F O R M   D E T E R M I N A T I O N

AND

V O L U M E   E S T I M A T I O N

OF

STANDING   TREES.

With special reference to

Permanent Sample Plots.

By

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FORM DETERMINATION AND VOLUME ESTIMATION OF STANDING TREES.

With Special Reference to Permanent Sample Plot Work.

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INTRODUCTION.

The establishment of Permanent Sample Plots for the express purpose of studying the volume production and increment of various tree species under different conditions of locality and management, has formed a regular part of the research work of the Forestry Commission since May 1920. Large areas of homogeneous forest growth are not of common occurrence in Great Britain and this has resulted in the laying down of Permanent Plots which, to be uniform, had to be rather on the small side. The needfor investigation of various methods of treatment is so obvious that it has generally been the rule to endeavour to secure two small plots in a suitable plantation rather than one large one. This implies a certain undesirable reduction in the area of the individual plot.

As the method of measurement now in use is one based on a number of felled sample trees, which cannot, of course, be cut from the actual plot area, it is usual to leave a zone round each plot, which is treated just like the plot itself and from which the required number of sample trees are felled at each period of measurement, that is to say, every five years.

For some time past it has become increasingly obvious that the size of zone or "surround" which will be necessary for a given plot, must be anything up to twice the area of the plot itself, for, in the course of a number of years, especially with light thinnings, by the removal of sample trees, the zone is bound to become quite different, as regards stocking, from the actual plot area. Again, repeated removal of large stems from the zone makes for increased risk from wind and exposure. Further, it is often true that locality conditions are not uniform over both plot and surround, especially in the case of exposed woods, so that the sample trees selected may never be truly representative of the sample plot. Most of our plots, too, are established in privately owned woods and owners are naturally chary about allowing the removal of good stems, particularly if these are large.

If a method of measurement could be devised which would be sufficiently accurate for the purpose, but without requiring the felling of sample trees, the advantage would be enormous. It would mean in the first place a longer life for many of our plots and secondly, increased acreage per plot, since surrounds could be made much smaller. The natural solution to the problem would appear to be the selection and measurement of Standing Sample Trees, the great advantage of which would be that a larger number could be selected, that most of these could be retained permanently as Sample Trees throughout the life of the plot and that, being in the plot area, they would be more truly representative of the plot.

The problem is an urgent one not only in this country but abroad, where efforts are being made to meet it. In Switzerland standing sample trees are used and these are measureed in sections with the aid of long ladders of special construction. The method is an expensive, if accurate one. In Sweden, investigations are being carried out to arrive at a solution. Recent developments in forest mensuration in that country give good grounds for hoping that a satisfactory solution will be reached.

The present investigation was undertaken to test a proposed method of measuring standing trees which, briefly, is based upon the determination of the total height by use of a Hypsometer; on the determination of the tree form from several girth measurements taken with the use of a short ladder up to a height of 25 feet from the ground; and <u>on the assumption that the taper of trees can be expressed by a given mathematical formula.</u>

GENERAL SURVEY OF THE PROBLEM.

A. Expression of Form.

To arrive at volume of timber in a standing tree a knowledge of three stem characters is essential. These are the total height, the girth or sectional area at or near the base of the tree - usually taken at breast height, 4'3" above ground, - and the form or taper of the stem, by which is meant the rate of diminution in girth from the butt to the top of the stem.

Following continental practice, up till now the Form factor has been most extensively used in this country as an expression for the form of tree stems. This, however, is simply a factor for comparison between the volume of a tree and that of a certain geometrical figure with the same diameter or girth as the stem at its point of measurement and with the same height as the tree. It is not a true expression of taper at all, varying not only with the form or taper of the stem, but also with the height. Moreover, the form factor of a given tree can only be accurately found when its height, basal area and volume are known, and therefore as an expression of form for use in the determination of the volume of individual trees, it is useless. For this purpose, some expression of form is required which can be arrived at more easily and which is obtainable without first having to find the volume of the tree. Clearly, the desired sequence should be height, basal area, form, volume, and not height, basal area, volume, form.

To meet this requirement the idea of the "Diameter-Quotient" was introduced. Much work was done on this basis by Schiffel and Maass, amongst others. Trees which differed in form were allocated to different Form-classes, according to the relationship between the diameter at the middle of the total length of stem and the diameter at breast-height. This expression of form is thus based essentially on the two characters - height and basal area, with the addition of a new stem character, namely, the diameter or girth, at the middle of the stem. As this new character is more readily measureable than the total volume, the diameter-quotient is clearly a more suitable expression of form than the form factor. It is not, however, quite correct for, owing to the varying proportion which breast-height bears to the total height, trees of the same form may not have the same diameter or "Form-Quotient".

This is clearly illustrated in the case of two trees of the same form, one of which is 8'6" high and the other 58'6" high. In the first case, the form-quotient is 1, since the middle of the stem lies at 4'3" and coincides with breast-height, while that of the latter is something less than 1.

To overcome this difficulty, the correct method in theory would be to fix the points of measurement at proportionately the same places on the stem, e.g. at 1/10th and ½ of the whole length of stem. Practically, however, this would be inconvenient.

In Sweden, Professor Tor. Jonson (1) proposed getting over the difficulty by leaving that part of the stem below breast-height out of account in form determination. His upper diameter is thus located at the mid-point between breast-height and the top of the tree. Even this, however, is not an exact expression of form, but, as it is quite impracticable to locate the lower diameter at the base of the tree instead of at breast-height, it remains so far the best obtainable.

This conception of the Absolute Form Quotient, as Jonson calls it, as an expression for stem form, marks a very distinct advance in Forest Mensuration. Schiffel was able to show a relationship between his own form-quotient and the diameter quotients at a ¼ and ¾ of the height for stems in the same height class. Maass followed this up by producing taper series for different height classes, that is to say, he showed that in a given form class and with the same height, there was a constant relationship between the diameter at any given height on the stem to the Diameter at Breast-Height. With his new conception of the Absolute Form Quotient, Jonson, however, found that with a given Form Class, the same taper series applies even with varying height, that is to say, that with a given Form Class the relationship between the diameters at given percentages of the stem's height to the breast-height diameters were constant.

Further, Jonson found that these relationships could be expressed by a mathematical formula, namely, Höjer's stem curve equation which reads:- $\frac{d}{D} = C \log \frac{c + S}{c}$ in which C & c are constants, differing in each form class, d and D represent diameters, of which D is the diameter at Breast-Height and d is located at a distance S from the top where S is a percentage of the height of the tree above 4'3". The constants can be calculated for any desired Form Class. Thereafter, it is a simple matter to work out values of d for different values of S. These values, determined when S is 10.20,30 etc., % of the length of stem above breast-height, form the normal "Taper Series" of the Form Class in question and together express the normal "Stem Curve" of that Form Class. The points on the stem where the 10,20,30 etc., % of the length of stem above breast-height are located are termed "Height Quotients".

With regard to the agreement in nature with the mathematically deduced stem curves for the Form Classes, Jonson found that for Spruce the curves agreed very well for both over and under bark measurements. For Pine, however, owing to its varying percentage of bark in different parts of the stem, there was no agreement over bark, while for under bark measurements he found that it was necessary, in order to obtain agreement, to modify the "Stem Curve" equation to the following:-

$\frac{d}{D} = C \log \frac{c + S - 2.5}{c}$ the effect of which is that all the upper diameters are calculated in the "Stem Curve" at a point 2·5% higher up than in the original formula, for it was found in actual practice that the values of "d" were less than in the case of Spruce, especially in the upper parts of the stem. The figure 2·5 is termed the "Biologic Constant".

Once satisfied as to the general applicability of the formula, the next step was to prepare Volume Tables based upon this. It is clear that if the formulae do hold, once the height, basal area and Absolute Form Class of any stem is known, then its volume can be worked out, since the diameter at any desired height on the stem can be found. Jonson has published such tables.

A considerable amount of research work has been carried out into Form Quotient methods since the publication of Jonson's work, chiefly in Sweden by L. Mattsson Mårn and Sven Petrini. Work has been done also in Canada by H. Claughton Wallin, F.McVicker and W.G. Wright and H.R. Wickenden, and in the United States by G. Edward Behre.

Much of the Swedish work has been directed to what is clearly the main problem, namely finding reliable methods of determining the Form Class of standing stems. Jonson himself evolved a method which is based upon the position and form of the crowns. It is claimed that the stem of a tree is built to offer the best resistance to breakage by wind pressure and that the larger the crown the more rapid the taper and vice versa. As it is against the crowns that the wind comes into play, it is claimed that the form or taper of the stem will vary with the height, form and position of the crown. The point on the stem at which the force of the wind may be considered to be concentrated, is termed the "Formpoint" and Jonson claims that the percentage which the height of this point above ground, is of the total height, is an indication of the form class of the tree. This method of Form Class determination is called the Form Point method. In practice, the position of the Form Point is presumed to lie at the same height from the ground as the centre of gravity of the crown. This centre of gravity varies in position according to the shape of the crown, and it is, to a great extent, a matter of personal judgement to estimate where it actually lies. Once its position has been decided, the relation between its height from the ground to the total height of the tree is a matter of simple measurement.

Mattsson (3) carried out an investigation on 250 stems of Scots Pine and his conclusions were briefly, that, though the Form Point method presented no difficulties in fully stocked Pine woods, it only gave accurately the mean Form Class of the stand and not the Form Classes of individual trees. For Spruce, Petrini (5) found that everything pointed to a close connection between the mean Form point and the mean Form Class of a stem, but that the Form Point method cannot be used with sufficient accuracy for single trees. In a later research into Lapland Pine (6) he again states similar conclusions. It thus seems clear that this method of determining the Form Class would hardly be suitable for Sample Plot purposes.

Mattsson (4) carried out an elaborate investigation into the form of European and Siberian Larch. His conclusions were that the general stem construction is the same in the two species and that hardly any difference can be observed compared with Scots Pine.

Wickenden (10) states that he has found the Jonson volume Tables to apply in Canada to Balsam, Spruce and Jack Pine. J.Claughton-Wallin and F.McVicker (9) are satisfied that the Table can be used with great accuracy for White and Red Pines in Canada.

C. Edward Behré (2) in a recent publication, gives the result of work on 200 Western Yellow Pine, for which species he was unable to get conformity with Jonson's curves. An attempt to obtain a suitable "biologic constant" proved unsatisfactory, so that he evolved a fresh set of stem curves based on a new equation which represents the form of an ordinary hyperbolic curve - namely $y = \frac{X}{a + bx}$ or, expressed in the terms of Höjer's formula :- $\frac{d}{d} = \frac{S}{a + bs}$. He claims that the formula is more in agreement not only with his own material, but also with that of Jonson, Mattsson and others. This appears to be true in certain cases, although the actual differences, except in the top sections of the highest Form Classes, are very small. The formula, however, has the advantage of simplicity and ease of working. As it would seem to be more applicable to Larch and Pine than Jonson's formula, Behré stem curves have been used in the present investigation. These curves have been drawn for Form Classes 0.50 to 0.80

and are shown in Graph A. attached.

B. Work done in Britain to date, with special reference to Tintern Larch.

Since January 1923, a considerable amount of preliminary work of a tentative nature has been carried out, mainly towards testing the applicability of the mathematical formulae to trees grown in this country.

Data were first collected in 1921 in the Beacons Wood, Tintern, Monmouthshire, the same wood in which the present investigation was carried out. Certain trees selected throughout the wood for telegraph poles were measured over and under bark at ½ 10, 20, 30 etc., % of the height above breast-height. The 188 trees were grouped into Form Classes and mean Taper series for each Form Class were marked out. Although graphical methods such as the one described in the sequel, were not used to eliminate root-swelling, close agreement with Jonson's theoretical Taper series was obtained with similar deviations in the extreme Form Classes to those found by Mattsson (4). The root-swelling was eliminated by trial of varying girths at breast-height, until a stem curve was obtained agreeing with the trend of one or other of the theoretical curves.

Since 1923, 129 felled stems of various species have been measured in the same way, comprising Scots Pine - 17, Norway Spruce - 50, Larch 32, Japanese Larch 6, Corsican Pine 6, Sitka Spruce 11, Dougles Fir 11, Abies grandis 6. The results were surprisingly good with all species, except perhaps the Corsican Pine and close conformity with Behre's stem curves was obtained, particularly with Scots Pine, Japanese Larch and Abies grandis. After allowing for distension at the butt in Spruce, Sitka, Larch and Douglas Fir, very close agreement was again obtained. These preliminary tests, which it should be noted were carried out actually on sample plot trees in different parts of the country, show sufficient conformity with the theoretical curves to warrant further work being carried out into methods of measurement <u>based on these curves.</u>

C. Present Method of Sample Plot Measurement.

The present procedure in measuring Permanent Sample Plots is as follows. All trees in the plot are girthed at Breast-height. Thinnings are marked and removed. The Main Crop is divided into a number of groups in which the number of trees varies according to the size of the plot. Usually, however, the 20 largest trees are grouped together, then the next 20, and so on, until there are 4 groups of 20, 3 groups of 40, 3 groups of 80, etc. In smaller plots the groups run, 4 groups of ten, three groups of 20, 3 groups of 40, etc., while in larger plots the first group may consist of 40 trees. A number of sample trees are felled which should cover the range of girth in the plot and should be representative of the crop. The number varies with circumstances from 8 to 12 or more. Where possible, as in the case of heavy thinnings, as many sample trees are obtained from the thinnings as possible, the rest coming from the surround.

The sample trees are felled and measurements are obtained of the actual height, the Timber Height to 3" diameter, crown length, all measured to the nearest ½ ft. and volume over and under bark. The volume is obtained by measuring the tree in 10 ft sections, i.e., agirth is measured over and under bark, to the nearest ½" at 5, 15, 25, etc. ft. The top section, which will vary in length from 6½ to 16 ft. is also measured at its mid-point, and it is assumed that the sectional area at the mid-point of each section, multiplied by the section length gives the true volume of the ~~xxxx~~ section. The Form Factor of each tree is worked out from the equation $F = \frac{V}{sh}$, where F is the Form Factor, V is the volume under bark, s is the Basal Area over bark and h is the total height.

Three graphs are then constructed from the data obtained from the Sample Trees, namely, a Height-Girth graph, a Form-factor

-Girth graph and a Volume-Girth graph.

The mean girth of each group in the plot having been worked out on the Basal Area basis, it is then possible to read from the graphs, the mean Form Factor, mean Height and mean Volume for each group. This enables the volume of each group to be arrived at in two ways; firstly, from the equation V = s.h.F. and secondly by multiplying the group-mean-tree volume by the number of trees in the group. These two methods should give results, which closely correspond If they do not, then alterations must be made in the graphs.

Such is the method which is at present considered sufficiently accurate for Sample Plot Work. It is clear, however, that it is not entirely objective. It is quite certain that the selection of representative sample trees is a difficult matter, especially when the surround is small and perhaps differs somewhat from the plot itself Again, with a view to avoiding large and dangerous gaps in the canopy, usually small-crowned trees are selected, which probably thus have a higher form class than the crop average. Further, with so few sample trees, the drawing of graphs is also somewhat subjective, especially when the crop is clearly irregular and the sample trees correspondingly so. It is part of this investigation to test the accuracy of the present method now in use.

D. Description of Form Quotient Method and Proposed Procedure.

The object of this investigation is to test a proposed method of measuring standing sample trees for Permanent Sample Plot work. It is assumed that more elaborate and tedious methods of measurement are permissible in such experimental work than would be applicable in commercial practice. The method proposed is entirely new, and is based upon the Jonson Absolute Form Quotient principles, although the Taper Series or Stem Curves, derived by Behré's formula are preferred to those from Jonson's (Hojër's) equation, on the assumption that the former agree more closely for the species dealt with, namely, European Larch. To apply the Form Quotient method correctly to a single stem, a knowledge of its Total Height, normal Breast-height girth, Form-class and Bark percentage is required. It is proposed that the height should be taken with a suitable Hypsometer and that the Bark per cent at Breast-height and for some distance up the stem should be obtained with a suitable Bark-measuring instrument. Unfortunately, such an instrument was not available for this investigation, so that all measurements were obtained over bark for purposes of comparison. Where required, a reducing factor was obtained from the Larch, previously measured in this wood. An opportunity has since presented itself of using the Bark-measurer of the type used by the Swedish Research Institute. The instrument was found to be very satisfactory

To arrive at an estimate of the normal Breast-Height girth and Form-class of the tree, it is proposed that as many Girth Quotients should be obtained on the stem as possible with the use of a short ladder - say up to 30 ft. from the ground. The Girth Quotients are to be taken at 95%, 90%, 85%, 80%, etc., of the length of the stem above breast-height measured from the top, which length is obtained by deducting 4'3" from the Hypsometric height. (An additional quotient at 102½% was also measured so that the course of the stem-curve below breast-height might be known.) These quotients are then to be plotted on millimeter paper and a graph drawn through them. In this way the presence of abnormal "<u>root-swelling</u>" or deviation of the stem's curve from the normal curve at breast-height will be detected and allowed for. (See Part V. Page 20 and Part VIII, Page 36 .) The girth at breast-height is correspondingly reduced and fresh girth quotients are worked out for the 95, 90, 85 etc. height quotients. These are again plotted on squared paper upon which one or more of Behre's curves have been drawn with girth quotients as abscissae and the height quotients as ordinates. A graph is drawn from the origin O, which represents the normal reduced girth, through these points and is produced to conform in direction with the nearest theoretical curve. It is then assumed that this represents the actual stem curve of the tree, so that its form-class can be read off at 50% of the height above breast-height, i.e., against the 50% height quotient. Similarly any girth can be worked out from this curve for any desired height on the stem; moreover, the position of timber height may be located in the same way. To secure greater conformity with the sectional method of measurement the plotted points near the base of the curve are joined together, so that root-swelling at the 5 ft. point of measurement or abnormalities at the 15 ft. point are duly taken into account. The above procedure is more clearly shown in Graph B attached, in which the method has been worked out for tree No. 24. For each sample stem such a graph would be drawn; timber height obtained as the height-quotient, corresponding to the girth quotient 9½" divided by the normal or reduced girth of the tree; and girths at 5, 15, 25 etc., ft. worked out so that the sectional method of measurement could be applied as at present. The only difference would be that the timber-height and mid-section girths would be indirectly determined and not directly measured. When a suitable bark measuring instrument is provided, it is possible to measure the bark thickness for each girth measurement taken on the stem, thus obtaining under-bark girths. In that case the under bark stem curve would be drawn, so that the mid-section girths obtained would be under-bark and the under-bark volume could be arrived at direct. Thereafter, the Form Factor of each tree could be worked out.

It is proposed to test various ways of applying the method, such as (1) using the mean Form-class obtained, in conjunction with Jonson's volume tables; (2) using these tables in conjunction with a Form-class-Girth curve; (3) using the present method of measurement with Hypsometric heights, estimated volumes and estimated Form Factors. At the same time the ordinary sample plot method based on 8 sample trees selected outside the plot was applied for purposes of comparison. The basis for comparison for all these methods of volume measurement will, of course, be the total volume of the area dealt with as obtained by sectional measurements over and under bark on all the individual stems. Certain error calculations will be possible, such as Hypsometric against Actual heights and, since the form quotients were measured on every stem at every 10% of the height above breast-height, estimated Form-class against

Actual Form-class. Further, some insight will be obtained into the Form-factor, rootswelling and its effect on the Form-factor, Bark conditions in Larch and into Form variation within the stand.

PART III. DATA.

The area available for testing the method consists of an extent of European Larch, 60 years old, at the Beacons, Tintern, Monmouthshire, which is being clear-felled in strips and artificially regenerated. In January 1924, the plot was staked out in the strip due for felling in the following season. This plot was .557 acre in extent and contained 100 stems. The wood is situated at an elevation of 850 feet above sea-level and appears to have been planted amongst Oak and Beech coppice stools. The aspect is S.E. and the slope is very gentle. The soil is a sandy loam of variable depth with frequent large blocks of sandstone over Old Red Sandstone. The ground vegetation consists mainly of grasses, Bilberry, Bracken, Blackberries and Mosses. The plot area was moderately sheltered. The Quality Class was II (70 ft.) (See British Yield Tables.) The canopy was complete and the stocking dense. The crowns, though regular were small. Some trees were slightly forked and a few were deformed, but on the whole their appearance was good. The stems varied a good deal, many being straight and well-formed. Canker and deformities undoubtedly interrupted the even-ness of the stem taper in most cases. The wood appears to have been densely grown and subjected to heavy thinnings, probably late in life. As may be observed, the Form-class is high, namely .708, the average height was 81 ft.; and the average girth 38".

The 100 stems in the plot were numbered with white paint and the 4'3" or breast-height mark was painted on each tree. This mark was subsequently used as the basis for all measurements of height or length, so that any error due to variation in the position of the breast-height was eliminated. The stems were girthed to the nearest ½" at breast-height and classified according to the system adopted in Sample Plot work. The trees were then separated on a girth basis into 5 groups of 20 trees each, in the usual way. The heights of the Sample trees selected outside the plot area were taken with the aid of the Abney Level. They were then felled and measured in the usual way. At the same time over-bark Girth-quotients were measured up to the 75% Height-quotients. This should have been done while the trees were standing, but was postponed to save time, until they were on the ground. From these Girth-quotients and the hypsometric heights it was afterwards possible to work out the Form-class and volume of the trees in the same way as if they had not been felled, but were measured standing. A comparison with the usual method was then possible.

30 sample trees were then chosen on a basis of girth and stem class in the plot. That is to say, not only normal, but also abnormal stems were chosen in all canopies. The hypsometric heights of these were measured, after which as many girth quotients were obtained on the standing stems as possible, with the use of a 20 ft. ladder. A belt, such as is used by G.P.O.Telegraph Department, was found to be useful in this operation, as it was necessary to have the ladder resting perpendicular in order to be able to girth round the stems. This belt was fastened round the body of the measurer and round the tree, the ladder having first been fastened to the stem with rope. The belt could readily be loosened or tightened as desired. In practice the measuring of the girths was found to be complicated by local swellings on the stem, probably due to healed-over cankers. It was found that an observer standing some little distance from the tree could usually detect these irregularities, and the girth was then taken below the swelling if the reading so obtained was lower than the girth at the theoretically correct spot.

All the 100 stems in the plot were then felled and measurements of height and volume made on the ground. Many of the tops were broken and some of the leading shoots were lost in this operation, so that the actual height measurements can only be taken to be correct to the nearest foot. As stated above, all measures of height and length were made from the painted mark at breast-height

In addition to taking all over and under-bark volumes by measurements in 10 foot sections, girths over and under bark were measured at 10, 20, 30 etc., per cent of the stem's height above breast-height, so that Girth quotients could be worked out, together with the true Form-class of each tree and the degree of root-swelling. Obvious abnormalities on the stem were avoided where possible.

The age and size of the trees on the whole, were what we may expect to deal with later on in sample plots when the shortage of sample trees has come to be felt. At the same time, the irregularity of stem, high degree of root-swelling and small number of attainable girth quotients make the trial a very complete and thorough one.

Owing to no suitable bark-measuring instrument being at hand, recourse was had to data obtained from the previous Form-quotient measurements made in this wood. From this data a graph was obtained of Bark per cent against breast-height girth which was utilised. It should also be stated that the preference for Behré's equation over Höjer's equation was justified on the results of the previous Form-quotient measurement, from which it is clear that the trees showed closer agreement with Behré's values.

PART IV. Height Measurement. Trial of Hypsometer.

The heights of the 8 sample trees and of the 30 inside sample trees were taken by means of two Abney Levels, termed S and G, of which G was known to have a systematic error of - 2 ft. in 50 ft. which was allowed for. In the case of the 30 inside sample trees the height was taken twice for each tree, once with each instrument, and the mean was assumed to be the correct height.

The 8 outside trees were measured with one Abney Level only, namely, G and the results were as follows:- the means being obtained graphically from girth-height graphs:-

Actual Graphical Mean	=	80.7 ft.	
Hypsometric " "	=	78.9 ft.	
Difference	=	-1.8 ft.	= -2.23%

This result appears to be satisfactory.

The average height of all the trees in the plot, measured after they had been felled, amounted to 81.17 ft. ± 3.724 S.D. The outside sample trees were thus, with regard to height, truly representative of the plot. Taking the hypsometer results, however for the outside trees, the difference is - 2.27 ft. or 2.78%.

Results with the inside sample trees were as follows:-

Actual Measured Heights	=	81.6 ± 3,215 S.Dev.
Abney Level "S"	=	80.87 ± 3.805 "
Abney Level "G"	=	79.97 ± 4.096 "
Means of 2 instruments	=	80.33 ± 3.845 "

As may be seen, the inside sample trees are on the whole very slightly taller than the whole stand, while the range of height is less. The hypsometric mean heights, which were, of course, used to fix the position of the Height Quotients on the standing sample trees, are about 1¼' too short. The percentage difference amounted to - 1.47% ± 2.651 S.Dev., i.e., almost constantly 1½%.

Such a slight difference with this height of tree does not affect the position of the lower Height Quotients at all so that the error involved in arriving at the height of such trees should not affect the results of the method as a whole.

Further, there are more accurate hypsometers than the Abney level, and in using such, two readings taken for each tree gives very accurate results.

PART V. Root-swelling.

If the stem curve of a tree closely followed the theoretical curve, according to either Behré's or Jonson's formula throughout its entire length, this would imply that there would be a gradual decreese in the rate of taper or rate of girth increase from the top to the base of the tree. As a matter of fact, however, in all trees, whether normal or abnormal, there occurs a marked deviation from the theoretical curve at the base of the tree where the roots come into play. Here, where the stem is anchored to the ground by its roots, extraordinary strains and pressures occur, to meet which, extra strengthening is required. This is supplied by an increase of material either all round or in the form of buttresses which pass from the main roots into the trunk. Such strengthening may be termed "Rootswelling" According to Petrini (6) the extent of the swelling varies with different conditions, e.g., character of soil and type of root system. Under the same conditions, he says it becomes greater in larger trees, as one would expect.

Petrini has found this rootswelling to extend with Lapland Pine as far up as 10% af the total height from the ground. Jonson at one time proposed raising the height of the point of measurement of the basal area so as to get above the root-swelling which with Pine and Spruce seldom extends above breast-height. This proposal was abandoned. Mattsson (4) found with Larch that rootswelling was of regular occurence up to 4½ or 6 feet, and even at times up to 9 feet above ground, which of course, for practical purposes precludes the possibility of varying the point of measurement in this speies.

It would seem then, that rootswelling is a factor which is of considerable importance in Forest Mensuration and one which demands special attention. It should be observed that it has a very important influence upon the size of the Form Factor. Other things being equal, the tree with the greatest degree of root-swelling has the smallest Form Factor. The same applies to the various species and this no doubt accounts for the relatively small Form Factor in Larch and Douglas Fir. With these species and others such as Sitka Spruce, rootswelling appears to be a regular feature and it is worthy of note that Wright (11) proposes in the case of certain Canadian species to assume that this is so, and to deduce empirical stem curves for those species without eliminating rootswelling in any way. That is to say, he assumes rootswelling to be a normal addition to the stem's taper. This may be of considerable practical value but it is obviously desirable to try to obtain a standard set of Form-class curves applicable to all species with one standard set of volume tables, and to make the necessary alteration in respect of rootswelling, bark, etc., rather than to deal with different curves for the different species.

Moreover, it is clear that, apart from the systematic root-swelling above breast-height peculiar to some species, swellings of an abnormal nature occur on some types of ground, and where heart-rot is present or threatening. This is specially true of Norway Spruce in some stands of which trees may occur with marked root-swelling, while others have none.

With regard to the Form-quotient data available in Great Britain, it may be remarked that most of the woods were young or middle aged. It certainly appears to be the case, however, that systematic root-swelling occurs in European Larch and Douglas Fir of all ages. It is also very marked in Sitka Spruce. As stated above, it varies a good deal in the case of Norway Spruce, but is seldom present above breast-height in young stands. Very slight swelling was noticeable with Scots Pine about 50 years of age, but in the case of Corsican Pine, 'Abies grandis', Japanese Larch and, as a rule, in Scots Pine, little or no rootswelling was found as high as breast-height, at least in young woods.

It was obvious even from ocular observation that well marked rootswelling occurred in the Beacons Larch. For each sample tree the degree of this swelling was determined graphically as follows With the over-bark girth at 95, 90, 85, 80, 75 and in some cases 70% of the stem's height above breast-height as numerators and the actual measured girth at breast-height as denominator, girth quotients were worked out for each stem. These values were graphed as illustrated in graph B for tree No. 24, with the Girth-quotients as abscissae and the height quotients as ordinates. Where rootswelling exists, these values, instead of following the even trend of a hyperbolic curve, form a curve with the origin, which represents actual breast-height, shaped roughly like the letter 'S'. If, however, no account is taken of the origin, and possibly of the 95% girth-quotient, and and even curve be drawn through the remaining values and produced downwards, a true representation of the normal stem curve is obtained. The deviation of this curve from the origin is an index of the degree of rootswelling and the girth-quotient of what may be termed the 'normal' breast-height girth in relation to the actual breast-height girth is easily read off from the graph. If the 'actual' breast-height girth be now multiplied by this quotient, the value of the 'normal' girth is obtained in absolute measure, e.g., in tree No. 24 the actual breast-height girth was 41 inches; the normal breast-height girth-quotient as read off the graph was .940. 41" x .940 = 37½" which is the reduced breast-height girth. The difference between the two breast-height girths gives the amount of rootswelling in absolute measure, i.e., 41 - 37½ = 3½" rootswelling.

This elimination of rootswelling is essential if the Absolute Form-class of a stem is to be ascertained. It is clear that if the breast-height girth is abnormally large all the Girth-quotients calculated with this girth as denominator are abnormally small. Thus, though these values represent the actual stem curve, they are not in a form which is strictly comparable with the theoretical curves, which are the true standard of comparison. To remedy this, the 'normal' breast-height girth must be substituted as denominator in all values. If the new Girth-quotient values thus obtained are now plotted on millimeter paper and an even curve drawn through the points, this curve will pass through the origin. By plotting the theoretical curves on the same graph they can be used as a standard of comparison for the particular stem curve just drawn. It is then a simple matter to produce this particular stem curve upwards, in conformity with the nearest plotted theoretical curve, to pass through the remaining Height-quotients, which are beyond reach with a ladder, up to the top of the tree which is a known fixed point. On the assumption that these theoretical stem curves do apply in nature, we have thus obtained an exact graphical representation of the whole of the stem curve of the tree in question. <u>This is the basis of the pr. proposed method of measuring standing sample trees</u>. The idea of using the Form-quotients in the lower part of the stem is entirely new, and is certainly less subjective than the Form-point method of determining the Form-class.

Rootswelling was ascertained in the graphical manner described for all Sample Trees, from the over-bark girth measurements at the 95, 90, 85, 80 and 75% Height-quotients. (See Graph B.)

Rootswelling was also ascertained in the same way under bark from the Form-quotients for all the trees in the plot.

The results were as follows:-

For the 30 inside sample trees, the average rootswelling ascertained from the 95-75 Form-quotients which were measured over bark on the standing trees, amounted to 2.04 inches on the breast-height girth, with a Standard Deviation of $\pm$ 1.079 inches. Rootswelling expressed in absolute measure is thus a very variable character.

The average rootswelling for the same trees obtained by graphing all the under-bark Form-quotients measured on the felled stems, came to 2.21 inches with a Standard Deviation of $\pm$.908".

It will be seen, assuming that the second method gives the real rootswelling, that the estimated rootswelling is about $\frac{1}{4}$" too low. A better idea of the difference may be obtained from the following:-

In 10 trees the degree of rootswelling was the same for both methods - standing and felled trees.
" 5 " the difference amounted to $\frac{1}{4}$" on the girth at breast-height.
" 6 " " " " " $\frac{1}{2}$" " " "
" 6 " " " " " $\frac{3}{4}$" " " "
" 3 " " " " " 1" " " "

For the same trees, the results stated in percentages of the actual Breast-height girths, are as follows:-

The actual Rootswelling amounted to 6.35% of the Girth at Breast-height with a Standard Deviation of $\pm$ 2.22%

The estimated Rootswelling amounted to 5.35% of the girth at Breast-height with a Standard Deviation of $\pm$ 2.42%

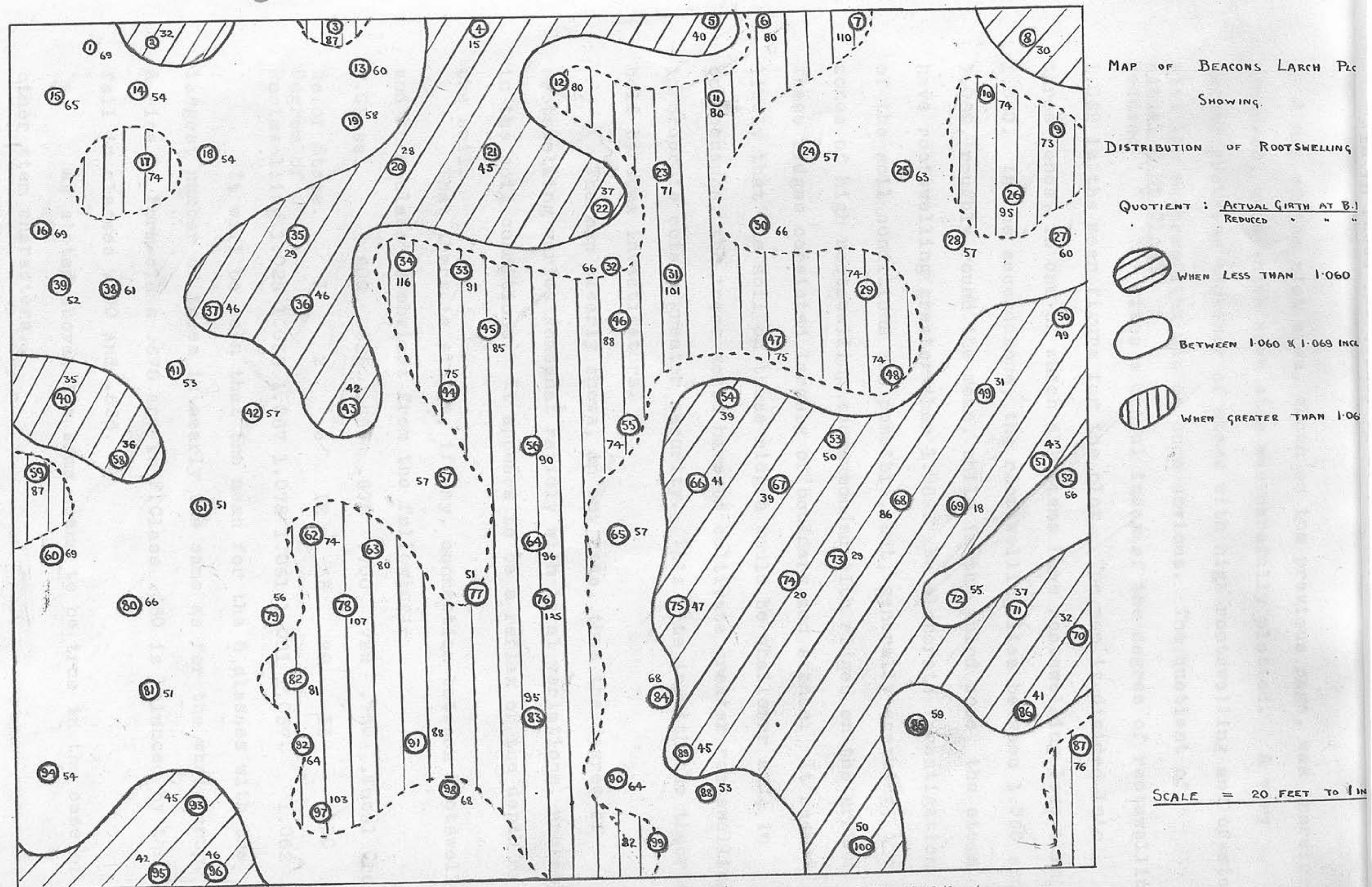
The mean difference per stem amounted to - .72% of the girth at Breast-height with a Standard Deviation of $\pm$ 1.62%

<u>It is thus possible to determine the rootswelling with considerable accuracy from a small number of Form-quotients on standing trees.</u>

This is further supported by results from the 8 outside sample trees. The Arithmetic Mean Rootswelling actually came to 5.91%, while the estimated arithmetic mean was 5.65%, the determination being exact in 4 cases out of the 8.

For the whole of the trees in the plot, the actual rootswelling amounted to 5.92% of the girth at breast-height, with a Standard Deviation of $\pm$ 2.12%. Both sets of sample trees were thus satisfactorily representative of the degree of rootswelling over the whole plot. There is a clear tendency, however, towards estimating the rootswelling too low from the small number of Form-quotients measured on the standing trees. This occurs when drawing the original stem curves based on these values and, as a result, there is also an under-estimation of Form-class.

From a close inspection of the whole data, no connection between rootswelling and any other stem character such as Girth, Height or Form-class,seemed likely. It was observed, however, in working out the degree of rootswelling, that there was a distinct tendency for several trees of high rootswelling to occur together, while groups of trees with low rootswelling were also noticed. It was thought that probably the rootswelling is mainly influenced by the local soil conditions, more especially by depth of soil.


MAP OF BEACONS LARCH PL
SHOWING
DISTRIBUTION OF ROOTSWELLING
QUOTIENT : ACTUAL GIRTH AT B.H. / REDUCED " " "
WHEN LESS THAN 1·060
BETWEEN 1·060 & 1·069 INCL
WHEN GREATER THAN 1·06
SCALE = 20 FEET TO 1 IN

A map of the plot area, shown on the previous page, was therefore prepared, upon which each stem was carefully plotted. A very marked grouping together of stems with high rootswelling and of stems with low rootswelling was at once obvious. The quotient of $\frac{\text{Actual B.Ht.Girth}}{\text{Reduced " " "}}$ gives a useful index of the degree of rootswelling. 1.062 is the mean figure for the plot. The map is divided into three zones, in one of which all stems have rootswelling less than 1.060. In the second zone, the rootswelling lies between 1.060 and 1.069, roughly round the mean, while in the third zone, the stems have rootswelling greater than 1.069. No elaborate investigation of the soil conditions was possible, but, generally speaking, the zones of high rootswelling corresponded with ridges on the ground. These ridges consisted largely of boulders and stones. It seems likely that the soil on these ridges would be shallower and, in consequence, the trees would have to cultivate greater rootswelling in order to obtain greater security. This fits in with the theories held by some investigators.

The map clearly shows, in any case, that the degree of rootswelling varies somewhat rapidly with local variations, probably in the soil conditions. It appears to be a reflex of the depth of the soil.

That there is slight, if any, connection between Rootswelling and Form-class is obvious from the following:-

F.Class.	.600	.625	.650	.675	.700	.725	.750	Total Crop.
No.of Stems.	1	2	6	12	35	29	15	100
Degree of Rootswelling.	1.028	1.036	1.067	1.078	1.061	1.061	1.057	1.062

It will be seen that the mean for the 5 classes with the largest number of trees is nearly the same as for the whole crop. A rise in Form-class .675 and in F.Class .650 is balanced by the fall in classes .600 and .625.

As stated above, the same seems to be true in the case of other stem characters.

PART VI. BARK.

As no suitable bark measuring instrument was available, all the girths measured on the standing trees were taken over bark. It is proposed in future work to adopt the special instrument which is used by the Swedish Research Institute, by means of which the thickness of bark at each point of measurement may be obtained and a reducing factor applied in order to obtain the under-bark girth from the over-bark girth. Bark measurements are essential with species like Pine in which the thickness varies considerably. The instrument mentioned has since been used in the measurement of several standing sample trees, with complete satisfaction.

Research has been carried out into the bark of Larch by Flury, Schiffel, and Mattsson, and several of their conclusions are of interest in the present investigation. Schiffel found that the Bark% on diameter inside bark remains relatively constant for parts of the stem between $\frac{1}{4}$ and $\frac{3}{4}$ of the height. Flury showed that the bark percents in relation to the inside bark diameters are at a minimum in the vicinity of the mid-point of the stem, whence they increase upwards and downwards. Schiffel and Mattsson found the same result. The increase is most marked in the top sections and near the base. The important point to note is that the percentage of bark is relatively constant for the part of the stem between Breast-height and the 50% Height-quotient. This being so, it was assumed that the stem curve obtained in the graphical manner explained above from over-bark girths would give the same result as if the actual under-bark girths had been available. Subsequent examination of the bark for the whole available material justified this assumption.

When the trees had been felled, all girth measurements made, including that at breast-height, were taken both over and under bark. The mass of data thus obtained lent itself to inspection, and some interesting information was obtained.

Bark at Breast-height. The bark% at breast-height in relation to the over-bark girth is clearly of some practical importance. These percentages were worked out for all trees in the plot and the average value amounted to 9.585% withaa Stan. Deviation of $\pm$ 1.029%.

In the previous mesurement made of certain trees in this wood it was found that the bark % showed a slight fall with increase in girth. The same thing was apparent in the data for the present measurement. The trees were grouped in two-inch girth classes and the average value of the Bark % on the over-bark girth at breast-height were found for each girth class. The values were plotted and a curve was drawn. The results were as follows and are compared with the results of the former measurement.

<u>Bark % at Breast-height.</u>

Girth-Class. / No. of Trees.	24" / 1	26" / -	28" / 3	30" / 7	32" / 9	34" / 12	36" / 18	38" / 15	40" / 10	42" / 10	44" / 5	46" / 5	48" / 3	50" / 1	52" / 1
Actual Bark %	10.10	-	10.15	9.72	10.03	9.94	10.09	9.87	8.97	8.84	8.06	9.30	8.71	9.41	9.52
Evened-off Values	10.20	10.13	10.00	9.90	9.80	9.70	9.60	9.49	9.38	9.25	9.15	9.05	8.95	8.85	8.75
Evened-off Values of Former Measurement.	10.10	10.00	9.85	9.70	9.58	9.45	9.30	9.15	9.03	8.90	8.78	8.63	8.50	8.38	8.20

These two results agree in a satisfactory way, the data in the present case giving a slightly higher value for the Bark.

<u>Bark percent above Breast-height.</u>

From the particular point of view of Form-quotient methods of measurement, it is of great importance to have some knowledge concerning the variation of the Bark % on the over-bark girths up the stem and especially at the 90, 80, 70, etc., Height-quotients. All the trees in the plot were dealt with together and average values for the bark % on the over-bark girths at 90, 80, 70, etc. percent of the stem's height above breast-height were obtained. The results were as follows:-

Height-quotient.	B.Ht.	90	80	70	60	50	40	30	20	10
Bark % on O.B.Girth.	9.58	9.47	9.63	9.88	10,13	10,11	10.07	9.98	10.80	13.05

The mean of all the bark percentages used amounted to 10.26.

It will be seen from the above that for practical purposes the values are nearly constant up to the 30 Height-quotient. There is a slight increase at the 60, 50 and 40 Height-quotients, then a fall at the 30 height-quotient and a marked increase to the tip. This result completely justifies the use of the O.B. Form-quotients up to the 70 Height-quotient, for obtaining the true Form-class of the standing trees.

Bark % of the Whole Stem.

As a measure of the bark for the whole stem, the percentage at breast-height, based as it is on a single measurement, is rather unreliable. A better index would be the mean percentage of all the values from breast-height up to the 20 Height-quotient. With one exception, all the 10% Height-quotients lie above timber-height. This, together with the fact that the value is so much greater than the remaining values, is a good reason for ignoring the bark % at the 10 Height-quotient. The mean of the remaining percentages from breast-height to the 20 height-quotient may thus be taken as an index of the bark for the whole stem. These averages were worked out and results were as follows:-

The mean bark % amounted to 9.958% with a Standard Deviation of ± .931%. Compared with the breast-height bark the result is a little higher, and, as might have been expected there is less variation.

Bark Variation.

Cursory examination of the whole material showed that there was a good deal of variation in individual stems. Some trees showed unusually thick bark throughout the stem, e.g. No. 8.

Height Quotient	100	90	80	70	60	50	40	30	20	10
No. 8. Bark %.	11.76	12.50	13.34	11.99	12.72	13.34	13.34	12.16	12.50	15.00

Others again showed unusually thin bark throughout, e.g. No. 74.

No. 74. Bark %	6.63	5.23	6.71	7.80	9.92	8.55	9.90	8.43	11.11	15.38

Out of the hundred stems, 62 appeared to have uniform or fairly uniform bark throughout up to the 20 height-quotient. In 30 stems there was a distinct increase in thickness from breast-height breast-height to the tip. In the other 8 stems there was a well-marked decrease. No explanation can be given of these variations but in certain cases they are clearly due to inherent differences in the individuals.

Volume % of Bark.

So far only the bark % in relation to the over-bark girth has been dealt with, which gives no indication directly of the percentage of bark in the total over-bark volume. It would be a tedious proceeding to work out percentages of bark in all the sectional areas at all height-quotients. Some indication of the volume percent of bark may be obtained by considering a mean tree of the average girth for the plot, on a basal area basis, namely 38 inches, and of the average Form-class for the plot, say, .700. The average rootswelling amounts to 2", so that the 'normal' girth over-bark is 36" for the average stem. From the theoretical Form-quotient values for Form-class .700, the over-bark girths for all height-quotients on the stem can be obtained. From the Bark % values already found, the corresponding under-bark girths are found. It is then possible to work out sectional area bark %'s up the stem. The mean of these gives an index of the volume % of bark for the plot, corresponding to the girth % of bark of 9.58. The procedure is as follows:-

Height- quotients	100	90	80	70	60	50	40	30	20	10
Form-quotients	1.000	.955	.903	.845	.777	.700	.609	.501	.369	.206
Girths O.B.	38	34½	32½	30½	28	25	22	18	13½	6½
" U.B.	34½	31	29½	27½	25	22½	20	16	12	5½
Section Areas O.B.	.798	.658	.584	.514	.433	.345	.268	.179	.101	.023
" " U.B.	.658	.531	.481	.418	.345	.280	.221	.142	.080	.017
Volume % of Bark	17.54	19.31	17.64	20.62	20.32	18.84	17.54	20.66	20.79	(26.09)

By this rough method, the Mean Volume % of Bark is thus 19.25% which corresponds to 18.36% found in the usual way from the 10-foot sectional measurements at 5, 15, etc., feet on the stems, from 8 sample trees taken outside the plot.

The percentage of bark in the over-bark volume of individual trees was worked out for all stems from their over- and under-bark total volumes. The average amounted to 18.748% with a Standard Deviation of ± 1.796. For the 30 inside Sample Trees the average came to 18.808% ± 1.709 S.Dev. The sample trees selected both within and without the plot are thus very satisfactory from the point of view of bark percentage. It is noteworthy that there is greater variation in the volume bark percentages than in the girth bark percentages.

Conclusions.

From the point of view of this trial, the most important result of the Bark investigation is the uniformity of the girth bark percentages up to the 70 Height-quotients, as a whole. Satisfactory stem-curves may thus be drawn with the over-bark Form-quotients up to the 70 height-quotient as a basis, or even higher.

PART VII. FORM-CLASS AND FORM-FACTOR.

Comparison with Theoretical Curves.

Since the proposed method is based essentially on Behré's theoretical stem-curves, it is of primary importance to examine the data in order to ascertain whether there is satisfactory agreement with these curves.

To do this the under-bark Form-quotients for each stem were worked out for all trees, from the under-bark girth measurements made at 90, 80, 70, etc.% of the length of stem above breast-height, on the felled trees.

These were then graphed and rootswelling was eliminated as previously explained. Fresh Form-quotients were then worked out on the reduced breast-height girth as denominator. When these had been graphed, the evened-off value at the 50 % height-quotient was taken to be the correct Form-class value for the tree. All the trees were then grouped according to this Form-class into 7 Form-class groups from .600 to .750. The distribution over these groups was as follows:-

Form-class.	.600	.625	.650	.675	.700	.725	.750
No. of Trees.	1	2	6	12	35	29	15

The mean Form-quotient values at each height-quotient for each Form-class group were then worked out from the actual measured quotients, not the evened-off values from the graphs. These means were then compared with the theoretical values of the stem curves, according to Behré's equation. The results are given on the next page --

Form-class.		No. of Trees.	FORM-QUOTIENT VALUES AT 90	80	70	60	50	40	30	20	10
			% of the Stem's Ht. above B.Ht.								
.600	Actual.	1	.930	.852	.761	.669	.599	.507	.402	.296	.134
	Theoretical.		.931	.858	.778	.693	.600	.500	.391	.273	.143
625	Act.	2	.939	.882	.801	.714	.639	.527	.422	.306	.174
	Theor.		.941	.876	.805	.726	.639	.541	.431	.307	.164
650	Act.	6	.953	.877	.809	.730	.644	.561	.460	.319	.122
	Theor.		.942	.879	.808	.731	.644	.547	.437	.311	.167
675	Act.	12	.954	.892	.832	.749	.676	.590	.491	.346	.166
	Theor.		.949	.893	.829	.757	.675	.581	.471	.342	.188
700	Act.	35	.958	.902	.850	.771	.695	.608	.507	.369	.180
	Theor.		.954	.901	.842	.774	.695	.603	.494	.363	.202
725	Act.	29	.959	.914	.863	.796	.724	.642	.532	.388	.195
	Theor.		.961	.914	.860	.799	.725	.638	.531	.397	.227
750	Act.	15	.962	.921	.872	.816	.743	.665	.549	.421	.217
	Theor.		.963	.920	.871	.813	.743	.659	.553	.420	.243

A table of the differences between the Actual and the Theoretical Form-quotients, which is given below, gives a better idea of the conformity of the Larch in this plot with the theoretical curves derived from Behre's equation.

Form-class.	No. of Stems.	DIFFERENCES from Theoretical Values at 90	80	70	60	50	40	30	20	10
		% of the Stem's Ht, above B.Ht.								
.600	1	-.001	-.006	-.017	-.024	-.001	+.007	+.011	+.023	-.009
.625	2	-.002	+.002	-.004	-.012	±.000	-.014	-.008	-.001	+.010
.650	6	+.011	-.002	+.001	-.001	±.000	+.014	+.023	+.008	-.045
.675	12	+.005	-.001	+.008	-.008	+.001	+.009	+.020	+.004	+.022
.700	35	+.004	+.001	+.008	-.003	±.000	+.005	+.013	+.006	-.022
.725	29	+.002	±.000	+.003	-.003	-.001	+.004	+.001	-.009	-.032
.750	15	-.001	+.001	+.001	+.003	±.000	+.006	-.004	+.001	-.026

Leaving the single stem of Form-class .600 out of account, it will be seen that deviations from the stem-curves are very small, except at the 10% height-quotient. With regard to the latter, there is considerable deviation but, as this point of measurement lies above the usual timber-height girth, it is not of much significance. It would appear that root-swelling occasionally extends above the 90% height-quotient, thus accounting for the positive deviation shown in Form-classes .650, .675 and .700.

If Jonson's theoretical curves were to be used for the purposes of comparison, it is certain that greater deviations would occur, especially in the top sections of the higher Form-classes. The use of Behré's curves is therefore, justified in this particular wood. It may be remarked that every tree in the plot has been retained for the above analysis, no abnormal stems having been omitted. Further, had the evened-off values been used instead of the actual measured values, a better and more regular agreement would have been obtained.

Form-class of Standing Sample Trees.

The Form-classes of all the standing sample trees were arrived at from girth measurements made on the bottom part of each stem up to about 25 feet from the ground, i.e., up to, in this case, the 75% Height-quotient, and occasionally up to the 70% Height-quotient. These girths were taken at 95, 90, 85, 80 and 75% of the stem's length above breast-height and were measured over-bark. Form-quotients were then calculated and graphed. Rootswelling was eliminated and fresh form-quotients worked out with the reduced breast-height girth as denominator. These values were plotted and a curve drawn and produced in conformity with one or other of the theoretical curves. (See Graphs A and B.) This curve was then assumed to represent the actual under-bark stem curve, so that the girth-quotient read off against the 50% height-quotient would represent the true Form-class of the stem.

As explained under the heading "Rootswelling", Part V, owing to the small number of points available for plotting, the drawing of the graphs in order to eliminate rootswelling, was somewhat subjective. The result was, as shown on p.20 that too small an allowance for rootswelling was made, which was reflected in too small a Form-class, compared with the actual Form-class obtained by graphing all the under-bark Form-quotients measured on the felled stems. (Since this investigation has been completed, it has been found possible with the use of a special extension-ladder, to reach up to 35 feet from the ground. The addition of one or more Form-quotients thus obtained, is a great improvement.)

With regard to the 8 outside sample trees, the results were as shown below.

	Form-class from Standing measurements.	Form-class from Felled measurements.	Hypsometric Height.	Actual Height.
A.	.712	.688	$81\frac{3}{4}$'	84'
B.	.716	.760	$84\frac{1}{2}$'	82'
C.	.750	.727	78'	$81\frac{1}{2}$'
D.	.732	.712	$72\frac{1}{4}$'	74'
E.	.694	.694	$79\frac{1}{4}$'	$79\frac{1}{2}$'
F.	.763	.740	$77\frac{3}{4}$'	$81\frac{1}{2}$'
G.	.685	.712	$76\frac{1}{2}$'	$78\frac{1}{4}$'
H.	.713	.708	$75\frac{1}{2}$'	77'
Means.	.721	.708	78.2'	79.7'

As may be seen, the Form-classes of two out of the eight trees have been under-estimated, namely B. and G., while 5 have been over-estimated. This may be entirely due to the errors in height-measurement, which are, with the exception of tree B, all negative. When the heights are underestimated on the standing trees, all the form-quotients are naturally measured at a point too low on the stem. This means that the girth-quotients obtained would tend to be too high. Consequently the Form-class derived from these girth-quotients would tend to be too high. The opposite would hold where the hypsometric height error was positive. With the exception of tree G, this appears to have been the case with the above sample trees. The exception is explained by the fact that rootswelling on tree G, as determined from the standing measurements was estimated much lower than from the felled measurements, and resulted in a reduction of the corresponding Form-class.

The balancing effect between the errors in height measurement and the errors in Form determination, undoubtedly is important from the point of view of volume determination, increasing the accuracy of the proposed method over the Form-point method of form determination.

With regard to the 30 inside sample trees the average Form-class as determined from the standing measurements amounted to .693 with a Standard Dev. of ± .037. The average Form-class as determined from the felled stems and which may be accepted as the true value, amounted to .7033 with a Stan. Dev. of ± .032. Taking into account the under-estimation in rootswelling from the standing measurements, this result must be considered very satisfactory. Had this rootswelling determination been closer, to judge from the 8 outside Sample Trees, the Form-class would have been over-estimated, for the difference between Hypsometric and actual height was the same in both cases. For the 8 outside sample trees, however, the determination of rootswelling was more satisfactory.

Form-class of Whole Plot.

The average Form-class of the whole stand, as determined graphically from the under-bark form-quotients from the felled stems, came to .708 with a Stan. Dev. of ± .030. It is clear that both sets of Sample Trees were very satisfactorily representative of the crop in respect of Form.

It is interesting to observe that the mean Standard Deviation found by Mattsson (4) for 26 Larch plots in Sweden, was ± .044, so that the form in this wood must be considered to be exceptionally uniform. In only 2 cases did he obtain a smaller standard deviation than ± .030. Further, the mean Form-class agrees with the series Mattsson gives of Form-class against Height.

Form-class and Girth.

The mean breast-height girths of the trees in each Form-class group are as follows:-

F-class Group.......	600	625	650	675	700	725	750
No. of Trees.....	1	2	6	12	35	29	15
Mean Girth	39.75"	46.63"	38.63"	42.40"	37.61"	35.95"	33.98"

This appears to indicate a rise of Form-class with a fall in girth within the stand. Although it is likely that the relationship is not a rectilinear one, a correlation-calculation was made. The co-efficient of correlation amounted to - .376 ± .085, which confirms this relationship. That is to say, on the average there is a fall in Form-class with a rise in breast-height girth in the stand. Clearly, however, the relationship is not a strong one. The regression of Form-class on Girth was .00213, indicating a rise of .002 in Form-class, on the average, with every fall of one inch in Girth.

Form-Factor.

The Form-factor of each tree was ascertained from the formula $F = \frac{V}{sh}$, in which F = Form-factor, V = under-bark volume, s = total Basal area at breast-height and h = total height.

The average Form-factor for the whole plot amounted to .381 with a Standard Deviation of ± .022.

The average Form-factor for the 30 inside Sample Trees came to .374 ± .026, i.e., slightly lower than for the whole plot. The average Form-factor as found by the usual sample plot method from the 8 outside Sample Trees was .385.

Form-factor and Girth.

In view of the significance of the relationship between Girth and Form-factor in the present sample plot method of measurement, the co-efficient of correlation was calculated for these two factors from the data and found to be -.234 with a Standard Deviation of ± .095. Here again the relationship is probably not rectilinear, but the result would imply a slight fall in Form-factor with rising Girth, as might have been expected from the result of the Form-class and Girth correlation. The regression of Form-factor on Girth was .00098, indicating a fall of .001 in the Form Factor on the average with every rise of 1 inch in Girth.

Form Factor and Rootswelling.

The data are suitable for studying the effect upon the Form Factor of the presence of rootswelling. Form-factors were again worked out for every tree but, instead of 's' being equal to the Basal Area corresponding to the actual over-bark breast-height girth, a reduction was made on each tree according to the amount of rootswelling present, and 's' then represented the reduced or 'normal' basal area at breast-height. For the whole plot, the average of these new Form-factors came to .420 with a Standard Deviation of $\pm$.021. Rootswelling therefore has had the effect of reducing the Form-factor from .420 to .381. From this it is quite clear that the Form-factor does not express the form or taper of stems satisfactorily. (See also an article by me in Trans. Roy. Scott. Arb. Soc. Vol. xxxvi 1922.) According to the British Yield Tables, the Form-factor for European Larch of this age and Quality class should be from .370 to.383, while that for Norway Spruce is from .395 to .399. This does not necessarily mean that the Larch has poorer form throughout the stem but may be due to constantly greater rootswelling. The elimination of rootswelling graphically and determination of the Form-class, obviously gives a more exact expression of the form of the whole stem, so that the Form-class becomes a very valuable basis for comparison between stands and between species. On the basis of Form-class, it should be possible in future to undertake exact studies of the changes in Form of trees with age or with various treatments..

PART VIII.

VOLUME DETERMINATION OF INDIVIDUAL STANDING STEMS.

The over-bark volume of each standing sample tree was found by the following process from the stem-curve graph for that tree, based on the Form-quotients of the tree up to the 75% Height-quotient, rootswelling having first been eliminated.

(1). The first step is to determine the timber-height of the tree, i.e., the height on the stem at which a girth of 9½" over bark occurs. The girth-quotient corresponding to 9½ inches is obtained by dividing 9½ by the reduced over-bark girth at breast-height. From the stem-curve graph (See Graph B.) is then read off the height-quotient corresponding to this girth-quotient. This gives a percentage value of the stem's height above breast-height, taken from the tip, so that the actual height above breast-height can readily be found in absolute measure. This height added to 4'3" gives the timber-height of the tree.

As an example we may take tree No. 24, whose reduced girth after elimination of rootswelling is 38½ inches. (See Graph B.) Timber-height-Girth-quotient then is $\frac{9.5}{38.5} = .247$. Reference to the stem-curve of this tree gives us a height-quotient of 12.0%. The length of stem above Breast-height is 76¾'. 12% of this is 9¼'. The total height is 81'. Therefore timber-height is 81 - 9¼ = 71¾'.

(2). The next step is to divide the stem into 10 foot sections according to the usual method in sample plot work. The length of the top section varies. In this case it is 11¾ ft. The mid-point of each of these sections must next be expressed as a percentage of the stem's length above breast-height - or, in other words, as height quotients. The mid-point of the first section is at 5', of the second section at 15' above ground, and so on up to the top section, where it varies, and is in this case at 66'. The height of these sectional mid-points above breast-height is found by subtracting 4'3" from 5', 15' etc. These heights can then be expressed as percentages of the length of stem above breast-height, in this case 76¾'. These percentages are Height-quotients and reference to the stem-curve graph gives the corresponding girth-quotients. These girth-quotients multiplied by the 'reduced' girth at breast-height yield the sectional mid-points in absolute measure. From these the section volumes and the total over-bark volume of the tree are found in the usual way. It is important to note that the stem curve used is the actual irregular stemcurve at the base of the stem and not the evened-off curve through the origin. The following figures illustrate the process for tree No. 24.-

Tree No.24:- Timber-height = 71¾ ft. Total Ht.=81'

Mid-section Heights above Breast-height.	¾'	10¾'	20¾'	30¾'	40¾'	50¾'	61¾'
Corresponding Height-quotients	99	86	73	60	47	34	19½
" Girth-quotients.	1.030	.956	.867	.792	.692	.570	.380
Mid-Section Girths (over-bark)	39½"	37"	33½"	30½"	26½"	22"	14½"
Volumes of sections (cu. feet)	8.62	7.57	6.20	5.14	3.88	2.68	1.37

For comparison the actual mid-section girths and over-bark section volumes obtained from the same tree when felled may be given.

Actual Measured Mid-section Girths.	39½"	36"	34"	30½"	26"	22"	14"
" " Section Volumes.	8.62	7.16	6.39	5.14	3.74	2.68	1.24

The total volume of the tree by the standing tree method is thus 35.46 cubic feet and by the actual sectional measurements on the ground, 34.97 cubic feet. This is a fairly typical tree as may be seen from the data appended, and does not represent the best result obtained. It gives a striking illustration of the possibilities of the method.

Determination of Timber Height on Standing Stems.

The determination of timber height on the standing sample stems was extremely satisfactory, as the following figures show. The actual measured timber height on the felled stem is the basis of comparison. The difference between actual and estimated timber-height was found for each tree and the average difference amounted to - .759 feet with a Standard Deviation of ± 2.08 feet. The estimation was thus on the average ¾ of a foot too low, which would be due to the under-estimation of Form-class.

Differences between Actual and Estimated Over-bark Volumes.

The average difference between the volumes determined from the standing measurements and those from the felled stems comes to -1.365% with a Standard Deviation of ± 3.413%. It is possible that the negative difference of 1.365% is entirely due to an under-estimation of Form-class. The result must be considered as very satisfactory.

Petrini (5) gives the following figures for 104 Norway Spruce stems whose volumes were found by use of the Form-point method and Jonson's Tables and compared with sectional measurements. The systematic error amounted to -3.5% with a Standard Deviation of ± 8%.

The method on trial would thus appear to be more accurate than the Form-point method for single stems.

Systematic Error of the Half-Timber Method.

A common method of arriving at the volume of a tree is to obtain the sectional area at half-timber height and to multiply it by the timber height. It would be of interest to compare the results of this method with the sectional method. This was done for the 30 inside Sample Trees. The average difference or systematic error amounted to - .79% with a Standard Deviation of ±3.5 per cent. Compared with the error of the method, there is very little difference, while the range of variation is practically the same.

Considering the disadvantages under which the trial was made, the method has given remarkably good results. Better results would certainly be obtained if a few more Girth Quotients could be measured, say up to 35 feet above ground. This has since been confirmed in two further comparative trials made in two younger Larch woods, with the aid of a longer ladder and the Swedish Bark-measurer.

PART IX.

TOTAL VOLUME OF PLOT FROM STANDING TREE MEASUREMENTS.

The volume of the whole plot may be arrived at in several different ways from the standing sample tree measurements.

A. By proportion between basal areas.

The simplest method, when the number of Sample Trees is relatively large, as in the case of the 30 inside sample trees, is to find the volume by the formula $V = \frac{v.S}{s}$, where V and v are the volumes of the whole plot and of the sample trees respectively, and S and s represent the basal areas of the whole plot and of the sample trees respectively.

Substituting in this equation the values obtained from the data, we get -

$$V = \frac{849.04 \times 79.085}{23.051} = 2914 \text{ cubic feet over-bark} \ldots\ldots\ldots (6).$$

Using the figures from the 8 outside Sample trees the result is as follows -

$$V = \frac{232.76 \times 79.085}{6.163} = 2986 \text{ cubic feet over bark} \ldots\ldots\ldots (2)$$

B. From Form-Factor, Height and Volume-Girth Graphs.

The volumes used were those arrived at from the data obtained on the standing sample trees. The heights used were those obtained with the hypsometer. The under-bark form-factors were found by allowing 18% for bark on the volume of each sample tree. The usual sample plot method of grouping was then applied, group mean values being read off from the graphs.

(i). The result in the case of the 8 outside Sample Trees was as follows:-

			Form-Factor Graph.	Volume Graph.
Group I.	20	trees	744.7	740.0
" II	20	"	557.2	558.0
" III.	20	"	469.5	468.0
" IV.	20	"	399.7	400.0
" V.	20	"	302.1	305.0
Total	100	"	2473.2	2471.0 cubic feet

under bark...............(3).

(ii). The result from the 30 inside Sample Trees, in this case over-bark, was:-

Group I.	20	trees	842.2	by the Form-factor Graph Method.
" II.	20	"	652.4	
" III.	20	"	560.7	
" IV.	20	"	481.5	
" V.	20	"	375.0	
Total	100	"	2911.8	cubic feet over-bark............(7)

C. By applying Jonson's Volume Tables.

The value of Jonson's Volume Tables for obtaining the volume of a stand was also tested, first by using mean values of height, girth and Form-class and secondly, by using Group-mean values for five groups of 20 trees each, as before.

(i). By Mean Values of Height, Girth and Form-class.

(a) The mean Height of the 8 Outside Sample Trees was 79 feet = 24.07 metres.
" " Girth of the plot by the Basal Area method = 38 ins.
" " Rootswelling of the 8 sample trees was 2.08", so that
" " Reduced Girth of the plot = 36" = 29.10 cms Diameter.
" " Form-class of the sample trees was .721 = .725.

From the tables the volume corresponding to a diam. of 29 cms a height of 24 metres and a Form-class of .725 = 0.837 kbms. = 29.56 cubic feet. Therefore the vol of 100 trees = 2956 cu.ft. over bark

A correction, however, has to be made for rootswelling. If we take the bottom 8½' of the mean stem, its actual mid-section area is not the area corresponding to 36 ins. of girth but that corresponding to 38" of girth. It is not .716 but .798 sq. ft. It is greater by .082 sq.ft. If we multiply this by 8½ and again by 100 we get the volume which is contained in the rootswelling = 70 cu.ft

The corrected over-bark volume of the plot is thus = 2956 + 70 = 3026 cu.ft O.B.............(4)

(b) The Mean Height of the 30 Inside Sample Trees is 80½ feet = 24.53 metres, say 25 metres.
" " Girth is reduced as before by the rootswelling of 2.21 inches to 36" = a diam. of 29 cm
" " Form-class of the Sample trees is .693, say, .700.

From the tables the volume corresponding to a diam. of 29 cms, a height of 25 metres and a Form-class of .700 = 0.832 kbms. = 2939 cubic feet.

Correcting for rootswelling, the over-bark volume = 2939 + 70 = 3009 cu.ft.......(8)

(ii) By the Group method and Group-Mean Values obtained from Height-girth, Form-class-Girth and Rootswelling-Girth graphs.

For each group the same procedure as above was carried out.

(a) From the 8 outside Sample tree data.

Girth	Root-Swelling.	Reduced Girth.	Diam.	Height feet.	Height Mets.	Form Class.	Volume Kbms.	Volume O.B. Cubic feet
I.45½"	3"	42½	34cm.	83	25	.725	2.388	843.5 +23.36 = 866.86
II.40"	2½"	37½	30 "	80	24	.725	1.790	632.3 +17.12 = 649.42
III.37"	2"	35	28 "	78½	24	.725	1.560	550.9 +12.80 = 563.70
IV.34½"	1½"	33	27"	77	23	.725	1.394	492.3 + 8.96 = 501.26
V.30½"	1"	29½	24 "	75	23	.725	1.100	388.6 + 5.12 = 393.72
								2974.96
								i.e. 2975 cu.ft............(5)

(b) From the 30 inside Sample trees.

Group. No.	Girth.	R.S.	Reduced Girth.	Diam. cms.	Height feet.	Height Mets.	Form Class	Volume Kbms.	Volume O.B. C.ft.	C.Ft.+ R.S.
I.	45½	4	41½	34	84	26	.700	2.372	837.7 +30.88	=868.78
II.	40	3	37	30	82	25	.700	1.780	628.7 +20.32	=649.02
III.	37	2	35	28	81	25	.700	1.552	548.1 +12.80	=560.90
IV.	34½	1½	33	27	79½	24	.700	1.390	490.9 + 8.96	=499.86
V.	30½	1	29½	24	78	24	.700	1.o98	355.8 + 5.12	=393.02
										2971.34
									i.e. 2971 cu.ft.	...............(9)

PART X. VOLUME BY USUAL SAMPLE PLOT METHOD.

The under-bark group volumes and the total volume by the usual method at present employed in Sample Plot work, 8 sample trees being felled outside the plot, were as follows:-

			Form-factor Graph.	Volume Graph.	
Group	I.	20 trees	738.9 (744.7)	740.0	
"	II.	20 "	558.0 (557.2)	558.0	
"	III.	20 "	467.6 (469.5)	468.0	
"	IV.	20 "	399.7 (399.7)	400.0	
"	V.	20 "	303.1 (302.1)	305.0	
Total		100 "	2467.3(2473.2)	2471.0	.......(1)

For purposes of comparison, the group volumes obtained by the same method but from the measurements made on the sample trees standing, are given in brackets, 18% being allowed for bark. The two sets of graphs for the two lots of data were identical in trend, but the Height graph from the felled tree data was higher than that from the hypsometric data, while the Form-factor graph of the felled tree data was lower than that from the standing tree data. These two differences appear to have balanced each other in a very satisfactory way. No difference could be distinguished in the two Volume-girth graphs.

<u>In this instance, the volumes from the standing tree data and those from the felled tree data are identical.</u>

PART XI. VOLUMES BY SECTIONAL MEASUREMENT AND COMPARISON OF RESULTS

The total volume obtained as the sum of the section volumes of all the trees in the plot, measured on the ground was as follows:-

Over-bark = 3008.18 cubic feet.

Under-bark = 2449.43 " "

This is assumed to be the correct volume of the whole plot and is therefore the standard to which the other results must be compared. This comparison and the percentage differences of the methods above used, may be given in tabular form.

	Over-bark C.ft.	Under-bark C.ft.	Differences. C.ft.	Differences. Percent.
Volumes by Sectional Measurements	3008	2449		
(1) Volume by usual plot method from 8 felled trees.		2467	+ 18	+ 0.74%
(From Standing Measurements on 8 outside sample trees.)				
(2) Proportion of Basal Areas.	2986		- 22	- 0.73%
(3) Form-factor Graphical method. (18% Bark Allowance.)		2473	+ 24	+ 0.98%
(4) From Jonson's Tables by Mean Tree Values.	3026		+18	+ 0.60%
(5) From Jonson's Tables by Group Mean Values	2975		- 23	- 0.77%
(From Standing Tree measurements on 30 inside sample trees.)				
(6) Proportion of Basal Areas	2914		-94	- 3.13%
(7) Form-factor Graphical method. (Over-bark.)	2912		- 96	- 3.19%
(8) From Jonson's Tables by Mean Tree Values.	3009		+ 1	+ 0.03%
(9) From Jonson's Tables by Group Mean Values.	2971		- 27	- 0.90%

__Observations:-__ Neglecting for the present the Volume Table methods, it is apparent that the results are fairly satisfactory, especially from the data obtained from the 8 outside sample trees, where in every case the difference is under 1% and in two cases, positive. The differences are greater in the case of the 30 inside trees and they are negative. It would be of great interest to examine these two sets of trees in order to see how representative they are of the whole crop.

A simple and reliable indication of their relationship to the whole crop is obtained from the ratio of volume, actually measured, to basal area, since the basal area is the basis of all the methods of measurement. This ratio for the whole plot is $\frac{3008.18}{79.085} = 38.03$.

The corresponding ratio for the 8 outside sample trees is 38.19. The difference between the two ratios is + .42%, indicating that the relation between basal area and volume in the sample trees is different from the same relationship in the plot, and that results based on the sample tree relationship would be 0.42% too high.

The corresponding ratio for the 30 inside trees is 37.31. The difference in this case is -1.89%, indicating that results based on the sample tree basal area - volume relationship, would be 1.89% too low. Turning back to Part VIII, p.38, it will be seen that the average error in arriving at the volumes of the 30 inside trees individually amounted to - 1.365%, which accounts for the remainder of the difference in the total volume found by using these trees, i.e., 1.89% due to the sample trees not being representative and 1.365% due to errors in measuring the sample trees standing = 3.26% in the volume found.

In this way we get an idea of the amount of error due to the selection of unrepresentative sample trees and can obtain a better indication of the error due to the method of measurement.

In this case, it so happens that the 8 trees are more truly representative of the plot conditions than the 30 trees taken inside the plot, which is a most unexpected and unusual event.

Allowing for the error due to sample tree selection, in no case above is the difference higher than 1½%, which must be considered to be extremely satisfactory.

Where the sample trees are thoroughly representative, the application of the usual plot methods, based on standing sample tree data, even from as few as 8 sample trees, gives satisfactory results with European Larch. It, therefore, seems advisable to retain the graphical methods even when sample trees are measured standing.

With regard to the methods involving the use of Jonson's Volume Tables, owing to the fact that these are based on Höjer's stem-curve equation, and not on Behré's curves, one would have expected positive differences. This effect is certainly seen in the case of the 30 inside tres where instead of a large negative error, due to the selection of unrepresentative sample trees, the differences are + .03% and -.90%. That a similar effect is not so marked in the case of the 8 outside sample trees is probably due to the evening-off of values in applying the tables. The value of such tables for practical purposes is obvious. In the event, however, of similar tables being prepared for English measure, Behré's curves should be used.

PART XII. SUMMARY.

The purpose of the investigation was to test a method of measuring standing sample trees for Permanent Sample Plot work. Up to date the sample trees have had to be felled before measurement, which has many disadvantages.

Form-quotient principles and the assumption of the general applicability of a mathematical formula representing the stem-curve or taper of coniferous trees, form the basis of the method.

The Basal area of the tree is found in the usual way. The height is taken with a hypsometer and the Form is arrived at from girth measurements taken with the aid of a ladder up to 25 feet from the ground. These girth measurements are expressed as Form-quotients and they not only give the curve at the base of the stem, but, used as indicators of the Form-class of the stem in conjunction with the stem-curve formula, they show the trend of the whole stem curve of the tree. Once this is known, the volume of the tree can be accurately obtained.

The data were collected from a half-acre plot of 100 stems of European Larch, 60 years old, of Quality Class II, in a fully-stocked wood near Tintern, Monmouthshire. These trees were felled and accurately measured in 10 foot sections and the total volume arrived at in this way is taken to be the true volume.

Thirty sample trees were measured standing inside the plot by the proposed method.

The plot was also measured in the usual way by felling 8 sample trees outside the plot area. These 8 trees were also treated as if they had been measured standing.

The heights were taken with the Abney Level. In the case of the 30 sample trees within the plot, the systematic error came to -1.47% with a Standard Deviation of ± 2.65% For the 8 trees outside the error was -2.35%. These results are sufficiently exact for the purposes in view.

Rootswelling was found to be present in all stems. It was found that this could be satisfactorily eliminated graphically from the standing tree Form-quotient measurements. The average rootswelling for the 30 sample trees was 2.04 inches of the breast-height girth ± 1.079 S. Dev. From the same trees felled, the rootswelling worked out at 2.21 inches with a S. Dev. of ± .91 inches. Similar satisfactory results were found in the case of the 8 outside trees.

From an examination of rootswelling over the plot area there seemed good reason for assuming that the degree of rootswelling is closely dependent upon local ground variations.

An examination of the percentage of Bark in the girth up the stem, showed that this remains very uniform up to the 70% height-quotient at least, so that the use of the over-bark girth measurements for finding the stem curve was justified in this case, no bark-measuring instrument being available.

The Form-class was arrived at graphically from the standing tree measurements. For the 30 sample trees a value of .693 with a S. Dev. of ± .037 was found. For the 8 sample trees the mean Form-class was .721. The true average for the whole plot from the felled stems came to .703 with a S. Dev. of ± .032. The positive error in the case of the 8 trees was clearly due to the negative error in the height determination.

The average difference in the over-bark volume of individual trees between standing tree measurements and felled tree sectional measurements amounted to - 1.365% with a S. Dev. of ± 3.413%. This corresponds to a maximum variation for a single stem of ± 10,2%, which is highly satisfactory. The negative error is almost certainly due to the under-estimation of Form-class from graphs based on a limited number of Form-quotients obtained up to 25 feet only. Greater accuracy can be secured if one or more additional Form-quotients are measured. The type of wood and size and type of tree were against the method, so that as a rule better results may be expected.

Various methods of arriving at the total volume of the plot were applied, based on data from both sets of sample trees measured standing. Better results were obtained from the data from the 8 outside trees and in no case was the error larger than 1 %. Errors up to - 3.19% were obtained with the data from the 30 inside trees which were partly due to the unrepresentative character of these trees and partly to the error involved in obtaining the Form-class and volume by the new method.

The difference between the actual volume and that found by the usual sample plot method was only -0.73% which is extremely good, but not better, in this case, than the result from the same trees measured standing.

It thus appears that the proposed method is quite as accurate as the one in use, even for a single volume measurement. For recurring measurements, it would undoubtedly, therefore, be much more valuable, since the error involved in the use of different sets of sample stems would be eliminated.

The graphical method could therefore be retained but the data for constructing the graphs would be obtained from standing sample trees.

Further investigation is, however, necessary to see whether the method is completely applicable to other species and types of wood. If this, as seems likely, proves to be so, then a wide field for accurate research into tree-form is opened up.

12th October 1924.

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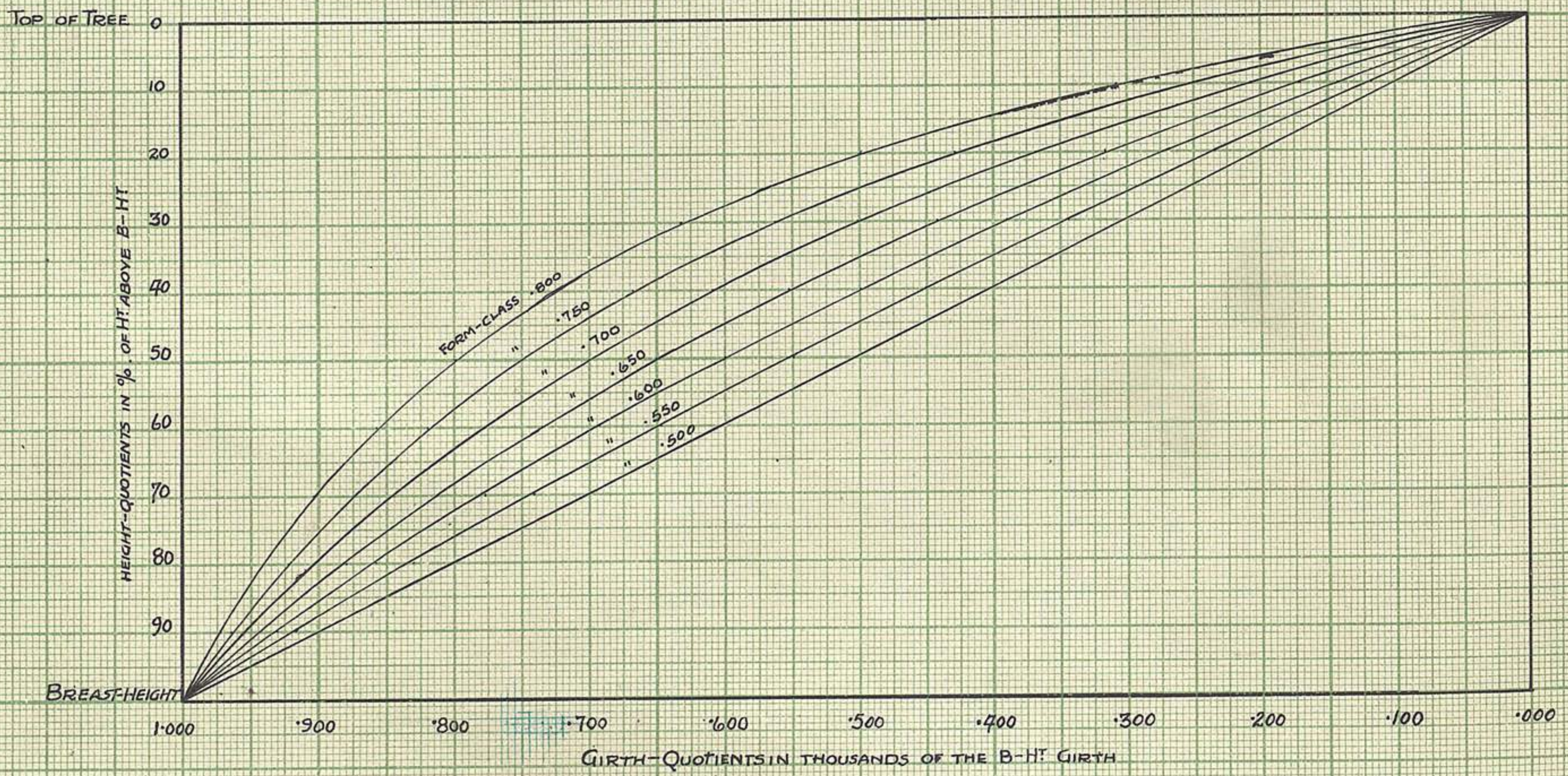
Graph A.

Behre's Stem-curves

These curves are derived from the formula $\frac{d}{D} = \frac{x}{Q+bx}$, in which 'D' is the Girth or Diameter at Breat-Height, 'd' is any girth or diameter above breast-height, 'x' is the distance from d to the top of the stem, expressed as a percentage of the length of stem above breastheight, and 'Q' and 'b' are constants, which vary for different form classes, i.e, for different values of $\frac{d'}{D}$ when 'x' = 50



GRAPH B.

STEM-CURVE OF TREE No. 24

SHOWING METHOD OF DETEMINING ROOTSWELLING AND OF FINDING THE MID-SECTION GIRTHS

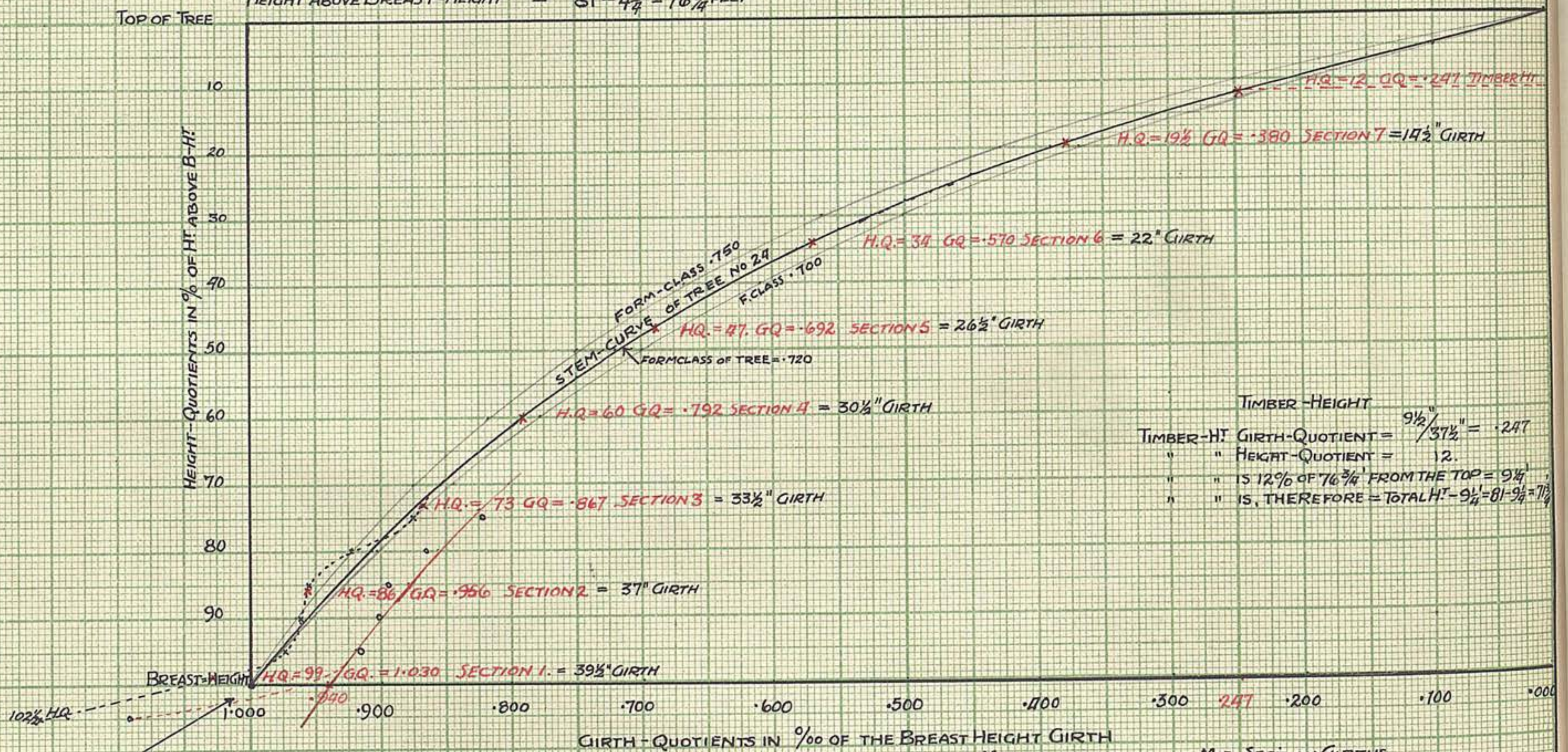
FROM STANDING TREE MEASUREMENTS.

DATA:- OVER BARK GIRTHS AT BREAST HEIGHT. 41" — 101½% 44¾", 95% 37½", 90% 37", 85% 36¾", 80% 35½" AND 75% 33¾" OF STEM'S HEIGHT ABOVE BREAST-HEIGHT

TOTAL HEIGHT BY HYPSOMETER = 81 FEET

HEIGHT ABOVE BREAST-HEIGHT = 81 − 4¼ = 76¾ FEET

AND BEHRE'S MATHEMATICAL STEM-CURVES.



METHOD OF ELIMINATING ROOTSWELLING

EXPLANATION.
- ACTUAL OVER-BARK BREAST-HEIGHT GIRTH = 41 INCHES
- FORM-QUOTENT VALUES BASED ON THAT GIRTH = o o
- CURVE DRAWN THROUGH THESE PLOTTED VALUES
- VALUE ON THIS CURVE AGAINST BREAST-HEIGHT = ·940
- REDUCED OR 'NORMAL' GIRTH AT BREAST-HEIGHT = 41 × ·940 = 37½ INCHES
- FORM QUOTIENT VALUES BASED ON THAT REDUCED GIRTH = × ×

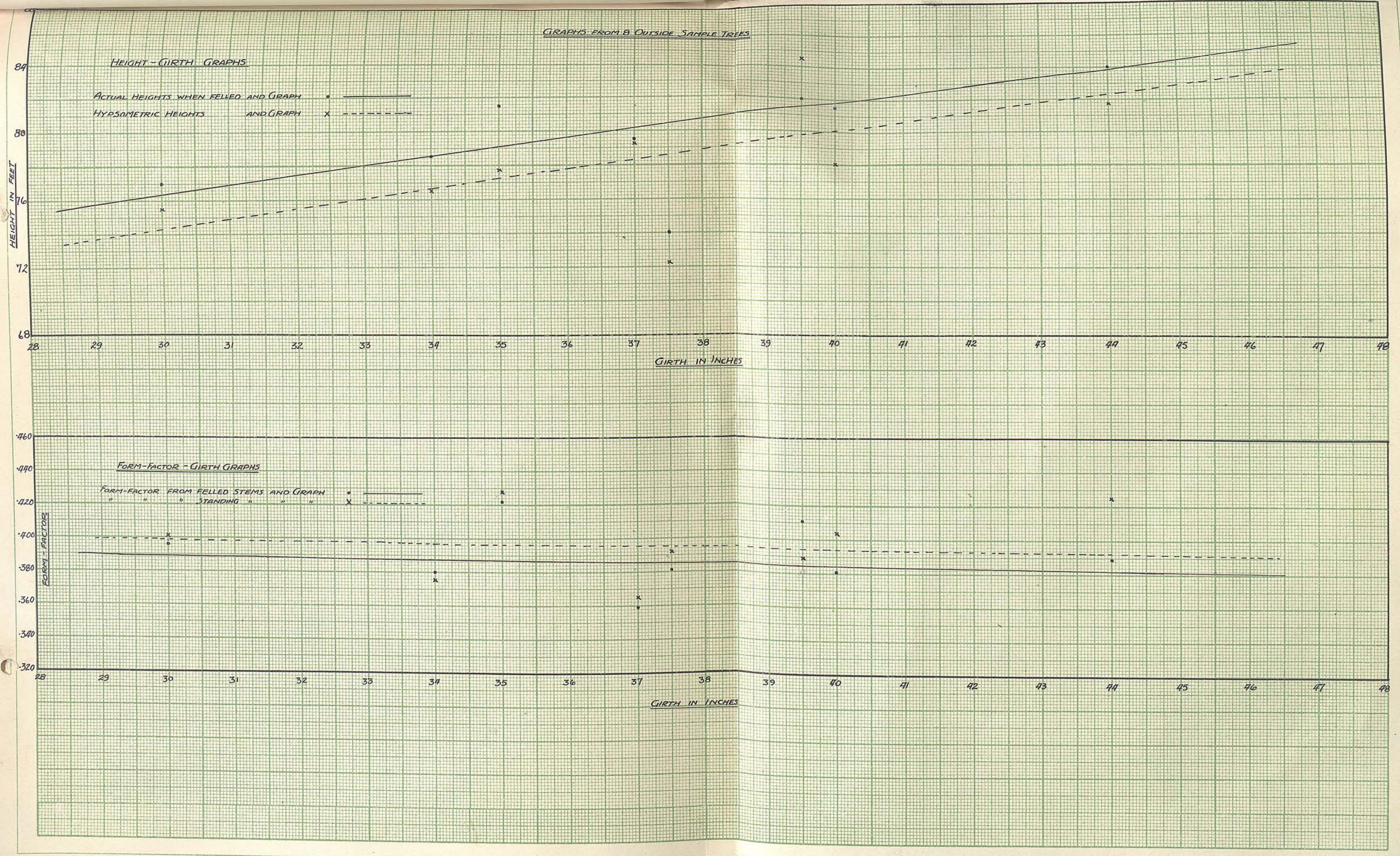
METHOD OF OBTAINING MID-SECTION GIRTHS

STEM-CURVE DRAWN THROUGH × × AND IN CONFORMITY WITH BEHRE'S CURVES =

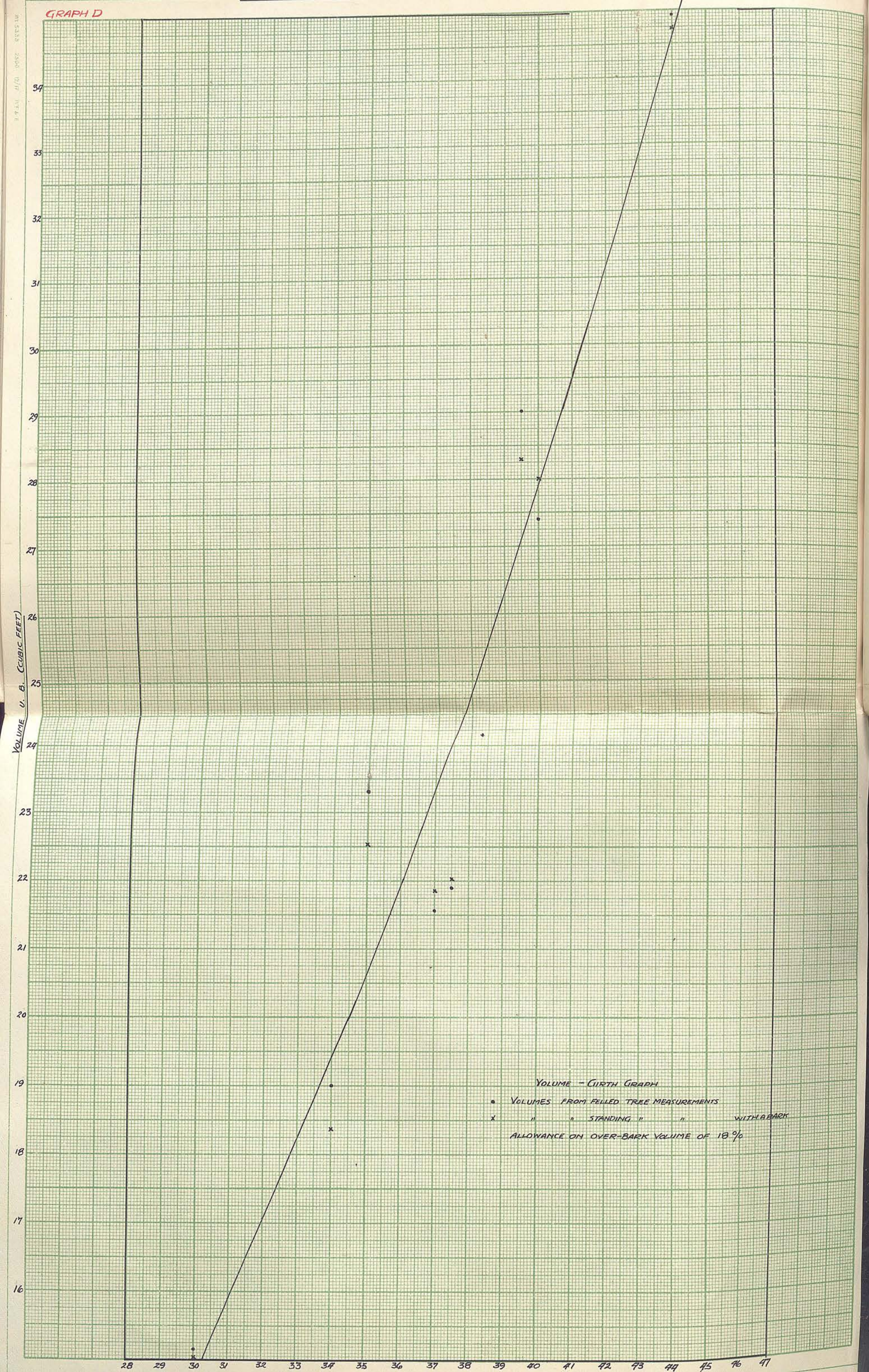
ACTUAL STEM-CURVE AT BASE OF STEM BETWEEN MEASURED QUOTIENTS =

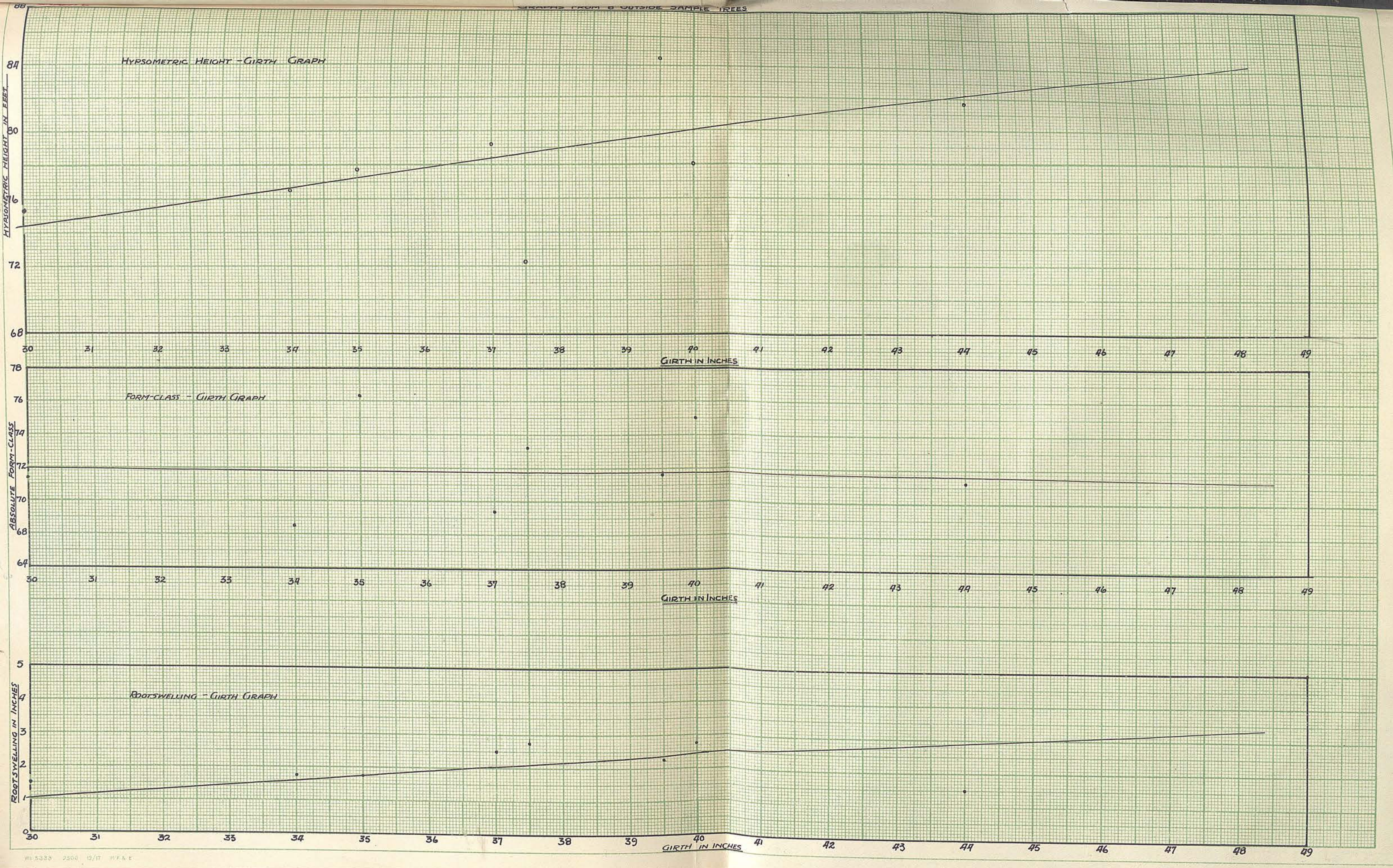
POSITIONS ON THE STEM-CURVE OF TIMBER-HEIGHT AND OF MID-SECTIONS = × ×

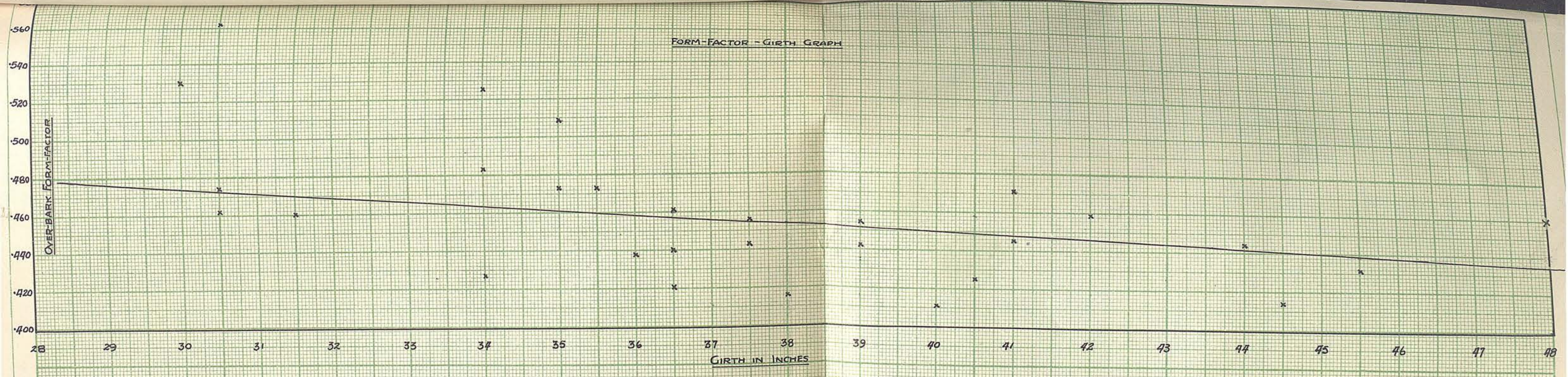
THE MID-SECTION GIRTHS ARE OBTAINED BY DIVIDING THE GIRTH-QUOTIENT VALUES AT THESE POINTS BY 37·5, THE REDUCED B.HT. GIRTH. THEY ARE SHOWN ABOVE.


GRAPHS FROM 8 OUTSIDE SAMPLE TREES
HEIGHT - GIRTH GRAPHS
ACTUAL HEIGHTS WHEN FELLED AND GRAPH
HYPSOMETRIC HEIGHTS AND GRAPH
HEIGHT IN FEET
68
72
76
80
84
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
GIRTH IN INCHES
FORM-FACTOR - GIRTH GRAPHS
FORM-FACTOR FROM FELLED STEMS AND GRAPH
" " " STANDING " " "
FORM - FACTOR
·320
·340
·360
·380
·400
·420
·440
·460
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
GIRTH IN INCHES

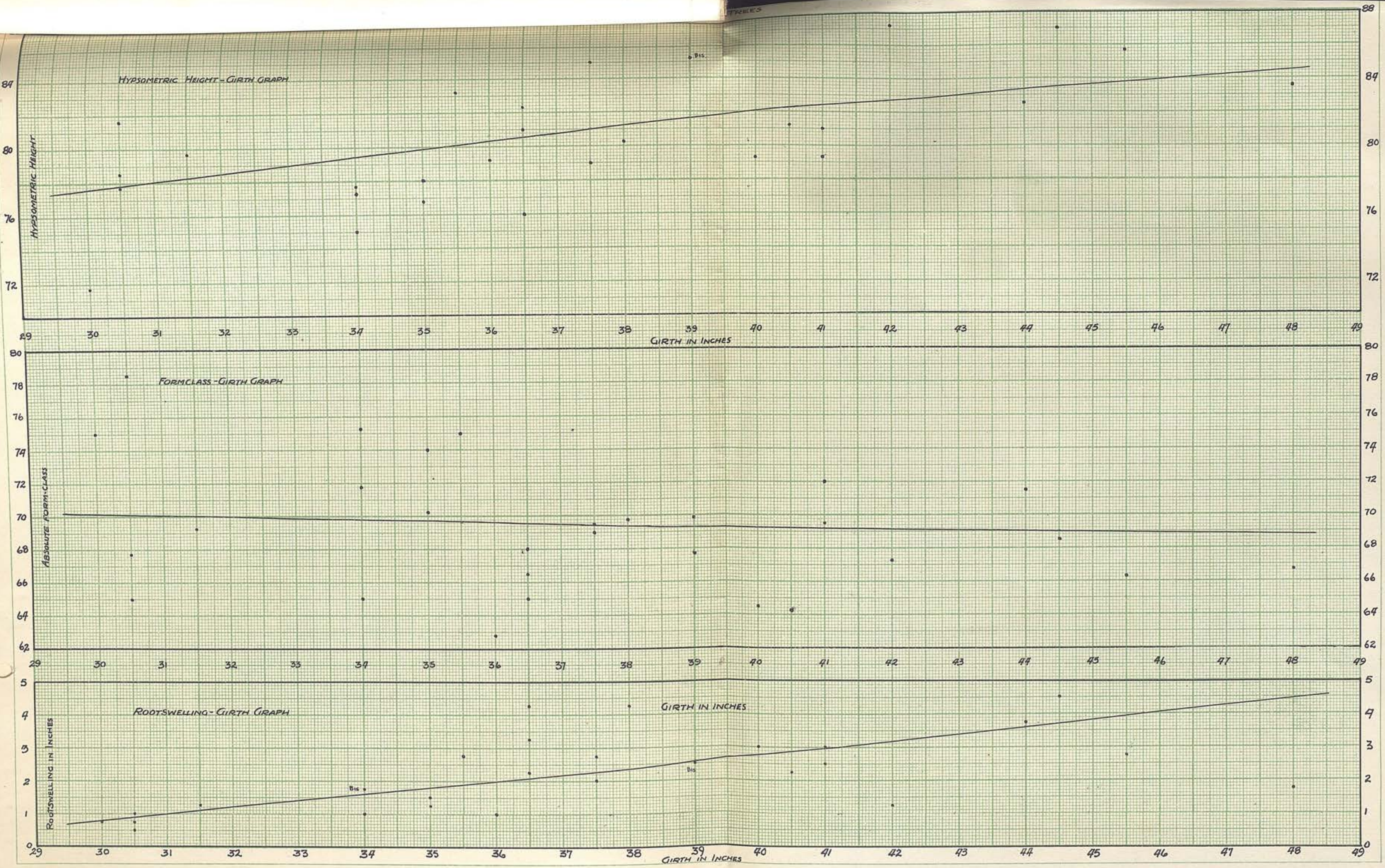
FELLED PLOT 8 OUTSIDE SAMPLE TREES




Graphs from 8 outside sample trees
Hypsometric Height - Girth Graph
Hypsometric Height in Feet
68
72
76
80
84
Girth in Inches
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
Form-class - Girth Graph
Absolute Form-Class
64
68
70
72
74
76
78
Rootswelling - Girth Graph
Rootswelling in Inches
0
1
2
3
4
5



Graph from 30 Inside Sample Trees


TREES
Hypsometric Height - Girth Graph
Hypsometric Height
Girth in Inches
Formclass - Girth Graph
Absolute Form-Class
Rootswelling - Girth Graph
Rootswelling in Inches
Girth in Inches
Big
Girth in Inches

CERTIFIED COPY

OF

D A T A.

12th October 1924

(1).

BREAST-HEIGHT GIRTHS AND STEM-CLASSES.

GENERAL REGISTER OF TREES IN THE PLOT

Girthed - January 1924.

Tree No.	Stem Class.	Girth ins.	Remarks.	Tree No.	Stem Class	Girth ins.	Remarks.
1	2b	34		32	1b	40	
2	1a	35½		33	1c	29½	
3	2b	34½		34	1b	42½	Forked
4	1a	37		35	2c	30	
5	1a	36½		36	1c	37½	
6	2c	33½		37	2a	31½	
7	3a	36½		38	1a	48	
8	1c	38	Curved stem	39	2b	33½	
9	3b	24½		40	1a	40	
10	1b	35½		41	2a	34	
11	1a	41½		42	2a	30½	
12	1a	44		43	1a	41	
13	1c	38½	Forked	44	1b	35	
14	1b	37		45	1a	43	
15	3b	27		46	1b	41	
16	2c	35	Forked	47	1a	47½	
17	1c	36	Forked	48	1a	40½	
18	2b	33		49	1a	45	
19	2b	34		50	2c	30	
20	1b	39½		51	2b	34	
21	1a	38½		52	1a	36	
22	2a	38½		53	1a	40½	
23	3b	33	Forked	54	1b	52½	
24	1a	41		55	2b	36	
25	2c	28½		56	1a	40	
26	1a	35½		57	2c	31½	
27	1b	33½		58	1b	30½	
28	2b	28		59	1c	37½	
29	1a	36½		60	1b	37½	
30	1b	40		61	1b	45	
31	1a	45½		62	2a	35	

Tree No.	Stem Class	Girth ins.	Remarks	Tree No.	Stem Class	Girth ins.	Remarks
63	2a	37½		92	1a	32	
64	1a	43½		93	2c	32½	
65	1a	35½		94	1b	43	
66	1c	42		95	1b	34	
67	1a	39		96	1b	38	
68	1b	41	Forked	97	1b	44½	
69	2b	30½		98	1b	35½	
70	2c	36½		99	2c	32½	
71	1c	38½		100	1a	45½	
72	1b	36½		~~101~~			
73	3b	29½		~~102~~			
74	1c	41½					
75	1c	43					
76	2b	38					
77	1b	46½					
78	2a	32					
79	2a	31					
80	1b	31½					
81	1b	35					
82	1a	44					
83	2b	35½					
84	1a	39					
85	3b	38½					
86	1a	48					
87	1c	39					
88	1b	33					
89	1a	45					
90	1a	50½					
91	1b	40½					

(2).

30 INSIDE SAMPLE TREES.

COMPARISON BETWEEN ACTUAL AND ESTIMATED

MID-SECTION GIRTHS AND AREAS.

COMPARISON between ACTUAL and ESTIMATED MID-SECTIONS

O. B. Girths and Volumes. 30 Standing Sample Trees.

Tree No.	Length of Section ft.	Girth O.B. act. ins.	Girth O.B. est. ins.	Volume O.B. act. cu.ft.	Volume O.B. est. cu.ft.
86	10	47½	47½	12.47	12.47
	10	42½	43	9.98	10.22
	10	38½	39½	8.19	8.62
	10	34½	35½	6.58	6.97
	10	29½	30½	4.81	5.14
	10	24½	25	3.32	3.45
	15(14½)	16½	16	2.25	2.06
				47.60	48.93
31	10	44½	44½	10.95	10.95
	10	39	39½	8.41	8.62
	10	36	37	7.16	7.57
	10	32	32½	5.66	5.84
	10	29	28½	4.65	4.49
	10	25	23	3.45	2.92
	10	18½ (15½)	15	1.89	1.93
	6½	11½		0.47	
				42.64	42.32
97	10	43	43½	10.22	10.46
	10	37½	37½	7.77	7.77
	10	34	34	6.39	6.39
	10	31½	31½	5.48	5.48
	10	27	28	4.03	4.33
	10	23	23	2.92	2.92
	15(15¾)	17	15½	2.40	2.10
				39.21	39.45
82	10	43	42½	10.22	9.98
	10	38	37	7.98	7.57
	10	35½	35½	6.97	6.97
	10	33½	32	6.20	5.66
	10	29½	28	4.81	4.33
	10	25	23	3.45	2.92
	12½ (13½)	16½	15½	1.88	1.80
				41.51	39.23
66	10	41½	41½	9.51	9.51
	10	38	37½	7.98	7.77
	10	36	35	7.16	6.77
	10	32½	31½	5.84	5.48
	10	28	28	4.33	4.33
	10	24½	23	3.32	2.92
	10	19½	17½	2.10	1.69
	7½(6½)	13½	12	0.76	.52
				41.00	38.99
24	10	39½	39½	8.62	8.62
	10	36	37	7.16	7.57
	10	34	33½	6.39	6.20
	10	30½	30½	5.14	5.14
	10	26	26½	3.74	3.88
	10	22	22	2.68	2.68
	11½ (11¾)	14	14½	1.24	1.37
				34.97	35.46 ~~28.68~~

Tree No.	Length of Section ft.	Girth O.B. act. ins.	Girth O.B. est. ins.	Volume O.B. act. cu.ft.	Volume O.B. est. cu.ft.
72	10	35½	36	6.97	7.16
	10	31½	31½	5.48	5.48
	10	29½	29	4.81	4.65
	10	26	26	3.74	3.74
	10	23	22½	2.92	2.80
	10	19	18½	2.00	1.88
	10 (10¼)	13½	13	1.01	.96
				26.93	26.67
5	10	35½	36	6.97	7.16
	10	31½	32½	5.48	5.84
	10	30½	29½	5.14	4.81
	10	27	27	4.03	4.03
	10	24	23	3.18	2.92
	10	20	18½	2.21	1.89
	12½ (9½)	14	12½	1.35	.82
				28.36	27.47
52	10	35½	35½	6.97	6.97
	10	31½	32½	5.48	5.84
	10	29	28½	4.65	4.49
	10	25½	24½	3.59	3.32
	10	22	20½	2.68	2.32
	10	18	16	1.79	1.42
	10½ (6¼)	13½	11½	1.06	.46
				26.22	24.82
7	10	35½	35½	6.97	6.97
	10	31	31	5.31	5.31
	10	28	27½	4.33	4.18
	10	24	24½	3.18	3.32
	10	20½	20	2.32	2.21
	13½ (13¾)	14	14	1.46	1.49
				23.57	23.48

Tree No.	Length of Section ft.	Girth O.B. act. ins.	Girth O.B. est. ins.	Volume O.B. act. cu. ft.	Volume O.B. est. cu. ft.
26	10	34	34	6.39	6.39
	10	30½	31	5.14	5.31
	10	28½	29	4.49	4.65
	10	26	27	3.74	4.03
	10	23	24	2.92	3.18
	10	19½	20½	2.10	2.32
	8½ (13½)	14½	14½	0.99	1.57
				25.77	27.45
44	10	34½	34½	6.58	6.58
	10	31½	31½	5.48	5.48
	10	29½	29½	4.81	4.81
	10	27	26½	4.03	3.88
	10	24	23½	3.18	3.05
	10	20½	18½	2.32	1.89
	13(8)	15½	12½	1.73	.69
				28.13	26.38
51	10	33	33	6.02	6.02
	10	30½	30	5.14	4.97
	10	28	28	4.33	4.33
	10	24½	25	3.32	3.45
	10	21½	21	2.56	2.44
	10	16	15	1.42	1.92
	7(15½)	11½		0.51	
				23.30	23.13
62	10	34	34½	6.39	6.58
	10	31	31	5.31	5.31
	10	28½	29	4.49	4.65
	10	25½	25½	3.59	3.59
	10	22½	22	2.80	2.68
	10	19	17	2.00	1.50
	9(7¼)	12½	12	0.77	.58
				25.35	24.99

Tree No.	Length of Section ft.	Girth O.B. act. ins.	Girth O.B. est. ins.	Volume O.B. act. cu.ft.	Volume O.B. est. cu.ft.
95	10	34	34	6.39	6.39
	10	30½	30½	5.14	5.14
	10	29	29½	4.65	4.81
	10	26	26½	3.74	3.88
	10	23	23½	2.92	3.05
	10	18	19	1.79	2.00
	8(9)	13	13	0.74	.84
				25.37	26.11
19	10	33½	33½	6.20	6.20
	10	29½	29½	4.81	4.81
	10	27	26½	4.03	3.88
	10	23	23	2.92	2.92
	10	19	19	2.00	2.00
	13½	13½	13	1.36	1.26
				21.32	21.07
57	10	31	31	5.31	5.31
	10	27½	27½	4.18	4.18
	10	26	25½	3.74	3.59
	10	23½	23	3.05	2.92
	10	20½	20	2.32	2.21
	10	17	16	1.60	1.42
	8½(6½)	13	11½	0.79	.47
				20.99	20.10
58	10	30½	30½	5.14	5.14
	10	28	27½	4.33	4.18
	10	26	25½	3.74	3.59
	10	23½	23	3.05	2.92
	10	21½	19½	2.56	2.10
	10	17	16	1.60	1.42
	9(7¾)	12½	11½	0.77	.57
				21.19	19.92

Tree No.	Length of Section ft.	Girth O.B. act. ins.	Girth O.B. est. ins.	Volume O.B. act. cu.ft.	Volume O.B. est. cu.ft.
42	10	30	30	4.97	4.97
	10	27	27	4.03	4.03
	10	25	25	3.45	3.45
	10	23	22	2.92	2.68
	10	20½	18½	2.32	1.89
	10	15½		1.33	
	6½(14¼)	12	13½	0.48	1.44
				19.50	18.46
69	10	30½	30	5.14	4.97
	10	28½	28½	4.49	4.49
	10	26	27	3.74	4.03
	10	24	25	3.18	3.45
	10	20½	22½	2.32	2.80
	10	18	19	1.79	2.00
	9½(9¼-)	12½	13½	0.82	.93
				21.48	22.67
35	10	30	30	4.97	4.97
	10	27	27½	4.03	4.18
	10	26	25½	3.74	3.59
	10	23	23	2.92	2.92
	10	19.	19	2.00	2.00
	13½ (12¼)	13½	13½	1.36	1.24
				19.02	18.90
9	10	24½	24	3.32	3.18
	10	22½	22½	2.80	2.80
	10	21	20½	2.44	2.32
	10	19	18	2.00	1.79
	10	16½	15	1.50	1.24
	10(9¼)	12	11½	0.80	.68
				12.86	12.01

(3).

MEASUREMENTS OF FELLED TREES.

30 INSIDE TREES

Followed by

REMAINING 70 TREES.

MEASUREMENTS OF FELLED TREES

Tree No.	Total Ht.	Timber Ht.	Section. Volume O.B. act.	O.B. est.	U.B. act.	U.B. est.	½ Tim.Ht. Vol.O.B.	Form Factors Red. B.A.	Act.B.A.	O.B.	Form Class
86	85½	75	47.60	48.93	40.33		46.50	.403	.371	.459	636
31	87½	76½	42.64	42.32	34.01		40.62	.399	.340	.431	.682
97	85	75	39.21	39.45	31.94		38.55	.405	.343	.414	679
82	82	72½	41.51	39.23	34.35		41.04	.451	.391	.444	737
66	88	77½	41.00	38.99	33.59		41.15	.421	.391	.458	698
24	82½	71½	34.97	35.46	28.68		36.75	.413	.374	.471	.732
46	80½	69½	33.00	32.74	26.76		33.43	.417	.358	.445	.693
91	81	70	32.68	31.34	26.93		31.43	.428	.367	.425	.698
56	81½	70½	29.81	28.81	24.57		28.41	.398	.341	.411	.653
84	82	70½	31.51	31.65	25.66		31.65	.413	.372	.442	.718
87	85	72½	33.47	32.63.	27.21		33.71	.435	.381	.455	.742
76	82½	71	26.42	26.66	21.28		24.50	.392	.323	.416	.687
63	83	72	28.77	29.22	23.26		26.93	.414	.361	.443	.702
59	84	71½	27.86	27.98	23.56		26.74	.414	.361	.456	.680
72	81	70	26.93	26.67	22.28		26.18	.406	.374	.440	.695
5	83½	72½	28.36	27.47	23.32		28.13	.401	.380	.461	.700
52	82½	70½	26.22	24.82	21.50		25.31	.396	.364	.438	.655
7	76	63½	23.57	23.48	18.70		23.75	.397	.334	.420	.685
26	81½	68½	25.77	27.45	20.51		26.58	.418	.361	.473	.735
44	83½	73	28.13	26.38	22.46		29.42	.447	.397	.508	.752
51	79	67	23.30	23.13	18.56		23.12	.390	.368	.483	.690
62	80½	69	25.35	24.99	20.44		25.81	.422	.375	.473	.710
95	77½	68	25.37	26.11	20.87		25.43	.447	.422	.526	.740
19	78	63½	21.32	21.07	17.20		20.19	.378	.345	.427	.647
57	81½	68½	20.99	20.10	16.27		20.89	.402	.364	.460	.727
58	82½	69	21.19	19.92	17.59		21.05	.443	.415	.474	.717
42	77	66½	19.50	18.46	16.11		19.42	.450	.407	.462	.737
69	80½	69½	21.48	22.67	17.21		22.10	.430	.416	.562	.724
35	76½	63½	19.02	18.90	15.16		18.54	.412	.399	.530	.690
9	74	60	12.86	12.01	10.19		13.92	.471	.415	.487	.759

Tree No.	Total Ht.	Timber Ht.	Section Volume O. B. act.	O. B. est.	U. B. act.	U. B. est.	$\frac{1}{2}$ Tim.Ht. Vol.O.B.	Form Factors Red. B.A.	Act.B.A.	Form Class
1	75½	65	22.81		18.86		22.43	.442	.391	.720
2	81	70	27.90		22.33		27.16	.419	.396	.690
3	78½	66	22.97		17.97		23.69	.404	.348	.694
4	83	72½	30.67		24.28		31.39	.397	.386	.700
6	78	67	22.67		18.71		22.24	.438	.387	.718
8	82	70	32.31		24.97		33.67	.402	.382	.695
10	79	68½	26.78		21.79		27.61	.445	.396	.733
11	83	72½	37.32		30.60		38.50	.450	.388	.735
12	86½	75½	42.74		35.05		46.81	.436	.379	.710
13	79	67½	29.01		23.84		27.20	.410	.368	.670
14	83	70	28.48		23.20		30.31	.401	.369	.705
15	66	59½	14.42		11.47		14.52	.484	.431	.745
16	78½	67½	25.08		19.37		25.25	.410	.365	.722
17	79	67½	26.23		21.92		29.23	.434	.388	.733
18	79	67	22.90		17.97		24.55	.415	.378	.735
20	80	68	29.69		23.95		27.40	.366	.347	.603
21	83	73	34.83		27.85		35.11	.443	.410	.743
22	81	71	32.12		26.03		33.02	.414	.392	.717
23	78½	63	20.29		16.64		20.03	.399	.352	.661
25	74	62	16.13		13.08		18.10	.439	.394	.742
27	79½	69½	25.04		20.58		24.95	.457	.418	.742
28	75	62	15.50		12.83		15.87	.441	.395	.742
29	80	69	28.67		22.93		29.88	.436	.389	.730
30	81½	69½	32.40		26.38		31.21	.406	.366	.703
32	81	70½	31.83		26.27		30.53	.406	.367	.694
33	84	71	18.86		14.73		18.18	.420	.365	.706
34	79	68½	33.76		27.89		30.76	.420	.354	.697
36	83½	71½	31.63		25.71		33.25	.430	.396	.719
37	77½	65½	20.89		17.04		19.98	.428	.401	.727
38	86½	76½	49.46		39.72		47.43	.402	.361	.687
39	78½	66½	23.68		19.11		24.87	.430	.393	.708
40	81	70	33.67		27.59		34.79	.405	.385	.702

Tree No.	Total Ht.	Timber Ht.	Section. Volume O. B. act.	O. B. est.	U. B. act.	U. B. est.	½ Tim.Ht. Vol.O.B.	Form Factors Red. B.A.	Form Factors Act.B.A.	Form Class
41	78	67½	23.53		18.22		23.29	.400	.366	.696
43	84	73½	37.31		30.97		37.78	.428	.397	.700
45	88	77	42.27		34.19		46.35	.439	.380	.746
47	82	71	43.13		35.36		42.74	.394	.346	.653
48	83½	72	33.93		27.59		33.48	.414	.364	.702
49	87	76	41.46		35.23		40.36	.378	.362	.627
50	77½	65	18.37		14.61		18.98	.405	.385	.715
53	80	68	31.34		25.84		30.53	.384	.356	.639
54	88	78½	64.11		51.81		62.64	.410	.386	.687
55	82	70	25.00		20.76		24.15	.396	.354	.667
60	82½	71½	30.04		25.36		30.96	.441	.396	.727
61	84	74½	43.87		37.12		44.85	.432	.395	.703
64	87½	76	40.00		34.02		39.06	.440	.372	.702
65	85	74	26.85		21.83		26.57	.402	.369	.683
67	86	75	36.16		28.34		39.83	.413	.392	.730
68	83	73	36.46		29.65		37.52	.448	.385	.716
70	80½	70	30.02		23.72		32.55	.423	.400	.739
71	83	70½	32.78		27.07		35.04	.420	.398	.688
73	77	66	18.73		15.14		20.99	.423	.409	.742
74	85	73	40.45		34.04		42:63	.431	.421	.708
75	79	69½	39.98		32.95		41.84	.439	.408	.727
77	87	78	48.44		39.59		49.84	.416	.381 ✓	.696
78	82	69½	19.91		15.84		18.63	.402	.341	.704
79	80	69½	20.00		16.21		20.29	.421	.382	.710
80	80	67	19.40		15.94		18.76	.401	.364	.697
81	80	71	27.69		21.52		28.61	.434	.397	.752
83	77	66½	23.94		18.95		22.08	.409	.353	.700
85	72	63½	28.75		23.56		28.51	.445	.400	.705
88	79½	67	21.96		18.22		21.31	.418	.381	.705
89	79	69½	42.76		35.10		44.41	.425	.397	.719
90	87½	77½	56.02		45.05		55.49	.404	.365	.677
92	82	72	22.72		18.35		22.90	.435	.396	.735

Tree	Total	Timber	Section. Volume					Form Factors		Form
			O. B.		U. B.		$\frac{1}{2}$ Tim.Ht.	Red. B.A.	Act.B.A.	Class
No.	Ht.	Ht.	act.	est.	act.	est.	Vol.O.B.			
93	78	$66\frac{1}{2}$	23.09		18.37		22.94	.430	.403	.736
94	84	76	42.61		35.27		43.02	.431	.411	.740
96	$81\frac{1}{2}$	71	32.39		26.51		35.29	.442	.408	.740
98	$83\frac{1}{2}$	$72\frac{1}{2}$	26.88		21.54		26.03	.416	.370	.726
99	77	65	20.98		17.42		21.58	.440	.387	.713
100	85	74	44.30		37.01		41.88	.416	.381	.675
TOTAL VOLUMES =			3008 · 18		2449 · 43					

(4).

VOLUME CALCULATIONS.

(a). Outside Sample Trees as MEASURED.

(b). " " " " ESTIMATED.

(c). Inside Sample Trees Standing by the Over-bark Form-factor method.

See Graphs C. & D.

OUTSIDE SAMPLE TREES AS MEASURED

Group No.	No. of Trees	By Groups Basal area Sq. ft.	Calculated Means sample Tree. Basal Area Sq.ft.	Girth Sq.ft.	Graphical Readings Ht. Ft.	Form Factor Under bark	Volume Form Factor Graph	Volume Graph.
1	20	22.887	1.144	45½	84½	.382	738.9	740.0
2	20	17.717	.886	40	82	.384	558.0	558.0
3	20	15.179	.759	37	80	.385	467.6	468.0
4	20	13.110	.656	34½	79	.386	399.7	400.0
5	20	10.192	.510	30½	76½	.389	303.1	305.0
TOTALS	100	79.085	.791	38	81	.385	2467.3	2471.0

See Graphs C. & D.

OUTSIDE SAMPLE TREES AS ESTIMATED

1	20	22.887	1.144	45½	83	.392	744.7	740.0
2	20	17.717	.886	40	80	.393	557.2	558.0
3	20	15.179	.759	37	78½	.394	469.5	468.0
4	20	13.110	.656	34½	77	.396	399.7	400.0
5	20	10.192	.510	30½	74½	.398	302.1	305.0
TOTALS	100	79.085	.791	38	79½	.393	2473.2	2471.0

See Graphs F. & G.

FROM 30 INSIDE SAMPLE TREES STANDING BY OVER-BARK F.F. METHOD.

						Over bark.	
1	20	22.887	1.144	45½	84	.438	842.2
2	20	17.717	.886	40	82	.449	652.4
3	20	15.179	.759	37	81	.456	560.7
4	20	13.110	.656	34½	79½	.462	486.5
5	20	10.192	.510	30½	78	.472	375.0
TOTALS	100	79.085	.791	38			2911.8 o.b.

(5).

<u>FORM-QUOTIENT CALCULATIONS</u> For 100 Trees.

Also:-

GIRTH BARK %.

ROOTSWELLING

and

FORM-CLASS.

_0_

FORM QUOTIENTS.

Tree No.		100%	90%	80%	70%	60%	50%	40%	30%	20%	10%	Mean Bark %	Reduced Girth	R. S.	Form Class.
1	O. B.	34¼	30½	29½	27½	25	23¼	21	17½	12¾	6½	9.53	29¼	2"	.720
	U. B.	31¼	28	27	25	22½	20¾	18¾	15¾	11½	5¾			&	
	Bark %	8.76	8.20	8.47	9.09	10.00	10.75	10.72	10.00	9.80	11.54			6.40	
	F.Q.with R.S.	1.000	.896	.864	.800	.720	.664	.600	.504	.368	.184				
	F.Q.without R.S.	1.069	.957	.923	.855	.769	.710	.641	.539	.393	.197				
2	O. B.	35¾	33	31½	29¾	26½	23¾	20½	17¼	13½	7	10.48	31¼	1"	.690
	U. B.	32¼	29¾	28	26¼	23½	21½	18½	15½	12	6			&	
	Bark %	9.79	9.85	11.11	11.77	11.32	9.48	9.75	10.15	11.11	14.29			3.10	
	F.Q.with R.S.	1.000	.922	.868	.814	.729	.667	.574	.481	.372	.186				
	F.Q.without R.S.	1.032	.952	.896	.840	.752	.688	.592	.496	.384	.192				
3	O. B.	34¼	30½	29¼	27	24¾	22½	20	15½	11¾	6	11.40	28½	2½"	.694
	U. B.	31	27¼	25¾	24¼	21½	19¾	17½	14	10¼	5			&	
	Bark %	9.49	10.65	11.97	10.18	13.13	12.22	12.50	9.68	12.76	16.66			8.06	
	F.Q.with R.S.	1.000	.879	.831	.782	.693	.636	.564	.452	.331	.161				
	F.Q.without R.S.	1.087	.956	.904	.851	.754	.692	.614	.491	.360	.176				
4	O. B.	37	35	32¾	31	28	25½	22¼	17½	13	6¾	10.79	32½	½"	.700
	U. B.	33	31½	29¼	27½	25¼	22½	19¾	15¾	11½	6			&	
	Bark %	10.81	10.00	1069	11.29	9.82	11.77	11.23	10.00	11.54	11.11			1·52	
	F.Q.with R.S.	1.000	.955	.886	.833	.765	.682	.599	.477	.348	.182				
	F.Q.without R.S.	1.015	.969	.900	.846	.777	.692	.608	.485	.354	.185				
5	O. B.	36	33¼	31½	29¾	27	24¼	21¼	17¼	13¼	7¼	9.77	31½	1¼"	.700
	U. B.	32¾	30	28½	26½	24½	22	19	15½	12	6¼			&	
	Bark %	9.03	9.78	9.52	10.92	9.26	9.28	10.59	10.15	9.43	13.79			3.82	
	F.Q.with R.S.	1.000	.916	.870	.809	.748	.672	.580	.473	.366	.191				
	F.Q.without R.S.	1.040	.952	.905	.841	.778	.698	.603	.492	.381	.199				
6	O. B.	33½	29½	28	27	24¼	23	19¾	16¼	12½	7¼	8.90	28¼	2¼"	.718
	U. B.	30½	26¾	25½	24½	22	20¾	18	15	11½	6½			&	
	Bark %	8.96	9.32	8.93	9.26	9.28	9.78	8.86	7.69	8.00	10.35			7.38	
	F.Q.with R.S.	1.000	.877	.836	.803	.721	.681	.590	.492	.377	.213				
	F.Q.without R.S.	1.080	.947	.903	.867	.779	.735	.637	.531	.407	.230				
7	O. B.	36½	31¼	29¾	27¼	25¼	22¾	19¼	15¼	11¼	6½	9.80	29½	3¼"	.685
	U. B.	32¾	28¼	26½	24½	22¾	20½	17¼	14	10¼	5½			&	
	Bark %	10.28	9.60	10.92	10.09	9.90	9.89	10.39	8.20	8.89	15.38			9.92	
	F.Q.with R.S.	1.000	.863	.809	.748	.695	.626	.527	.428	.313	.168				
	F.Q.without R.S.	1.110	.958	.898	.831	.771	.695	.585	.475	.347	.186				
8	O. B.	38¼	36	33¾	31¼	29½	26¼	22½	18½	12	5	12.63	32¾	1"	.695
	U. B.	33¾	31½	29¼	27½	25¾	22¾	19½	16¼	10½	4¼			&	
	Bark %	11.76	12.50	13.34	11.99	12.72	13.34	13.33	12.16	12.50	15.00			2.96	
	F.Q.with R.S.	1.000	.934	.867	.815	.763	.674	.578	.482	.311	.126				
	F.Q.without R.S.	1.030	.962	.893	.840	.786	.695	.595	.496	.321	.130				

Tree No.		100%	90%	80%	70%	60%	50%	40%	30%	20%	10%	Mean Bark %	Reduced Girth	R. S.	Form Class
9.	O. B.	24¾	22¼	21¼	21	19¾	17¾	16	13½	9¾	5¾	10.67	20¾	1½"	.759
	U. B.	22¼	20	19	18½	17¾	15¾	14½	11¼	9	5¼			&	
	Bark %	10.10	10.11	10.59	11.62	10.13	11.27	9.38	15.10	7.69	8.70			6.74	
	F.Q.with R.S.	1.000	.899	.854	.831	.798	.708	.652	.506	.404	.236				
	F.Q.without R.S.	1.073	.964	.916	.892	.855	.760	.699	.542	.434	.253				
10.	O. B.	35¾	31½	30½	28¾	27	24¾	21¾	18¼	13	5	9.55	30¼	2¼"	.733
	U. B.	32½	28¾	27¼	26	24½	22½	19¾	16½	11¾	4½			&	
	Bark %	9.09	8.00	10.65	9.56	10.18	10.10	9.19	9.59	9.62	10.00			6.92%	
	F.Q.with R.S.	1.000	.885	.839	.800	.746	.685	.608	.508	.362	.139				
	F.Q.without R.S.	1.074	.951	.901	.860	.802	.736	.653	.546	.389	.149				
11.	O. B.	41½	38½	36½	33¾	31	27¼	23¼	19¾	14¾	7¼	9.38	40¾	3¼"	.735
	U. B.	38	35	33	30½	28¼	24½	21	18	13½	6¾			&	
	Bark %	8.44	9.09	9.59	9.63	8.87	10.09	9.68	8.86	10.17	6.90			7.39%	
	F.Q.with R.S.	1.000	.896	.858	.807	.761	.682	.585	.477	.324	.153				
	F.Q.without R.S.	1.080	.969	.926	.871	.822	.736	.632	.575	.350	.166				
12.	O. B.	44	39½	37¾	35½	33½	30	25¾	21	14¼	6¾	9.91	37½	3"	.710
	U. B.	40½	36	34	32½	29	26¾	23¼	19	12¾	6			&	
	Bark %	7.95	8.86	9.93	8.45	13.44	10.83	9.71	9.52	10.53	11.11			7.41	
	F.Q.with R.S.	1.000	.889	.840	.802	.716	.660	.574	.469	.315	.148				
	F.Q.without R.S.	1.080	.960	.907	.867	.773	.713	.620	.507	.340	.160				
13.	O. B.	38½	35	32	30	26½	24	21¼	18	12½	5½	9.56	33	2"	.670
	U. B.	35	31¾	29¼	27½	24	21¾	19¼	16¼	11	4¾			&	
	Bark %	9.09	9.29	8.59	9.17	9.43	9.38	9.41	9.72	12.00	13.63			5.71%	
	F.Q.with R.S.	1.000	.907	.836	.779	.686	.622	.550	.464	.314	.136				
	F.Q.without R.S.	1.060	.962	.886	.826	.727	.659	.583	.492	.333	.144				
14.	O. B.	36¾	33½	31	30	27	25½	22½	17½	13¼	6¼	9.96	31¾	1¾"	.705
	U. B.	33½	30¼	28¼	27	24	23	20¼	15¾	11¾	5½			&	
	Bark %	8.84	9.70	8.87	10.00	11.11	9.80	10.00	10.00	11.32	12.00			5.22	
	F.Q.with R.S.	1.000	.903	.843	.806	.716	.687	.605	.470	.351	.164				
	F.Q.without R.S.	1.054	.953	.890	.850	.756	.724	.638	.496	.370	.173				
15.	O. B.	27½	24½	24	22½	21½	19¼	17¼	15¾	14	10½	10.46	23	1½"	.745
	U. B.	24½	22	21¼	19¾	18½	17	15½	14	12¼	9			&	
	Bark %	10.09	10.21	11.46	12.22	13.95	11.69	10.15	11.91	12.50	14.29			6.12	
	F.Q.with R.S.	1.000	.898	.867	.806	.755	.694	.633	.571	.500	.367				
	F.Q.without R.S.	1.065	.957	.924	.859	.804	.739	.674	.609	.533	.391				
16.	O. B.	34¾	31½	29¾	27¾	26	23¾	20¾	18½	14	7¾	12.62	28¾	2"	.722
	U. B.	30¾	27½	26¼	24¼	22¾	20¾	18¼	16	12	6¾			&	
	Bark %	11.52	12.70	11.77	12.61	12.50	12.63	12.04	13.51	14.29	12.90			6.50	
	F.Q.with R.S.	1.000	.894	.854	.789	.740	.675	.594	.520	.390	.220				
	F.Q.without R.S.	1.069	.956	.913	.843	.791	.722	.635	.556	.417	.235				
17.	O. B.	36	32¼	30½	29	28	25¼	23½	15½	12½	7½	9.77	30¾	2¼"	.733
	U. B.	33	29½	28¼	26¼	25¾	23	21¼	14	10½	6½			&	
	Bark %	8.33	8.53	7.38	9.48	8.04	8.91	9.57	9.68	18.00	13.33			6.82	
	F.Q.with R.S.	1.000	.894	.856	.795	.780	.697	.644	.424	.311	.197				
	F.Q.without R.S.	1.074	.959	.919	.854	.838	.748	.691	.455	.333	.211				

Tree No.		100%	90%	80%	70%	60%	50%	40%	30%	20%	10%	Mean Bark %	Reduced Girth	R. S.	Form Class
18.	O. B.	32¾	30	28¾	27	25½	23½	21	17	12½	6	11.27	27¾	1½"	.735
	U. B.	29¼	26½	25½	23¾	22¼	20¾	18½	15¼	11	5¼			&	
	Bark %	10.69	11.67	11.31	12.03	11.88	11.70	11.62	10.29	10.21	12.50			5.13	
	F.Q.with R.S.	1.000	.906	.872	.812	.761	.710	.633	.521	.376	.180				
	F. Q.without R.S.	1.054	.955	.919	.856	.802	.748	.667	.549	.396	.189				
19.	O. B.	34¼	30¾	28	26	24	20¾	17¾	14	10½	5½	9.97	29	1¾"	.647
	U. B.	30¾	27½	25½	23¼	21¼	18¾	16	12¾	9½	4¾			&	
	Bark %	10.22	10.57	8.93	10.58	11.46	9.64	9.86	8.93	9.52	13.63			5.69	
	F.Q.with R.S.	1.000	.894	.829	.756	.691	.610	.520	.415	.309	.155				
	F. Q. without R.S.	1.058	.948	.879	.802	.733	.647	.552	.440	.328	.164				
20.	O. B.	39¾	36	33½	30	26½	23½	20¼	15¾	12	5½	9.57	35½	1"	.603
	U. B.	36½	33	30½	27	23¾	21½	18	14½	10½	4¾			&	
	Bark %	8.18	8.33	9.02	10.00	10.38	9.57	8.64	9.52	12.50	13.63			2.74	
	F. Q. with R.S.	1.000	.904	.829	.740	.651	.582	.493	.390	.288	.130				
	F. Q. without R.S.	1.028	.930	.852	.761	.669	.599	.507	.402	.296	.134				
21.	O. B.	38¾	35¼	33½	32¼	30	27½	24	21	14	6¾	9.61	33½	1½"	.743
	U. B.	34¾	32	30½	29	27	24½	21¾	19	12¾	5¾			&	
	Bark %	10.32	9.22	8.96	10.08	10.00	10.09	9.38	9.52	8.93	14.81			4.32	
	F. Q. with R.S.	1.000	.921	.878	.835	.777	.705	.626	.547	.367	.166				
	F. Q. without R.S.	1.045	.963	.918	.872	.812	.737	.654	.572	.384	.173				
22	O. B.	38½	35¼	33½	32	29	26½	23½	19¾	14½	6¾	10.05	33½	1¼"	.717
	U. B.	34¾	32¼	30¼	28½	26	24	21¼	17¾	12¾	6			&	
	Bark %	9.74	8.51	9.70	10.94	10.35	9.43	9.57	10.13	12.07	11.11			3.60	
	F. Q. with R.S.	1.000	.928	.871	.820	.748	.691	.612	.511	.367	.173				
	F. Q. without R.S.	1.037	.963	.903	.851	.776	.716	.634	.530	.381	.179				
23.	O. B.	33¼	29¼	27¼	25¼	22¾	20½	18	15	9	5	9.49	28	2"	.661
	U. B.	30	26½	24¾	22¾	20½	18½	16¼	14	8	4½			&	
	Bark %	9.78	9.40	9.19	9.90	9.89	9.75	9.72	6.67	11.11	10.00			6.67	
	F. Q. with R.S.	1.000	.883	.825	.758	.683	.617	.542	.467	.267	.150				
	F. Q. without R.S.	1.071	.946	.884	.813	.732	.661	.580	.500	.286	.161				
24.	O. B.	41	37½	35¾	33¼	30½	26½	23¾	19½	14	7¼	9.96	35	2"	.732
	U. B.	37	33¼	32	30	27½	23¾	21½	17½	12¾	6¼			&	
	Bark %	9.76	10.74	10.49	9.78	9.84	10.38	9.48	10.26	8.93	13.79			5.41	
	F. Q. with R.S.	1.000	.898	.865	.811	.743	.642	.581	.473	.345	.169				
	F. Q. without R.S.	1.057	.950	.914	.857	.786	.678	.614	.500	.364	.179				
25.	O. B.	28½	25½	24¾	23	21½	19½	18	14½	11¼	6	10.00	24	1½"	.742
	U. B.	25½	23	22¼	20¾	20	17½	16	13	10	5¼			&	
	Bark %	10.53	9.80	10.10	9.78	6.98	10.26	11.11	10.35	11.11	12.50			5.88	
	F. Q. with R.S.	1.000	.902	.873	.814	.784	.686	.628	.510	.392	.206				
	F. Q. without R.S.	1.063	.958	.927	.865	.833	.729	.667	.542	.417	.219				

26. /

Tree No.		100%	90%	80%	70%	60%	50%	40%	30%	20%	10%	Mean Bark %	Reduced Girth	R. S.	Form Class.
26	O. B.	35½	31½	29¾	28¼	26	23¾	21	17½	12	5½	11.19	28¾	2¾"	.735
	U. B.	31½	28	26¼	25¼	23	21	19	15½	10½	5			&	
	Bark %	10.64	11.11	11.77	10.62	11.53	11.58	9.52	11.43	12.50	9.09			8.73	
	F.Q.with R.S.	1.000	.889	.833	.802	.730	.667	.603	.492	.333	.159				
	F. Q. without R.S.	1.095	.974	.913	.878	.800	.731	.661	.539	.365	.174				
27	O. B.	33½	30¾	29¾	27½	26½	23¾	21½	17½	13¾	6¾	10.18	29	1¾"	.742
	U. B.	30¾	27¾	27	24¾	23½	21¼	19	15¾	12¼	6			&	
	Bark %	8.21	9.76	9.24	10.00	11.32	10.53	11.62	10.00	10.91	11.11			5.69	
	F. Q. with R.S.	1.000	.903	.878	.805	.764	.691	.618	.512	.398	.195				
	F. Q. without R.S.	1.060	.957	.931	.854	.810	.767	.655	.543	.422	.238				
28	O. B.	28	25¾	24½	23	21½	18½	16¼	13½	9¾	5	9.50	26¼	1½"	.742 ~~.750~~
	U. B.	25¼	23½	22	20½	19¼	16¾	14¾	12½	8¾	4½			&	
	Bark %	9.82	8.74	9.28	10.86	10.47	9.46	9.23	7.41	10.26	10.00			5.41	
	F. Q. with R.S.	1.000	.910	.874	.814	.748	.703	.622	.504	.414	.216				
	F. Q. without R.S.	1.057	.962	.924	.857	.791	.743	.657	.533	.438	.229				
29	O. B.	36½	32¾	31½	29½	27¾	25	22	18	13½	7	10.53	30½	2¼"	.730
	U. B.	32¾	29½	28½	26	24½	22¼	19¾	16¼	12	6			&	
	Bark %	9.66	9.92	9.52	11.87	11.71	11.00	10.23	9.72	11.11	14.29			6.87	
	F. Q. with R.S.	1.000	.901	.870	.794	.748	.680	.603	.496	.366	.183				
	F. Q. without R.S.	1.074	.967	.934	.853	.803	.730	.648	.533	.393	.197				
30	O. B.	40½	35¾	34½	31¼	28¾	25¾	23½	19	13½	5¾	9.36	34¼	2¼"	.703
	U. B.	36½	32¾	31	28¾	25¾	23½	21¼	17¼	12	5			&	
	Bark %	9.32	8.39	9.49	8.00	10.43	8.74	9.57	9.21	11.11	13.04			6.17	
	F. Q. with R.S.	1.000	.897	.849	.788	.706	.644	.582	.473	.329	.137				
	F. Q. without R.S.	1.066	.956	.905	.840	.752	.686	.620	.504	.350	.146				
31	O. B.	45½	40¼	37	34½	31	28¼	24¾	19½	13¾	6¼	10.00	37¼	3¾"	.682
	U. B.	41	36	33¼	30¾	28	25¾	22¼	17¾	12¼	5½			&	
	Bark %	9.89	10.56	10.14	10.86	9.68	8.85	10.10	8.97	10.91	12.00			9.15	
	F. Q. with R. S.	1.000	.878	.811	.750	.683	.629	.543	.433	.299	.134				
	F. Q. without R.S.	1.101	.967	.893	.825	.752	.691	.597	.477	.329	.148				
32	O. B.	40¼	35¾	33½	31¾	28	26	22½	18¾	13	5¾	9.54	34	2¾"	.694
	U. B.	36¼	32½	30½	28¾	25½	23¾	20¼	17	11½	5			&	
	Bark %	9.94	9.09	8.96	9.45	8.93	8.65	10.00	9.33	11.54	13.04			6.21	
	F. Q. with R. S.	1.000	.897	.841	.793	.703	.655	.559	.469	.317	.138				
	F. Q. without R. S.	1.066	.956	.897	.846	.750	.698	.596	.500	.338	.147				
33	O. B.	29½	26¾	24½	23¼	21½	19¼	17	14¾	11	6	11.19	24½	2¼"	.706
	U. B.	26¾	24	22	20½	19	17	15¼	13	9½	5¼			&	
	Bark %	9.32	10.28	10.21	11.82	11.62	11.69	10.29	11.87	13.63	12.50			8.41	
	F. Q. with R. S.	1.000	.897	.822	.767	.710	.635	.570	.486	.355	.196				
	F. Q. without R. S.	1.091	.980	.898	.837	.776	.694	.622	.531	.388	.214				
34	O. B.	42½	36¼	34¼	31¾	29	26½	23½	20½	16½	7	8.91	34½	3¾"	.697
	U. B.	38¼	33	31¼	28¾	26½	24	21¼	18½	15¼	6			&	
	Bark %	10.00	8.97	8.76	9.45	8.62	8.57	9.57	8.64	7.58	14.29			9.80	
	F. Q. with R. S.	1.000	.857	.812	.747	.688	.623	.552	.481	.396	.156				
	F. Q. without R. S.	1.116	.957	.906	.833	.768	.696	.616	.536	.442	.174				

Tree No.		100%	90%	80%	70%	60%	50%	40%	30%	20%	10%	Mean Bark %	Reduced Girth	R. S.	Form Class
35	O. B.	30	27½	26	25½	22½	20¼	17¼	14¾	10¾	5¼	10.01	26¼	¾"	.690
	U. B.	27	25	23½	22¾	20¼	18½	15½	13¼	9½	4½			&	
	Bark %	10.00	9.09	9.61	10.78	10.00	8.64	10.15	10.17	11.62	14.29			2.78	
	F. Q. with R. S.	1.000	.926	.870	.843	.750	.685	.574	.491	.352	.167				
	F. Q. without R. S.	1.029	.952	.895	.867	.772	.705	.591	.505	.362	.171				
36	O. B.	37¾	34½	32½	31¼	29	25¾	22½	18½	13¾	7¾	10.01	32½	1½"	.719
	U. B.	34	31¼	29¾	28½	26¼	23	20	16¾	12	6¾			&	
	Bark %	9.93	9.42	8.46	8.80	9.48	10.68	11.11	9.46	12.73	12.90			4.41	
	F. Q. with R. S.	1.000	.919	.875	.838	.772	.676	.588	.493	.353	.199				
	F. Q. without R. S.	1.046	.962	.915	.877	.808	.708	.615	.515	.369	.208				
37	O. B.	31½	29	27¾	26	23½	22	19	16¾	11¾	6[illegible]	10.28	27	1¼"	.727
	U. B.	28¼	26	25	23¼	21¼	19¾	17	15	10½	5¼			&	
	Bark %	10.31	10.35	9.91	10.58	9.57	10.23	10.52	10.45	10.64	12.50			4.43	
	F. Q. with R. S.	1.000	.920	.885	.823	.761	.699	.602	.531	.3~~69~~72	.~~208~~181				
	F. Q. without R. S.	1.046	.963	.926	.861	.796	.731	.630	.556	.389	.195				
38	O. B.	48	43¾	40½	38½	34	31	27¼	22	16¾	-	10.71	40¾	2½"	.687
	U. B.	43¼	39	36½	34½	30	27½	24¼	19¾	15	-			&	
	Bark %	9.90	10.86	9.88	11.04	11.77	11.29	11.01	10.23	10.45	-			5.78%	
	F. Q. with R. S.	1.000	.902	.844	.792	.694	.636	.561	.457	.347	-				
	F. Q. without R. S.	1.061	.957	.896	.841	.736	.675	.595	.485	.368	-				
39	O. B.	33¾	30¾	28¾	27½	25½	22½	20	16¾	12¼	6¾	9.71	29	1½"	.708
	U. B.	30½	28	26	25	23¼	20¼	18	14¾	11	5¾			&	
		~~1.000~~	~~.918~~	~~.853~~	~~.820~~	~~.762~~	~~.664~~	~~.590~~	~~.484~~	~~.361~~	~~.189~~				
	Bark %	9.63	8.94	9.56	8.26	8.82	10.00	10.00	11.94	10.21	14.81			4.92	
	F. Q. with R. S.	1.000	.918	.853	.820	.762	.664	.590	.484	.361	.189				
	F. Q. without R.S.	1.052	.966	.897	.862	.802	.698	.621	.509	.379	.198				
40	O. B.	39¾	36¼	35	32¾	29¾	26	23½	19	14	8¼	9.09	35	1¼"	.702
	U. B.	36¼	33¼	31¾	29¾	27	23½	21	17½	12¾	7¼			&	
	Bark %	8.81	8.28	9.29	9.16	9.24	9.61	10.64	7.89	8.93	12.12			3.45 ~~4.02~~	
	F. Q. with R. S.	1.000	.917	.876	.821	.745	.648	.579	.483	.352	.200				
	F. Q. without R.S.	1.035	.950	.907	.850	.771	.671	.600	.500	.364	.207				
41	O. B.	34¼	30¾	29	27¼	25	23½	20½	17½	13	6¼	11.52	28½	1½"	.696
	U. B.	30	27¼	25¾	24¼	22	20¾	18½	15½	11½	5½			& 5.00	
	Bark %	12.41	11.39	11.20	11.01	12.00	11.70	10.97	11.43	11.54	12.00				
	F. Q. with R. S.	1.000	.908	.858	.808	.733	.692	.608	.517	.383	.183				
	F. Q. without R. S.	1.053	.956	.904	.851	.772	.728	.640	.544	.404	.193				
42	O. B.	30½	27¾	26½	24¾	22½	21¼	19	15½	12¾	7	8.92	26¼	1½"	.737
	U. B.	27¾	25¼	24¼	22½	20¾	19½	17¼	14	11½	6			&	
	Bark %	9.02	9.01	8.49	9.09	7.78	8.24	9.21	9.68	9.80	14.29			5.41	
	F. Q. with R. S.	1.000	.910	.874	.811	.748	.703	.622	.504	.414	.216				
	F. Q. without R.S.	1.057	.962	.924	.857	.791	.743	.657	.533	.438	.229				
43	O. B.	41¼	37¾	35½	32¾	30½	27¾	24½	19¾	15	7½	8.36	36	1½"	.700
	U. B.	37½	34½	32½	30	27¾	25¼	22½	18¼	13¾	6¾			&	
	Bark %	9.09	8.61	7.80	8.40	8.26	9.01	8.16	7.60	8.33	10.00			4.00	
	F. Q. with R. S.	1.000	.920	.867	.800	.740	.674	.600	.487	.367	.180				
	F. Q. without R. S.	1.042	.958	.903	.833	.771	.702	.625	.507	.382	.188				

Tree No.		100%	90%	80%	70%	60%	50%	40%	30%	20%	10%	Mean Bark %	Reduced Girth	R. S.	Form Class
44	O. B.	35¾	32	30¾	29	27	25	22¾	19	15½	6¼	11.56	29¾	2¼"	.752
	U. B.	32	28½	27¼	26	23¾	22	20	16¾	13½	5½			&	
	Bark %	10.49	10.94	11.39	10.35	12.03	12.00	12.09	11.84	12.90	12.00			7.03	
	F. Q. with R. S.	1.000	.891	.852	.813	.742	.688	.625	.524	.422	.172				
	F. Q. without R.S.	1.075	.958	.916	.874	.798	.739	.672	.563	.452	.184				
45	O. B.	42½	38	36½	35¼	33	29¾	26½	21¼	15	7¼	10.54	35½	3"	.746
	U. B.	38½	34¼	32¾	31½	29¼	26½	23½	19¼	13¼	6¼			&	
	Bark %	9.41	9.87	10.28	10.64	11.36	10.92	11.32	9.41	11.66	13.79			7.79	
	F. Q. with R. S.	1.000	.889	.851	.818	.760	.688	.610	.500	.344	.162				
	F. Q. without R.S.	1.085	.965	.923.	.887	.824	.746	.662	.542	.373	.176				
46	O. B.	40¾	35½	35¼	32½	29½	26¼	22¾	18¾	13½	6½	10.63	34	3"	.693
	U. B.	37	32¼	31¾	28¾	26½	23½	20	16½	12	5½			&	
	Bark %	9.20	9.16	9.93	11.53	10.17	10.47	12.09	12.00	11.11	15.38			8.11	
	F. Q. with R. S.	1.000	.872	.858	.777	.716	.635	.541	.446	.324	.149				
	F. Q. without R.S.	1.088	.949	.934	.846	.779	.691	.588	.485	.353	.162				
47	O. B.	47¼	42¾	39	36	33	29¼	25¾	19¾	14	6½	9.58	40¼	3"	.653
	U. B.	43¼	38¾	35½	32¾	29¾	26¼	23	18	12½	5¾			&	
	Bark %	8.47	9.36	8.97	9.03	9.85	10.26	10.68	8.86	10.72	11.54			6.94	
	F. Q. with R. S.	1.000	.896	.821	.757	.688	.607	.532	.416	.289	.133				
	F. Q. without R.S.	1.075	.963	.882	.814	.739	.652	.572	.447	.311	.143				
48	O. B.	40½	35¾	34	31¾	29	26¼	23	19½	13½	6½	9.69	34	2½"	.702
	U. B.	36½	32½	30¾	28¾	26¾	23½	20½	17¾	12	5¾			&	
	Bark %	9.88	9.09	9.56	9.45	7.76	10.47	10.86	8.97	11.11	11.54			6.85	
	F. Q. with R. S.	1.000	.890	.842	.788	.733	.644	.562	.486	.329	.158				
	F. Q. without R.S.	1.074	.956	.904	.846	.787	.691	.603	.522	.353	.169				
49	O. B.	45	40¾	38½	35	31	28½	22¾	17¾	12½	5¾	8.79	40¼	1¼"	.627
	U. B.	41½	37¾	35½	32¼	28¼	26	20¾	16	11¼	5			&	
	Bark %	9.79	7.36	7.79	7.86	8.87	8.77	8.79	9.86	10.00	13.04			3.01	
	F. Q. with R. S.	1.000	.910	.856	.777	.681	.627	.500	.395	.271	.121				
	F. Q. without R.S.	1.031	.938	.882	.802	.702	.646	.516	.398	.280	.184				
50	O. B.	30¼	27	26	24½	22	21	18	15	10¾	6	10.49	25½	1¼"	.715
	U. B.	26¾	24¼	23	21¾	19½	18¾	16	13¾	9¾	5¼			&	
	Bark %	11.57	10.18	11.53	10.30	11.36	10.72	11.11	8.33	9.30	12.50			4.67	
	F. Q. with R. S.	1.000	.907	.860	.813	.729	.701	.598	.514	.365	196				
	F. Q. without R. S.	1.049	.951 ~~.909~~	.902 ~~.857~~	.853 ~~.802~~	.765 ~~.736~~	.735 ~~.661~~	.628 ~~.562~~	.539 ~~.463~~	.382 ~~.347~~	.206 ~~.149~~				
51	O. B.	34¼	31¼	29¼	27¼	25	22¾	18¾	15½	11½	5½	10.83	29	1¼"	.690
	U. B.	30¼	27½	25¾	24¼	22¼	20	17	14	10½	4½			&	
	Bark %	11.68	11.99	11.97	11.01	11.00	12.09	9.33	9.68	8.70	18.18			4.13	
	F. Q. with R. S.	1.000	.909	.857	.802	.736	.661	.562	.463	.347	.149				
	F. Q. without R.S.	1.043	.948	.888	.836	.767	.690	.586	.483	.362	.155				
52	O. B.	36¼	32¾	30¼	27¾	25½	22½	19¼	17	12½	6¼	10.09	31	1¾"	.655
	U. B.	32¾	29¾	27¼	25	22¾	20¼	17½	15¼	11	5½			&	
	Bark %	9.66	9.16	9.92	9.91	10.78	10.00	9.09	10.29	12.00	12.00			5.34	
	F. Q. with R. S.	1.000	.908	.832	.763	.695	.618	.534	.466	.336	.168				
	F. Q. without R.S.	1.056	.960	.879	.806	.734	.653	.564	.492	.355	.177				

Tree No.		100%	90%	80%	70%	60%	50%	40%	30%	20%	10%	Mean Bark %	Reduced Girth	R. S.	Form Class.
53	O. B.	40½	36	34	31½	28¼	24½	21¼	17	12½	6	9.26	35¼	1¾"	.639
	U. B.	37	33	31	28¼	25¼	22	19	15¼	11½	5¼			&	
	Bark %	6.14	8.33	8.82	10.31	10.62	10.21	10.59	10.29	8.00	12.50			4.73	
	F. Q. with R. S.	1.000	.892	.838	.764	.682	.595	.514	.412	.311	.142				
	F. Q. without R.S.	1.050	.936	.880	.802	.716	.624	.539	.433	.319	.146				
54	O. B.	52½	48½	45¼	43¼	39¾	35	31	25	17¼	7¾	10.34	45¾	1¾"	.687
	U. B.	47½	43¾	41	39	35¾	31¼	27¼	22½	15¼	6½			&	
	Bark %	9.52	9.80	9.39	9.83	10.07	10.71	12.10	10.00	11.60	16.13			3.68	
	F. Q. with R. S.	1.000	.921	.863	.821	.753	.658	.574	.474	.321	.137				
	F. Q. without R.S.	1.039	.956	.896	.853	.781	.683	.596	.492	.333	.142				
55	O. B.	36	32	29½	27¼	24½	22½	19¼	16½	11¾	6	9.66	30¼	2¼"	.667
	U. B.	32½	29	26¾	24½	22½	20½	17½	14¾	10½	5			&	
	Bark %	9.72	9.38	9.32	10.09	9.18	8.89	9.09	10.60	10.64	16.66			6.92	
	F. Q. with R. S.	1.000	.892	.823	.754	.685	.631	.538	.454	.333	.154				
	F. Q. without R.S.	1.074	.959	.884	.810	.736	.678	.579	.488	.347	.165				
56	O. B.	40¼	35½	31½	30	27	23½	21	16¾	12	5½	10.10	33½	3"	.653
	U. B.	36½	32¼	28¾	27¼	24¼	21	18¾	15	10½	4¾			&	
	Bark %	9.32	9.16	8.73	9.17	10.18	10.64	10.72	10.45	12.50	13.63			8.22	
	F. Q. with R. S.	1.000	.884	.788	.747	.664	.575	.513	.411	.288	.130				
	F. Q. without R.S.	1.090	.963	.858	.816	.724	.627	.560	.448	.313	.142				
57	O. B.	31½	28½	27	26¼	23½	21¼	19	15	11¼	6¼	11.42	26¼	1½"	.727
	U. B.	27¾	25¼	23¾	23	20¾	19¼	16¾	13½	10	5¼			&	
	Bark %	11.91	11.40	12.03	12.38	11.70	9.41	11.84	10.00	11.11	16.00			5.41	
	F. Q. with R. S.	1.000	.910	.856	.829	.748	.694	.604	.486	.361	.189				
	F. Q. without R.S.	1.057	.962	.905	.876	.791	.733	.638	.514	.381	.200				
58	O. B.	30¾	28¼	26½	26	23½	21	20¼	17	11½	6	8.76	27¼	1"	.717
	U. B.	28¼	26¼	24¼	23½	21¼	19¼	18	15¼	10½	5			&	
	Bark %	8.13	7.08	8.49	9.61	9.57	8.33	8.64	10.29	8.70	16.66			3.54	
	F. Q. with R. S.	1.000	.929	.858	.832	.752	.681	.637	.540	.372	.177				
	F. Q. without R.S.	1.036	.963	.890	.862	.780	.706	.661	.560	.385	.184				
59	O. B.	37½	32½	30¾	29¼	26	23¼	20	16½	12½	7	8.84	31½	2¾"	.680
	U. B.	34¼	30	28¼	26¾	23½	21¼	18¼	15¼	11	6			&	
	Bark %	8.67	7.69	8.13	8.55	9.61	8.60	8.75	7.58	12.00	14.29			8.03	
	F. Q. with R. S.	1.000	.876	.825	.781	.686	.620	.533	.445	.404	.175				
	F. Q. without R.S.	1.087	.952	.897	.849	.746	.675	.579	.484	.349	.191				
60	O. B.	37¾	33¾	31½	30	27¾	25¼	22½	18	13~~0~~¾	7	8.74	32¼	2¼"	.727
	U. B.	34½	31	28¾	27¾	25½	22¾	20½	16¼	12½	6¼			&	
	Bark %	8.61	8.15	8.73	7.50	8.11	9.90	8.89	9.72	9.09	10.72			6.52	
	F. Q. with R. S.	1.000	.899	.834	.804	.739	.660	.594	.471	.362	.181				
	F. Q. without R.S.	1.069	.961	.892	.860	.791	.705	.636	.504	.388	.194				
61	O. B.	44¾	40¾	39½	36¼	33½	29¾	26	22	16¼	8¾	8.49	39½	2"	.703
	U. B.	41½	37¾	36	33½	31	26½	23¾	20	14¾	7½			& 4.82	
	Bark %	7.26	7.36	8.86	7.59	7.46	10.92	8.65	9.09	9.23	14.29				
	F. Q. with R. S.	1.000	.910	.868	.807	.747	.639	.572	.482	.356	.181				
	F. Q. without R.S.	1.051	.956	.911	.848	.785	.671	.601	.506	.374	.190				

Tree No.		100%	90%	80%	70%	60%	50%	40%	30%	20%	10%	Mean Bark %	Reduced Girth	R. S.	Form Class
62	O. B.	35	31	30	28½	25¾	23¼	20½	16¾	12¼	6¼	11.09	29¼	2¼".	.710
	U. B.	31½	28	26¾	25	22¾	20¼	18½	15	10¾	5½			&	
	Bark %	10.00	9.68	10.83	12.28	11.65	12.90	9.75	10.45	12.25	12			7.14	
	F. Q. with R. S.	1.000	.889	.849	.794	.722	.643	.587	.476	.341	.175				
	F. Q. without R. S.	1.074	.957	.915	.855	.778	.692	.633	.513	.368	.188				
63	O. B.	37½	32½	30¾	29¼	26½	23¾	20¾	18	13½	7½	9.46	31	2¾"	.702
	U. B.	33¾	29½	28	26½	23½	21½	18¾	16¼	12½	6½			&	
	Bark %	10.00	9.23	8.94	9.40	11.32	9.48	9.64	9.72	7.41	13.33			8.15	
	F. Q. with R. S.	1.000	.874	.830	.785	.697	.637	.556	.482	.370	.193				
	F. Q. without R. S.	1.088	.952	.903	.855	.758	.693	.605	.524	.403	.210				
64	O. B.	43½	38	36½	34	31	27¾	24½	19½	14	5¾	8.44	36½	3½"	.702
	U. B.	40	35	33	31½	28¼	25¼	22¼	18	12¾	5			&	
	Bark %	7.47	7.89	9.59	7.35	8.87	9.01	9.18	7.69	8.93	13.04			8.75	
	F. Q. with R. S.	1.000	.875	.825	.788	.706	.631	.556	.450	.319	.125				
	F. Q. without R. S.	1.096	.959	.904	.863	.774	.692	.610	.493	.349	.137				
65	O. B.	35¾	31¾	30	28¼	26	22¾	20¾	17½	13¼	6¾	10.51	30¾	1¾"	.683
	U. B.	32½	29¼	27¼	25½	23	20¼	18¼	15¼	11¾	5¾			&	
	Bark %	9.09	7.87	9.17	9.73	11.53	10.98	12.04	12.86	11.32	14.81			5.38	
	F. Q. with R.S.	1.000	.900	.839	.785	.708	.623	.562	.469	.362	.177				
	F. Q. without R.S.	1.057	.951	.886	.829	.748	.659	.594	.496	.382	.187				
66	O. B.	42	38¾	36	34½	31	28	24	21¼	14¾	6¼	9.77	36¼	1½"	.698
	U. B.	37¾	34¾	32½	31¼	27¾	25½	21¾	19¼	13¼	5½			&	
	Bark %	10.12	10.32	9.72	9.42	10.48	8.93	9.38	9.41	10.17	12.00			3.97	
	F. Q. with R. S.	1.000	.920	.861	.828	.735	.675	.576	.510	.351	.146				
	F. Q. without R. S.	1.041	.959	.897	.862	.766	.703	.600	.531	.366	.152				
67	O. B.	38¾	35¼	34	33	31	27	24¼	20	14¼	6¼	11.99	32¾	1¼"	.730
	U. B.	34	31¼	30	29	27¼	24	21¼	17½	12½	5½			&	
	Bark %	12.26	11.35	11.77	12.13	12.10	11.11	12.37	12.50	12.28	12.00			3.68	
	F. Q. with R. S.	1.000	.919	.882	.853	.802	.706	.625	.515	.368	.162				
	F. Q. without R.S.	1.039	.954	.916	.886	.832	.733	.649	.534	.382	.164				
68	O. B.	41	36¼	34¾	32½	31	27½	24½	18	14½	7½	9.64	34½	3"	.716
	U. B.	37½	33	31½	29½	27½	25	22	16¼	13	6½			&	
	Bark %	8.54	8.97	9.35	9.23	11.29	9.09	10.21	9.72	10.35	13.33			8.00	
	F. Q. with R. S.	1.000	.880	.840	.787	.733	.667	.587	.433	.347	.173				
	F. Q. without R.S.	1.086	.957	.913	.855	.795	.725	.638	.471	.377	.188				
69	O. B.	30¾	29¼	27¾	26	24	21¼	19	16	11¾	6¾	10.39	27	½"	.724
	U. B.	27½	26	24¾	23¼	21¼	19	17	14½	10¾	5¾			&	
	Bark %	10.57	11.11	10.81	10.58	11.46	10.59	10.52	9.38	8.51	14.81			1.82	
	F. Q. with R. S.	1.000	.946	.900	.846	.773	.691	.618	.527	.391	.209				
	F. Q. without R.S.	1.018	.963	.917	.861	.787	.704	.630	.537	.398	.213				
70	O. B.	36¼	33½	32¼	29¾	28¾	26¼	22¾	19¼	15	5½	11.42	31¼	1"	.739
	U. B.	32¼	30	28¾	26¼	26	23¼	20¼	17	12¾	4¾			& 3.10	
	Bark %	11.04	10.45	10.85	11.77	9.56	11.43	10.98	11.69	15.00	13.63				
	F. Q. with R. S.	1.000	.930	.892	.814	.806	.721	.628	.527	.395	.147				
	F. Q. without R.S.	1.032	.960	.920	.840	.832	.744	.648	.544	.408	.152				

Tree No.		100%	90%	80%	70%	60%	50%	40%	30%	20%	10%	Mean Bark %	Reduced Girth	R. S.	Form Class
71	O. B.	38½	35½	33¾	32¼	29½	26	22½	17½	12¼	5½	10.03	33¾	1¼"	.688
	U. B.	35	32¼	30½	29	26	23¼	20	16	11	4¾			&	
	Bark %	9.09	9.16	9.63	10.08	11.87	10.58	11.11	8.57	10.21	13.63			3.57	
	F. Q. with R. S.	1.000	.922	.871	.829	.743	.664	.571	.457	.314	.136				
	F. Q. without R.S.	1.037	.956	.904	.859	.770	.689	.593	.474	.326	.141				
72	O. B.	36½	32½	30½	28¾	26½	24¼	21	17	12¼	6¼	9.07	31¼	1¾"	.695
	U. B.	33	29¾	27¼	26½	24¾	22	19	15¼	11	5¼			&	
	Bark %	9.59	8.46	9.02	8.69	6.60	9.28	9.52	10.29	10.21	16.00			5.30	
	F. Q. with R.S.	1.000	.901	.841	.795	.750	.667	.575	.462	.333	.159				
	F. Q. without R.S.	1.055	.952	.888	.840	.792	.704	.608	.488	.352	.168				
73	O. B.	29½	27½	25¾	25	24	21½	18½	15½	12	5¾	9.48	25¾	¾"	.742
	U. B.	26½	25	23¼	22½	21½	19	17	14	11	5			&	
	Bark %	9.40	9.09	9.71	10.00	10.42	10.59	8.11	9.68	8.33	13.04			2.83	
	F. Q. with R.S.	1.000	.943	.877	.849	.811	.717	.642	.528	.415	.189				
	F. Q. without R.S.	1.029	.971	.903	.874	.835	.738	.660	.544	.427	.194				
74	O. B.	41½	38¼	37¼	35½	32¾	29¼	25¼	20¾	13½	6½	8.25	38	¾"	.708
	U. B.	38¾	36¼	34¾	32½	29½	26¾	22¾	19	12	5½			&	
	Bark %	6.63	5.23	6.71	7.80	9.92	8.55	9.90	8.43	11.11	15.38			1.94	
	F. Q. with R. S.	1.000	.935	.897	.839	.761	.690	.587	.490	.310	.142				
	F. Q. without R.S.	1.020	.954	.914	.855	.776	.704	.599	.500	.316	.145				
75	O. B.	42¾	39½	38	36	33	30½	25	21¼	14¾	6½	8.92	37½	1¾"	.727
	U. B.	39¼	36	34½	33	30	27¾	23	19¼	13¼	5½			&	
	Bark %	8.19	8.86	9.21	8.33	9.09	9.02	8.00	9.41	10.17	15.38			4.46	
	F. Q. with R.S.	1.000	.917	.879	.841	.764	.707	.586	.491	.338	.140				
	F. Q. without R.S.	1.047	.960	.920	.880	.800	.740	.613	.513	.353	.147				
76	O. B.	38	32	29¾	27¾	25	22½	20½	17½	12¾	6	10.45	30	3¾"	.687
	U. B.	33¾	28½	26¾	25½	22¼	20¼	18	15½	11¼	5			&	
	Bark %	11.19	10.94	10.08	9.01	11.00	10.00	8.64	11.43	11.77	16.66			11.11	
	F. Q. with R.S.	1.000	.845	.793	.748	.660	.600	.533	.459	.333	.148				
	F. Q. without R.S.	1.125	.950	.892	.842	.742	.675	.600	.517	.375	.167				
77	O. B.	46¼	41¾	39¼	38	35½	30	26½	21¾	15½	7¾	10.12	39¾	2"	.696
	U. B.	41¾	38	35¾	34½	31½	27	23½	19½	13¾	6¾			&	
	Bark %	9.73	8.98	8.92	9.21	11.27	10.00	11.32	10.35	11.29	12.90			4.79	
	F. Q. with R. S.	1.000	.910	.857	.826	.755	.647	.563	.467	.329	.162				
	F. Q. without R.S.	1.051	.956	.900	.868	.793	.679	.591	.491	.346	.170				
78	O. B.	31¾	28	26¼	24¾	22	20	17¾	15	11½	6¾	11.22	25¾	2¾"	.704
	U. B.	28½	24¾	23¼	22	19¾	17½	15¾	13½	10¼	6			&	
	Bark %	10.23	13.39	11.43	11.11	10.23	12.50	11.27	10.00	10.86	11.11			9.65	
	F. Q. with R.S.	1.000	.869	.816	.772	.693	.614	.553	.474	.360	.211				
	F. Q. with R.S.	1.107	.961	.903	.854	.767	.680	.612	.524	.398	.233				
79	O. B.	31	28½	26¼	25¼	22½	20	18½	15¾	13	8¼	9.92	26¾	1½"	.710
	U. B.	28¼	26	24	22½	20	18¼	16½	14	11¾	7¼			&	
	Bark %	8.87	8.77	8.57	10.89	11.11	8.75	10.81	11.91	9.62	12.12			5.31	
	F. Q. with R.S.	1.000	.920	.850	.797	.708	.646	.584	.496	.416	.257				
	F. Q. without R.S.	1.056	.972	.897	.841	.748	.682	.617	.523	.439	.271				

Tree No.		100%	90%	80%	70%	60%	50%	40%	30%	20%	10%	Mean Bark %	Reduced Girth	R.S.	Form Class
80	O. B.	31½	28½	25¾	24½	22¼	20	18	14¾	11½	6¼	9.95	26½	1¾"	.697
	U. B.	28¼	25½	23¼	22½	20	18	16¼	13¼	10¼	5½			&	
	Bark %	10.31	10.53	9.71	8.16	10.11	10.00	9.72	10.17	10.86	12.00			6.19	
	F. Q. with R.S.	1.000	.903	.823	.797	.708	.637	.575	.470	.363	.195				
	F. Q. without R.S.	1.066	.962	.877	.849	.755	.679	.613	.500	.387	.208				
81	O. B.	35	32	31	29½	28	25¼	22½	19	15¼	8½	11.58	29½	1½"	.752
	U. B.	31	28¼	27½	26½	24½	22¼	20	16¾	13½	7½			&	
	Bark %	11.43	11.71	12.10	10.17	12.50	11.88	11.11	11.84	11.48	11.77			4.84	
	F. Q. with R. S.	1.000	.911	.879	.855	.790	.718	.645	.540	.435	.242				
	F. Q. without R.S.	1.051	.958	.924	.898	.831	.754	.678	.569	.458	.254				
82	O. B.	43¾	38½	37	35	33¼	30¼	26¾	23	16¼	8¾	8.50	37	3"	.737
	U. B.	40	35½	33½	32¼	30½	27¼	24¼	21¼	15	7¾			&	
	Bark %	8.57	7.79	9.46	7.86	8.27	9.92	9.35	7.61	7.69	11.43			7.50	
	F. Q. with R.S.	1.000	.887	.837	.806	.763	.681	.606	.531	.375	.194				
	F. Q. without R.S.	1.081	.959	.905	.872	.824	.737	.655	.574	.405	.209				
83	O. B.	35¾	30½	29¼	27¼	24½	22½	20	17½	13¼	7	11.36	28¾	2¾"	.700
	U. B.	31½	27½	26¼	24	22	20	17½	15½	11¾	6			&	
	Bark %	13.65	9.84	10.26	11.92	10.21	11.11	12.50	11.43	11.32	14.29			8.73	
	F. Q. with R.S.	1.000	.873	.833	.762	.698	.635	.556	.492	.373	.191				
	F. Q. without R.S.	1.095	.956	.913	.835	.765	.696	.609	.539	.409	.209				
84	O. B.	38¾	34½	33	31½	28½	26	23	19½	15½	-	9.74	33	2¼"	.718
	U. B.	35¼	31½	30	28½	26	23½	20¾	17½	13½	-			&	
	Bark %	9.03	8.86	9.09	9.52	8.77	9.61	9.78	10.26	12.90	-			6.38	
	F. Q. with R.S.	1.000	.894	.851	.809	.738	.667	.589	.497	.383	-				
	F. Q. without R.S.	1.068	.955	.909	.864	.788	.712	.629	.530	.409	-				
85	O. B.	38½	34½	33¼	32¾	28¾	26½	22½	19¼	14	6¾	9.15	33½	2"	.705
	U. B.	35½	31¾	30½	30¼	26	23½	20¼	17½	12½	5¾			&	
	Bark %	7.79	7.97	8.27	7.63	9.56	11.32	10.00	9.09	10.72	14.81			5.63	
	F. Q. with R. S.	1.000	.895	.859	.852	.732	.662	.571	.493	.352	.162				
	F. Q. without R.S.	1.059	.948	.911	.903	.776	.702	.605	.522	.373	.172				
86	O. B.	48¼	43¾	41	37	33¼	29½	25½	21	16¼	8	8.67	42¾	1¾"	.636
	U. B.	44½	40¼	37¾	34¼	31	27	23	19	14¼	7			&	
	Bark %	7.77	8.00	7.93	7.43	6.77	8.47	9.80	9.52	12.31	12.50			3.91	
	F. Q. with R. S.	1.000	.904	.848	.770	.697	.607	.517	.427	.320	.157				
	F. Q. without R.S.	1.041	.941	.883	.801	.725	.632	.538	.446	.333	.164				
87	O. B.	39	34½	32½	31¾	29¼	27	24	18¼	12¾	5½	9.19	32½	2½"	.742
	U. B.	35	31¼	30	28¾	26¼	24½	22	16¾	11½	4½			&	
	Bark %	10.26	9.42	7.69	9.45	10.26	9.26	8.33	8.22	9.80	18.18			7.14	
	F. Q. with R. S.	1.000	.893	.857	.822	.750	.700	.629	.479	.329	.129				
	F. Q. without R.S.	1.076	.962	.923	.885	.808	.754	.677	.515	.354	.139				
88	O. B.	33	30	28¼	26¼	23½	22	18¾	16¼	11¼	5½	8.40	28½	1½"	.705
	U. B.	30	27¼	25¾	24¼	22	20	17¼	14½	10½	5			&	
	Bark %	9.09	9.17	8.85	7.62	6.38	9.09	8.00	10.76	6.67	9.09			5.00	
	F. Q. with R. S.	1.000	.908	.858	.808	.733	.667	.575	.483	.350	.167				
	F. Q. without R.S.	1.053	.956	.904	.851	.772	.702	.605	.509	.368	.176				

Tree No.		100%	90%	80%	70%	60%	50%	40%	30%	20%	10%	Mean Bark %	Reduced Girth	R. S.	Form Class
89	O. B.	45	41	39	36¾	34	31¾	27¾	21¾	15¾	7¼	8.96	39¼	1¾"	.719
	U. B.	41	37½	35½	33½	31	28¾	25	19¾	14¼	6¼			&	
	Bark %	8.89	8.54	8.97	8.84	8.82	8.00	9.91	9.19	9.52	13.79			4.27	
	F. Q. with R. S.	1.000	.915	.866	.817	.756	.701	.610	.482	.348	.152				
	F. Q. without R.S.	1.045	.955	.904	.854	.790	.733	.637	.503	.363	.159				
90	O. B.	50½	44¾	42	39¼	36	32½	29	24¾	16	7½	10.40	43	2¾"	.677
	U. B.	45¾	40¾	38¼	35¼	32¼	29	26	21¾	14	6½			&	
	Bark %	9.41	8.94	8.93	10.20	10.42	10.76	10.35	12.12	12.50	13.33			6.01	
	F. Q. with R. S.	1.000	.891	.836	.770	.705	.634	.568	.475	.306	.142				
	F. Q. without R. S.	1.064	.948	.890	.820	.750	.674	.605	.506	.326	.151				
91	O. B.	40½	36	33	31½	28½	26¼	22¾	19¼	14	7½	9.03	34	3"	.698
	U. B.	37	33	30¼	28¾	26	24	20¾	17¼	12½	6½			&	
	Bark %	8.64	8.33	8.33	8.73	8.77	8.57	8.79	10.39	10.72	13.33			8.11	
	F. Q. with R. S.	1.000	.892	.818	.777	.703	.649	.561	.466	.338	.176				
	F. Q. without R. S.	1.088	.971	.890	.846	.765	.706	.610	.507	.368	.191				
92	O. B.	31¾	29	27	26	24	22½	20¼	18¼	14	8	10.11	27½	1¾"	.735
	U. B.	29	26¼	24½	23½	21½	20	18	16	12¼	7			&	
	Bark %	8.66	9.48	9.26	9.61	10.42	10.11	8.64	12.33	12.50	12.50			6.03	
	F. Q. with R. S.	1.000	.905	.845	.810	.741	.690	.621	.552	.422	.241				
	F. Q. without R. S.	1.064	.963	.899	.862	.789	.733	.661	.587	.449	.257				
93	O. B.	32¼	29½	28¾	27½	25	23	20	17	12½	6	10.42	27¾	1¼"	.736
	U. B.	29	26¾	25¾	24½	22¼	20¾	18	15¼	11	5¼			&	
	Bark %	10.08	9.32	10.43	10.91	11.00	9.78	10.00	10.29	12.00	12.50			4.31	
	F. Q. with R. S.	1.000	.922	,888	.845	.767	.716	.621	.526	.379	.181				
	F. Q. without R. S.	1.045	.964	.928	.883	.802	.684	.649	.549	.396	.189				
94	O. B.	42¾	39¾	38	36½	32½	30¼	27	22	17¼	9	9.44	37¼	2"	.740
	U. B.	39¼	36	34½	33	29½	27¼	24¼	20	15½	8			&	
	Bark %	8.19	9.43	9.19	9.59	9.23	9.92	10.18	9.09	10.15	11.11			5.10	
	F. Q. with R.S.	1.000	.917	.879	.841	.752	.694	.618	.510	.395	.204				
	F. Q. without R.S.	1.054	.967	.926	.886	.792	.732	.651	.537	.416	.215				
95	O. B.	34¼	31¾	30¾	29	26½	23½	21¼	17¾	14	8	10.18	29¾	1¼"	.740
	U. B.	31	28¾	27¾	26	24	21½	19½	16¼	11½	7			&	
	Bark %	9.49	9.45	9.76	10.35	9.43	8.51	8.24	8.45	17.85	12.50			4.03	
	F. Q. with R. S.	1.000	.927	.895	.839	.774	.693	.629	.524	.371	.226				
	F. Q. without R.S.	1.042	.967	.933	.874	.807	.723	.656	.546	.387	.235				
96	O. B.	38¼	35¼	33¼	32	30	26¾	24	19½	14¾	7½	9.77	33	1½"	.740
	U. B.	34½	31¾	30	28¾	26¾	24¼	21¾	17½	13½	6½			&	
	Bark %	9.80	9.93	9.78	10.16	10.83	9.35	9.38	10.26	8.47	13.33			4.35	
	F. Q. with R. S.	1.000	.920	.870	.834	.775	.703	.631	.507	.391	.188				
	F. Q. without R.S.	1.046	.962	.909	.871	.811	.735	.659	.530	.409	.197				
97	O. B.	44½	38	35½	33¼	30	27	24	20½	14½	8¼	9.71	36½	3¾"	.679
	U. B.	40¼	34½	32¼	30¼	27½	24¼	21¾	18¼	12¾	7			&	
	Bark %	9.04	9.21	9.16	9.02	8.33	10.18	9.38	10.97	12.07	15.15			9.32	
	F. Q. with R. S.	1.000	.857	.802	.752	.683	.603	.541	.454	.317	.174				
	F. Q. without R.S.	1.103	.945	.884	.829	.753	.664	.596	.500	.349	.192				

Tree No.		100%	90%	80%	70%	60%	50%	40%	30%	20%	10%	Mean Bark %	Reduced Girth	R.S.	Form Class
98	O. B.	35½	31¾	31	28½	26½	24	21¼	18	13¾	7¾	10.65	29½	2"	.726
	U. B.	31½	28¼	27¾	25¾	23¾	21½	19	16	12¼	6¾			&	
	Bark %	11.27	11.03	10.48	9.65	10.38	10.42	10.59	11.11	10.91	12.90			6.35	
	F. Q. with R. S.	1.000	.897	.881	.818	.754	.683	.603	.508	.389	.214				
	F. Q. without R.S.	1.068	.958	.941	.873	.805	.729	.644	.542	.415	.229				
99	O. B.	32½	28¾	26¾	25¼	23¼	21½	19	15½	12¼	6¼	8.74	27¼	2¼"	.713
	U. B.	29½	26	25¼	23	21¼	19½	17¼	14¼	11	5½			&	
	Bark %	9.23	9.56	5.61	8.91	8.60	9.30	9.21	8.07	10.21	12.00			7.63	
	F. Q. with R.S.	1.000	.881	.856	.780	.720	.661	.585	.483	.373	.187				
	F. Q. without R.S.	1.082	.954	.927	.844	.780	.716	.633	.523	.404	.202				
100	O. B.	45¾	41	39½	36½	32¾	30¼	25	21	14¼	6¾	9.10	40	2"	.675
	U. B.	42	37¾	36	33	29¾	27½	22¾	19	12¾	6.			&	
	Bark %	8.20	7.93	8.86	9.59	9.16	9.09	9.00	9.52	10.53	11.11			4.76	
	F. Q. with R.S.	1.000	.899	.857	.786	.708	.655	.542	.453	.304	.143				
	F. Q. without R.S.	1.050	.944	.900	.825	.744	.688	.569	.475	.319	.150				