	29·23	...	...	
465	9	40	1·79	...	...	
466	32	110	62·23	...	...	
Total ...	1,325	4,857	1,892·54			

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Number of Tree.	Girth at 5 Feet.	Height of Tree.	Ideal Cylinder.	Reducing Factor.	Cubic Contents of Tree.	Remarks.
1	2	3	4	5	6	7
467	10	45	2·48	...	...	
468	20	90	19·89	...	...	
469	13	50	4·66	...	...	
470	13	45	4·20	...	...	
471	36	110	78·78	...	...	
472	16	75	10·61	...	...	
473	31	69	36·65	...	...	
474	27	100	40·28	...	...	
475	21	100	24·37	...	...	
476	30	105	52·21	...	...	
477	34	105	67·07	...	...	
478	14	45	4·87	...	...	
479	44	110	117·67	...	...	
480	20	95	20·99	...	...	
481	33	105	63·18	...	...	
482	15	40	4·97	...	...	
483	21	90	21·93	...	...	
484	12	50	3·97	...	...	
485	35	105	71·07	...	...	
486	20	100	22·10	...	...	
487	24	78	24·82	...	...	
488	10	30	1·65	...	...	
489	18	90	16·11	...	...	
490	12	65	5·17	...	...	
491	22	100	26·74	...	...	
492	42	105	102·35	...	...	
493	23	70	20·46	...	...	
494	23	70	20·46	...	...	
495	35	108	73·10	...	...	
496	35	107	72·42	...	...	
497	31	90	47·79	...	...	
498	6	30	·59	...	...	
499	7	30	·81	...	...	
500	6	41	·81	...	...	
501	8	55	1·94	...	...	
502	6	45	·89	...	...	
503	40	90	79·57	...	...	
504	38	100	79·79	...	...	
505	23	92	26·89	...	...	
506	13	70	6·53	...	...	
507	32	95	53·75	...	...	
508	25	91	31·43	...	...	
Total ...	944	3,286	1,366·02			

TOTAL OF SHEETS.	
Number of page.	Total of page, Cubic Feet.
33	2,065·77
34	2,429·56
35	2,137·90
36	2,108·77
37	2,378·61
38	2,131·56
39	2,146·02
40	1,366·02
41	1,892·54
Total ...	18,656·75

NORWOOD PLANTATION.

Eucalyptus Globulus.

Brought forward .. .. .. 18,656·75 cubic feet.

CALCULATION OF RESULTS.

The factor used is ·447, obtained from 20 trees in this Plantation.

Actual Stock.

Total stock on sample area = 18,656·75 × 0·447 = 8,339·56 cubic feet.
Stock per acre = 8,339·56 ÷ 1·2211 = 6,829·54 ,,
Total number of trees on sample area is 508
,, ,, per acre is 508 ÷ 1·22 = 416 trees.
Actual stock on the ground per acre is 6,829·54 cubic feet in 416 trees.

Yearly individual-increment = 6,829·54 cubic feet ÷ 416 trees ÷ 10 years = 1·64171 cubic feet.

Blanks.

The number of blanks in the canopy is estimated at 11 average trees, or 9 per acre, valued at 147·7539 cubic feet thus:

Individual-Increment.		Present Age.		No. of Blanks.	
1·64171	×	10	×	9	= 147·7539 cubic feet.

Thinnings

are estimated at 546 cubic feet per acre—*vide* the History of Norwood Plantation.

$$\text{Acre-increment} = \frac{\text{Actual stock} + \text{blanks} + \text{thinnings}}{\text{present age}}$$

$$= \frac{6{,}829{\cdot}54 + 147{\cdot}75 + 546}{10}$$

$$= 752{\cdot}329 \text{ cubic feet or (at 56 cubic feet per ton) } 13{\cdot}434 \text{ tons.}$$

NORWOOD AVERAGES.

Eucalyptus globulus.

Number of Sheets.	Girth at 5 Feet. Total of Sheets.	Height of Trees. Total of Sheets.	Ideal Cylinder. Total of Sheets.	Form factor.	Cubic Contents of Average Tree.	Remarks.
1	2	3	4	5	6	7
508 trees. 1	705	2,309	1,072·23	...	...	
2	779	2,439	1,225·59	...	...	
3	714	2,285	1,127·24	...	...	
4	691	2,373	1,090·16	...	...	
5	644	2,429	976·78	...	...	
6	679	2,528	1,009·59	...	...	
7	664	2,595	1,005·89	...	...	
8	613	2,390	961·41	...	...	
9	609	1,903	956·51	...	...	
10	630	2,130	921·41	...	...	
11	719	2,298	1,204·63	...	...	
12	634	2,098	884·08	...	...	
13	657	2,177	1,011·50	...	...	
14	723	2,595	1,074·39	...	...	
15	615	2,420	876·78	...	...	
16	647	2,430	1,041·25	...	...	
17	504	1,747	606·96	...	...	
18	584	2,109	823·11	...	...	
19	534	1,857	787·24	...	...	
Total ...	12,345	43,112	18,656·75			
Average ...	23·301	84·866	36·7258 × ·447		= 16·416	

Individual-increment × age = 16·4171.

NORWOOD.

Acacia Melanoxylons, in Sample Area growing under Eucalyptus Globulus with an Individual-increment of ·266 Cubic Feet per Annum ÷ the Age of the Tree is 10 Years.

Number of Tree.	Girth at 5 Feet.	Height of Tree.	Ideal Cylinder.	Reducing Factor.	Cubic Contents of Tree.	Remarks.
1	2	3	4	5	6	7
1	15	30	3·73	...	...	
2	12	25	1·98	...	...	
3	11	30	2·00	...	...	
4	12	25	1·98	...	...	
5	13	25	2.33	...	...	
6	14	30	3·24	...	...	
7	13	40	3·73	...	...	
8	13	40	3·73	...	...	
9	10	30	1·65	...	...	
10	16	35	4·95	...	...	
11	15	35	4·35	...	...	On edge of a glade.
12	19	65	12·96	...	...	
13	14	50	5·41	...	...	
14	13	50	4·66	...	...	
15	10	40	2·21	...	...	
16	12	35	2·78	...	...	
17	19	30	5·98	...	...	
18	11	30	2·00	...	...	
19	15	50	6·21	...	...	
20	9	45	2·01	...	...	
21	12	25	1·98	...	...	
22	14	50	5·41	...	...	
23	13	40	3·73	...	...	
24	14	40	4·33	...	...	
25	9	35	1·56	...	...	
26	10	35	1·93	...	...	
27	11	45	3·00	...	...	
28	23	80	23·38	...	...	
29	20	75	16·57	...	...	
30	24	35	11·14	...	...	
31	12	55	4·37	...	...	
32	11	45	4·87	...	...	
33	9	35	1·56	...	...	
34	12	40	3·18	...	...	
35	18	45	8·05	...	...	
36	12	35	2·78	...	...	
37	9	40	1·79	...	...	
38	14	50	5·41	...	...	
39	9	50	2·23	...	...	
40	15	55	6·83	...	...	
41	12	40	3·18	...	...	
42	19	45	8·97	...	...	
43	9	30	1·34	...	...	
44	16	30	4·24	...	...	
45	14	50	5·41	...	...	
46	11	50	3·34	...	...	
47	15	55	6·83	...	...	
48	15	50	6·21	...	...	
49	15	60	7·46	...	...	
50	19	75	14·96	...	...	
51	15	60	7·46	...	...	
52	17	50	7·98	...	...	
53	16	45	6·36	...	...	
54	11	35	2·34	...	...	
55	21	55	13·40	...	...	
56	10	30	1·65	...	...	
57	10	30	1·65	...	...	
58	8	25	·88			

Number of Tree.	Girth at 5 Feet.	Height of Tree.	Ideal Cylinder.	Reducing Factor.	Cubic Contents of Tree.	Remarks.
1	2	3	4	5	6	7
59	12	40	3·18	...	...	
60	8	40	1·41	...	...	
61	18	50	8·95	...	...	
62	14	50	5·41	...	...	
63	10	35	1·93	...	...	
64	9	35	1·56	...	...	
65	11	25	1·67	...	...	
66	13	40	3·73	...	...	
67	11	25	1·67	...	...	
68	8	20	·70	...	...	
69	11	50	3·34	...	...	
70	14	50	5·41	...	...	
71	8	35	1·23	...	...	
72	15	50	6·21	...	...	
Total ...	...	...	48·93			
Total of Sheets.	...	...	99·83 193·29 48·93	·5577		
			342·05		191·76 cubic feet.	
Average ...	...	...	...		2·66 "	

NORWOOD.

Specific gravity of Acacia Melanoxylon.

Girth in Inches.	Length of Billet in Feet.	Cubic contents in Feet.	Weight of Billet in lb.	Weight per Cubic Foot.	Remarks.
12	10	·79	43	54·4	Middle Section.
14	10	1·08	64	59·2	Section from base of tree.
10	12	·66	29	43·9	Top Section.

This is a tree divided into three sections, each of which was carefully weighed; in the top section the proportion of bark is much larger, and the specific gravity consequently less than in the others; and in the second section it is less than in that taken from the base. Weight of dry heart-wood (Gamble) is only 36 lb. For the factor of the Norwood trees the weight of the green wood is taken as 50 lb. per cubic foot.