FORESTRY COMMISSION

BULLETIN No. 31

CODE OF SAMPLE PLOT PROCEDURE

By

F. C. HUMMEL, M.A., D.Phil.,
G. M. L. LOCKE, B.Sc., J. N. R. JEFFERS, A.I.S.,
and J. M. CHRISTIE

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LONDON: HER MAJESTY'S STATIONERY OFFICE

FIFTEEN SHILLINGS NET

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FOREWORD

THE systematic measurement of sample plots in stands of growing timber provides the data for the compilation of yield tables and other estimates of increment which are essential to the economic management of woodlands. In order that such measurements shall be strictly comparable, both as between one sample plot and another, and within the same plot as measured on different occasions, a precise method must always be followed.

This bulletin sets out in detail the procedure that has been developed by the Forestry Commission's research officers since such measurements were begun in Britain, under the Board of Agriculture, forty-five years ago. Though intended primarily for the staff engaged on such work, it is believed that it contains much information of value to all who are concerned with the raising and accurate measurement of timber trees, both at home and abroad.

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INTRODUCTION

THE Forestry Commission now has more than 700 permanent sample plots, the oldest of which were established in 1913 by the Forestry Branch of the then Board of Agriculture and taken over by the Forestry Commission when it was formed in 1919. Most of these plots are in the Commission's own forests, but some, particularly the older ones, are on private estates. We are greatly indebted to the private woodland owners who have given us facilities to establish and measure these plots, for without their co-operation we would have had few data in the older age classes. Most of the permanent sample plots are in pure, even-aged stands of the commonly grown conifers. There are, however, about 100 plots in broadleaved species and about 70 in the less common, but promising, coniferous species, and these numbers are likely to increase. Some plots have also been established in mixtures, in stands which have been underplanted, and in stands which are under conversion from coppice-with-standards to high forest.

The objects of sample plot work and the procedure used were described by James Macdonald (1931). The objects as set out in that paper still apply. They are :

(*a*) The study of the growth, production and increment of different species under definite and continuous systems of management.

(*b*) The comparison of the effect of different methods of thinning on the growth of any given species in order to determine as far as possible the method of treatment best suited to that species.

(*c*) The investigation of silvicultural problems such as underplanting, conversion of coppice-with-standards to high forest, treatment of mixtures, etc.

(*d*) To provide areas where different methods of thinning can be demonstrated.

In addition to serving the above main objects, sample plots are now used :

(*e*) to study the degradation or improvement of a site over several rotations ;

(*f*) to study the effect of espacement, thinning treatment and provenance on the properties of the timber produced.

There are two main reasons why it has become necessary to prepare a code of sample plot procedure. In the first place, although the methods of measurement did not undergo any important changes between 1931 and 1955, sufficient minor modifications had been introduced to warrant the preparation of an up-to-date description of methods. The second reason was that the expansion of sample plot work and its execution by a larger number of research foresters made it necessary to replace James Macdonald's general description of methods by a more detailed code of instructions. In 1931 there were about 180 permanent sample plots and there was only one sample plot party whose sole duty it was to measure and thin these plots. The observance of strictly uniform standards thus presented no difficulties. Now, however, the position has changed ; on the 30th September 1958 there were 774 plots and the responsibility for these is divided between 12 different field parties, each of which performs a considerable range of other duties in addition to the measurement of sample plots. Under these changed conditions, strict uniformity of procedure can only be ensured by a detailed code of instructions. The code is intended to help in the training of new staff and to serve as a guide and source of reference to those who are already trained.

Before preparing the new code, the whole of the existing procedure was subjected to a thorough review. The object was to make the procedure more objective and to simplify it where possible without loss of accuracy. At a meeting in May 1954, the senior members of the Mensuration Section, including the leaders of all the field parties, were invited to criticise the existing procedure and to suggest improvements. A committee, consisting of F. C. Hummel (Mensuration Officer), G. M. L. Locke (Census Officer), J. N. R. Jeffers (Statistician) and J. M. Christie (Forester responsible for sample plot records), considered the suggestions made, arranged for testing the various proposals and then, having reached decisions on all major points, prepared a preliminary draft of the new code. The circulation of that draft to the field parties for further trials and criticism led to several further amendments. The code as it now stands, although drafted by the above committee, is thus very much the result of team work by the Mensuration Section as a whole.

The more important changes in procedure since 1931 are discussed below, and are summarized in Appendix XII where the new procedure is compared with the procedure described in 1931.

Before the 1st of March 1947 all volumes and basal areas were expressed in terms of *true measure*. Since this date, the British *hoppus* or *quarter girth* system for determining the volumes and basal areas of trees has been used, in order to bring measurements taken by the Research Branch of the Forestry Commission into line with those in general use among foresters and timber merchants throughout Great Britain. Volumes continue to refer to stem-wood measured to a top diameter of 3 inches over bark, but they are now measured and recorded *over bark* instead of *under bark* and only in certain circumstances are *under bark* volumes calculated as well.

With certain exceptions, until a sample plot has reached a top height of about 40 feet, or until about 90 per cent of the trees have a breast height girth of $8\frac{1}{2}$ inches or more, the trees are not numbered and an abbreviated procedure of measurement is adopted.

Sample plots are normally measured every third year, but a distinction is now made between measurements of a sample plot by the complete procedure, usually every ninth year, and intermediate measurements by an abbreviated procedure, which are made in the third and sixth years. The main difference between the complete and abbreviated procedures is that at intermediate measurements there is no volume assessment of the standing crop and heights are only measured under certain circumstances.

The selection of sample trees for height and for volume determination of the standing crop has been greatly simplified. An objective sample of trees is now selected systematically from the half-inch breast height girth classes in numbered plots, or up and down the rows in un-numbered plots, so that a sample of about 40 trees is measured for height, and 10 of these trees are measured as standing sample trees for the determination of volume. A test on four felled plots, in which the volume of all trees had been measured, showed that the objective method of selecting sample trees for the determination of volume reduces the precision of the estimate only slightly if at all (Hummel 1955) and removes the possibility of bias inherent in any subjective selection of sample trees. The sampling is confined to the standing trees and no thinnings are now accepted as sample trees for the standing crop.

For the volume determination of standing sample trees, climbing continues to be the standard method where trees are small. In tall stands or where climbing is difficult for other reasons, there are two alternatives :

(*a*) The use of a dendrometer.

(*b*) Where no dendrometer is available, climbing, supplemented by the use of the taper line described in Appendix V. (This method replaces the form quotient method formerly used.)

Previously, in order to calculate the volume of the plot, the volumes of the sample trees were plotted over girth, and a modification of Block's system of grouping was used. The volume of the plot is now determined from the regression of the sample tree volumes on their basal areas ; this relationship is assumed to be linear (Hummel 1955) and the method described in Appendix VI is used to determine the regression. This method obviates the need for grouping but the data for the 100 largest trees per acre are still computed separately, because the development of these trees throughout the life of a plantation is of special interest.

Where the number of thinnings is small, the volume of each individual tree is measured as in the past ; but where the number is large, the new code makes provision for the measurement of only a sample of the thinnings.

The mean height of the plot is now defined as the height corresponding to the mean basal area of the plot read directly from a graph. This replaces the calculation of mean height by Lorey's formula. The change represents a considerable simplification and is considered justified because, although there are certain theoretical objections to the use of this method, they are considered to be no greater than the objections to Lorey's method which assumes that the form factor in a stand is constant in all girth classes ; a condition not often met in practice. In any case, the difference between the mean height as determined by the two methods is usually very small.

The main text of this code of procedure is supported by a number of Appendices which describe in detail particular operations and other general topics allied to sample plot work which could not have been dealt with in the main text without obscuring the main issue. Particular attention is drawn to Appendix IX which gives a worked example of the procedure, and to Appendix X which, besides listing all the formulae mentioned in the text, gives a table of conversion factors, and also useful constants for use when laying out sample plots.

In preparing this code our aim has been, on the one hand, to omit nothing of importance and, on the other, to avoid unnecessary detail. The efficient measurement of sample plots therefore demands from the sample plot forester the exercise of his initiative, judgement and powers of observation, as well as a conscientious adherence to the code of procedure.

REFERENCES

HUMMEL, F. C. (1955). *The Volume—Basal Area Line*. Forestry Commission Bulletin No. 24. H.M.S.O. London.

MACDONALD, JAMES (1931). Sample Plot Methods in Great Britain. *Empire Forestry Journal*, Vol. 10, 1931, pages 241–58.

Note. Throughout this bulletin all references are placed at the end of the Chapter or Appendix to which they refer.

Chapter 1

SELECTION AND GENERAL MANAGEMENT

(1) The selection of sites for permanent sample plots is governed by the objects of the plot, and no general rules can be laid down. For most purposes, however, sample plots are established in pure, fully-stocked woods of uniform growth.

In thinning series, and other series of comparable plots, sample plots will not normally be established in experiments which show marked variation in growth. In spacing experiments, for example, it may happen that one or more plots may be of slower growth than the remainder, and it may only be possible to take full sample plot measurements in part of the experiment. In such a case, all the plot areas will be demarcated at the same time, and an assessment of height and a description of the condition of the crop will be made in those plots where full sample plot procedure is not applied. At the time when the last plot of the series is established, a full measurement will be made in all plots of the series, irrespective of the dates of the previous full measurements.

(2) The objects of the plot and its silvicultural treatment (thinning, underplanting, etc.) will be clearly defined by the officer ordering the establishment of the plot and they will be recorded either on the Description Form (Sample Plot Form No. 2a) or, if a lengthy explanation is necessary, on a separate sheet attached to it.

(3) In matters for which no special treatment is prescribed (e.g. drainage) generally accepted silvicultural practice will be followed.

(4) Sample plots will be inspected at least once every three years in order to determine whether thinning or other treatment is required. Any points of interest (e.g. changes in ground vegetation) will be recorded in the file on the Description Form (Sample Plot Form No. 2a or 2b) together with any decisions on future treatment.

(5) Sample plots will normally be thinned every three, six or nine years. A three-year thinning cycle will be applied to young plots, except where the rate of growth is very slow, whilst older plots will have intervals of at least six years between thinnings.

(6) Sample plots will be remeasured every time they are thinned. Measurements between thinnings will not normally be necessary except, for example, in thinning series, where if one plot in the series is thinned all must be measured ; in old plots of special silvicultural interest, etc. A distinction will be made between measurements at which the whole measuring procedure is applied—*full measurements*, and measurements at which only part of the measuring procedure is applied—*intermediate measurements*. (See paras. 40 and 41.)

Chapter 2

LAYOUT OF PLOT AND MARKING OF THINNINGS

Size and Shape of Plot

(7) Plots will normally be rectangular but the shape of the plot and the number of sides may be varied.

(8) The size of the plots will normally be 0·3 to 0·5 acre, but will vary according to the local site conditions, the objects of the plot, and the age to which it is to be continued. Normally no single coniferous plot will be less than 0·2 acre and no single hardwood plot less than 0·3 acre. The maximum size of single plots will be 1 acre in both conifers and hardwoods. In plots where the object is to study the development of a mixture, the size of the plot should not be less than 0·5 acre.

Surround

(9) The surround should extend half a chain outwards from the sides of the plot, but the width

may be varied. Where the thinning in the plot differs markedly from the thinning in the adjoining stand or adjoining plots, the width of the surround should be increased if possible. A widening of the surround is also permissible, where the plot occurs near the stand boundary, in order to make the edge of the surround coincide with the edge of the plantation. The width of the surround will not be reduced to less than a quarter of a chain.

Demarcation of Plots

(10) At establishment, the corners of the plot will be marked by white posts. When these posts have rotted or have disappeared, they need only be replaced,

(*a*) if the main crop trees have not yet been numbered,

(*b*) in thinning series,

(*c*) if there is an understorey of trees which have not yet reached measurable size.

(11) The outer limits of the surround will be clearly indicated by painting the letters denoting the thinning grade of the plot on an adequate number of dominant boundary trees. The letters will be painted so as to be easily seen from both inside and outside of the plot to which they refer.

(12) White paint will normally be used for symbols or letters on surround trees, bands at breast height (para. 22) and tree numbers (para. 28). On species such as birch, where white paint might not show up, red paint may be used. The use of yellow paint will be avoided to prevent confusion with trees marked for genetical work.

Survey of Plot

(13) Where planting rows can be distinguished, the boundary of the plot will be parallel to and half-way between adjacent rows of trees.

(14) The sides of the plot will be measured by a steel tape or by a 66-foot surveyor's chain (Gunter's), to the nearest link.

(15) The angles between the sides will be measured to the nearest half degree by prismatic compass or box sextant ; for rectangular plots an optical square may be used.

(16) To ensure accuracy of measurement, the plot will be surveyed once in a clockwise direction and once in an anti-clockwise direction. If the variations in readings exceed half a degree in angle and one link in length, the plot will be resurveyed until the desired accuracy is reached. Measuring the diagonals may serve as a further check.

(17) If a plot is situated on a slope exceeding five degrees, the measured lengths of the sides will be reduced to their horizontal equivalents by one of three methods :

(*a*) where the slope is uniform, by measuring the angle of slope with an Abney level and calculating the horizontal equivalent of the length ;

(*b*) where the slope is not uniform, by " stepping " the chain ;

(*c*) by using a trailer tape and Abney level.

(18) A plan of the plot will be drawn on Sample Plot Form No. 1, and the magnetic north point will be indicated. The horizontal length of sides, the included angles, and the scale used, will be recorded on the plan. The scale used will normally be 20 links to one centimetre.

(19) The area of the plot, correct to 0·001 acre, will be calculated on the reverse side of Sample Plot Form No. 1 and the result transferred to the front. (See Appendix IX.)

(20) The following *maps* will be drawn :

(*a*) A tracing, on the scale 6 inches : 1 mile, showing the location of the plot in relation to the nearest rides, compartment boundaries, etc.

(*b*) An outline map, on the scale 1 inch : 1 mile, to show the location of the plot in relation to the nearest main roads and towns. Where there is a series of comparative plots, or a group of single plots, the position of all the plots will be marked both on tracings from the 6-inch map and from the 1-inch map. A photographic copy of each tracing will be placed in each file, and the plot to which the file refers will be outlined in red.

Marking of Thinning

(21) The plot will be marked for thinning in accordance with the grade of thinning prescribed (see Appendix III), before the trees are banded and numbered ; but thinnings will not be felled until the plot has been girthed and classified (see para. 52).

Banding of Trees

(22) At establishment, all trees in the plot, both main crop and thinnings, which have a girth of 4 inches or more will have a narrow band about half an inch wide and two inches in length painted on them. The bands will be painted at a height of 4 feet 3 inches (breast height) from ground level to ensure that subsequent girth measurements are taken at the same point. An additional band will be painted on the opposite side of the tree to ensure that girth measurements are taken at right angles to the

main axis of the stem. On large trees, it may be necessary either to extend the lengths of the bands to four inches, or to paint two extra bands on the stem so that the height at which girthing is to be done is marked by four points at equal intervals round the stem.

(23) On sloping ground, the bands will be painted at a height of 4 feet 3 inches from ground level, on the upper side of the tree.

Leaning trees will be banded at a distance of 4 feet 3 inches measured parallel to the axis of the stem, on the side where the tree forms the smallest angle with the ground.

(24) Where the point on a tree 4 feet 3 inches from the ground coincides with a swelling on the stem, bands will be painted both above and below the swelling at points equidistant from the 4 feet 3 inches point.

(25) Where a tree is forked at or below 4 feet 3 inches the procedure will vary as follows :

(*a*) Tree forked below 4 feet 3 inches—each prong will be treated as a separate tree and will have the girth band painted on it at 4 feet 3 inches above ground level.

(*b*) Tree forked at 4 feet 3 inches—a band painted immediately below the point of swelling will be taken as the girthing point, and the height at which the band is painted will be recorded in the remarks column of the General Register. (Sample Plot Form No. 3.)

(26) At subsequent measurements of the plot the girth bands will be repainted if they have become indistinct, or are likely to become indistinct before the next measurement is due ; and trees which have been recruited to the 4-inch girth class, or above, since the last measurement will be banded.

Numbering of Main Crop Trees

(27) In single plots, the main crop trees will not normally be numbered until about 90 per cent of them are of 8½ inches girth or over, or until the top height of the crop is about 40 feet. Until such time as either of these limits is reached the plot will not be numbered. When a plot has reached these limits all main crop trees of 4 inches girth and over will be numbered, and the plot will be referred to as a " *numbered plot* ".

In thinning series or other series of comparable plots (e.g. spacing experiments) the trees in all plots will normally be numbered as soon as the first plot in the series is due for numbering in accordance with the above instruction.

(28) In numbered plots all main crop trees of 4 inches girth and over will be numbered in sequence. The numbers will be painted at a convenient height above the band, but not at exactly 5 feet because on rough-barked trees, where the bark needs to be scraped before numbers can be painted, the girth at this point on sample trees and thinnings may be underestimated. Only in exceptional circumstances, e.g. in a thinning series when a plot would not normally be due for numbering, may a system of partial numbering be used. With this system the trees at the beginning and end of each row, and approximately every fifth tree in between, will have the complete numbers painted on them and a dot painted to the right or left of the number to indicate the direction in which the numbers are running.

(29) On level ground, the numbers will be painted on the side of the tree away from the prevailing wind. On sloping ground, the numbers will be painted on the upper side of the trees, commencing at the bottom left hand corner of the plot, looking down the slope, and proceeding along the contours.

(30) Where trees of more than one species occur in the plot, the numbering will be done in sequence, irrespective of species.

(31) Numbers will be re-painted at each subsequent measurement if they have become indistinct, or are likely to become indistinct, before the next measurement is due.

(32) Any trees recruited at subsequent measurements into the 4-inch girth class or above will be given the next available number. To facilitate locating them, their approximate position in the crop in relation to adjacent numbered trees should be indicated in the remarks column of the General Register (Sample Plot Form No. 3).

Numbering of Thinnings

(33) Up to and including the measurement at which the first numbering of the main crop takes place, thinnings will not be numbered. At subsequent measurements, the thinnings will already have the numbers they were given previously when they were part of the main crop.

Plot Legend

(34) The plot legend will be painted either on the corner post nearest tree Number 1 or on a dominant surround tree near tree Number 1.

The legend will consist of at least :

(*a*) Plot number ;

(*b*) Thinning grade ;

(*c*) Planting year, if known accurately.

(Further details such as top height, number of stems per acre, plot area, etc. may be added if desired, and the year to which they refer recorded.)

Chapter 3

DESCRIPTIONS

Description on Establishment

(35) A Pre-establishment Form (Sample Plot Form No. 2) will be completed from information obtained locally. Particulars will be entered under the headings shown on the form, which are self explanatory except for the following :

Forest. The name of the forest and sub-unit will be given for Forestry Commission areas ; in privately owned woodlands the name of the estate.

Compartment Number. The number of the compartment will be given for Forestry Commission areas; in privately owned woodlands the name of the wood.

" P " year. The year of planting, if known for certain. Each " P " year, or Forest year, starts on the 1st October, but takes its number from the calendar year following, e.g. P.58 started on 1st October 1957.

Year of Sowing. Only applicable if the crop was established by direct sowing in the forest.

Natural Regeneration. Give the period of years during which regeneration took place, e.g. Forest years 1940–1945 inclusive.

Particulars of Beating Up. The percentage beat-up, species, identity number and age of plants used will be given.

(36) The plot will be described on the Description on Establishment Form (Sample Plot Form No. 2a) and particulars entered under the headings given below. If under any heading there is insufficient space, a separate sheet will be added.

(1) *Species.* Where two or more species are present after thinning, and the subsidiary species together occupy either more than ten per cent of the number of trees, or more than ten per cent of the total basal area, the crop will be classed as a mixture.

(2) *Area.* The area of the plot recorded to the nearest 0·001 acre.

(3) *Situation.* The name of the forest, sub-unit, and the compartment or sub-compartment number will be given for Forestry Commission areas ; in privately owned woodlands the name of the wood.

In addition, the position of the plot in relation to adjacent towns, villages, roads, etc., will be described and the national grid reference given.

(4) *Ownership.* On Forestry Commission areas, the Conservancy will be recorded. On private estates, the name and addresses of both owner and agent or factor will be recorded.

(5) *Object of sample plot and details of treatment to be applied.*

(6) *Intervals at which plot is to be measured and thinned.*

(7) *Height above sea level.* The height above sea level will be estimated from the contours on the 1-inch or 6-inch Ordnance Survey maps.

(8) *Relative elevation.* Plot situation in relation to any known heights in the neighbourhood will be described. Any markedly higher or lower ground within two miles of the plot will be recorded giving height, distance and direction.

(9) *Aspect.* Aspect to the nearest half cardinal point, N., NE., E. etc.

(10) *Exposure.* Details will be given of the direction of the prevailing wind, features providing shelter and their position in relation to the plot. Exposure will be classified into five groups as listed below :

Fully sheltered.
Considerable shelter from local topographical features.
Moderate exposure.
Considerable exposure to prevailing winds.
Severe exposure.

(11) *Slope.* The angle of slope will be measured with an Abney level or other suitable instrument, and recorded to the nearest degree. Where there is a variation, indicate its limits. The slope will be classified as concave, convex, even or irregular. If there is no appreciable slope, the site will be described as level or undulating.

(12) *Topography within the Plot.* Any topographical features within the plot such as streams, gullies, rock outcrops, etc., will be recorded.

(13) *Geology.* The geological series, type, parent rock material and details of drift.

(14) *Climate.* The following details will be recorded:

(*a*) Meteorological station or other source from which records were obtained and the period to which they refer.

(*b*) The distance and direction of the plot site from the station from which records were obtained.

(*c*) Mean annual rainfall ; if this cannot be obtained from local records it will be taken from the ten miles to one inch (1/625,000) rainfall map of Great Britain and recorded by the rainfall classes given on that map, e.g. 40–50 inches, 60–80 inches, etc.

(*d*) Other meteorological information that may be available, e.g. maximum and minimum temperatures, etc., stating the source if it is different from (*a*) above.

(15) *Age of crop at first measurement and how ascertained.* The age given will be the number of growing seasons which have elapsed since planting ; this can normally be obtained from plantation records as recorded on the Pre-establishment Form (Sample Plot Form No. 2). For example, a crop planted in autumn 1930 and another in spring 1931 will both be shown as having the same age. Nursery years will not be included in the age of the crop, except when their inclusion is unavoidable ; this may occur in stands for which there are no reliable records of the date of planting and the age has to be determined from ring counts.

The age of the crop will always be given to the nearest whole year, and the 1st of July will be taken as the operative date for increase in age, e.g. a crop which is planted between the end of the growing season 1930 and the start of growing season 1931 will be 24 years old if measured in 1955 on or before the 30th of June but will be 25 years old if measured on or after the 1st of July.

(16) *Date of first measurement, giving month and year.*

(17) *Numbering of main crop trees.* State whether the main crop trees were numbered. (See para. 27.)

(18) *Method of measurement.* State whether the plot received a *full measurement* or an *intermediate measurement.* If full measurement procedure was applied, state whether the sample trees were :

(*a*) climbed to timber point,

(*b*) climbed to a point below timber point, or

(*c*) measured with the dendrometer.

(19) *Density of Ground Vegetation.* The density of the ground vegetation within the plot will be assessed by eye and recorded as a decimal ; e.g., 1·0 indicating complete ground cover, 0·6 indicating six-tenths cover and so on. The distribution of incomplete cover may be described as patchy, sparse, etc. The species occurring will be recorded in order of frequency within each of the following five classes :

(*a*) Tree seedlings and saplings, if any, with note on age or height.

(*b*) Other woody species, with indication of stature.

(*c*) Herbs and grasses.

(*d*) Ferns.

(*e*) Mosses, liverworts and lichens.

The following frequency symbols will be used :—

va — very abundant *a* — abundant
f — frequent *o* — occasional
r — rare

Notes : An *abundant* species is practically never out of sight in the plot : if it covers a large part of the ground it may be listed as *very abundant. Frequent* species are very often met with, but cover no substantial area : there will be several plants of an *occasional* species in the plot, but only one or two of a *rare* species.

In vegetation survey it is often necessary to modify the frequency symbol with the letter l (*local*) e.g. la, locally abundant, as for instance, willow herb in gaps in a wood. In a small forest stand of uniform composition and treatment on a uniform site, the qualification *local* will seldom be applicable.

The effect of the time of year when the vegetation is recorded should be borne in mind, and care taken to include (with appropriate frequency symbol) all species (e.g. bluebell) which leave little or no trace above ground after their period of vegetative activity. When a plot is measured in winter the frequency of the vegetation will be recorded as it is seen at the time of measurement, even though the vegetation may appear to be dead. Any special factors, such as sheep grazing, which influence the vegetation will be noted.

Species observed outside the stand, on rides, or adjoining wasteland, will be listed separately : they are in many instances useful indicators of site factors.

(20) *Condition of crop.* The condition of the crop will be described as follows, any changes resulting from thinning being noted :

(*a*) *Stocking :* whether complete or incomplete.

(*b*) *Distribution :* whether regular or irregular ; if irregular, give particulars.

(*c*) *Canopy :* whether complete, dense, thin, etc. ; also record the density of the canopy as a decimal, e.g. 1·0—complete canopy, 0·8—eight-tenths canopy.

(*d*) *Crowns :* whether fully developed, or badly formed, one sided, whipped, etc. ; the vigour and depth of crowns ; the degree to which crowns have been freed as a result of thinning.

(*e*) *Branching :* whether heavy, moderate or light ; persistence ; angle of branching ; height to which branches are dead ; height to which trees are brashed ; height to which trees are pruned and number pruned per acre.

(*f*) *Stems :* whether straight or crooked, clean, leaning or bowed, frequency of forking or spiral grain, proportion defective and perfect.

(*g*) *Uniformity as regards girth and height :* whether uniform or not throughout plot, if not state where, e.g., if girth and height fall off on a slope, etc.

(*h*) *Damage or disease :* state nature of damage and its cause, e.g. frost, drought, extraction, insect, fungus.

(21) *Remarks.* Under this heading will be recorded :

(*a*) Points of interest for which no appropriate headings are given on the form.

(*b*) Departures from standard sample plot or silvicultural practice, giving reason.

(*c*) Inspection notes by visiting forest officers of the Forestry Commission and observations by other professional visitors.

Soil Description

(37) A soil pit will be dug near the centre of the plot ; where the soil is variable more than one pit may be required. The soil profile will be described on a Field Soil Description Sheet (Sample Plot Form No. 2c), by the system given in G. R. Clarke's book *The Study of the Soil in the Field.*

Description on Remeasurement

(38) Whenever a plot is visited for remeasurement it will be described on a Description on Remeasurement Form (Sample Plot Form No. 2b). One of these forms will serve for several remeasurements. Particulars will be entered under the following headings :

(1) *Species.* This will be the same as at establishment, except that the crop may, by definition, have become either pure or a mixture (see para. 36 (1)) as a result of the present thinning.

(2) *Date and Initials.* The month and year of remeasurement and the initials of the person making the entry.

(3) *Age of crop.* The age given will be the number of growing seasons that have elapsed since planting. The age will always be given to the nearest whole year, and the 1st of July will be taken as the dividing line between one growing season and the next (see para. 36 (15)).

(4) *Number of Times the Crop Has Been :*

(*a*) *thinned*—including any thinnings made prior to the establishment of the sample plot and the thinning made at the present measurement.

(*b*) *measured*—including the present remeasurement.

(5) *Grade of Thinning Applied.* This will normally be the grade of thinning prescribed at the establishment of the plot. If, for any reason, the grade of thinning has been altered, the new thinning grade will be entered in the appropriate column and the authority for the change quoted.

(6) *Future Thinning Treatment to be Applied.*

(7) *Proposed time for next thinning and measurement.*

(8) *Year of Numbering.* The year when the trees in the plot were numbered.

(9) *Method of Measurement.* State whether the plot received a *full measurement* or an *intermediate measurement.* If full measurement procedure was applied, state whether sample trees were :

(*a*) climbed to timber point,

(*b*) climbed to a point below timber point, or

(*c*) measured with the dendrometer.

(10) *Surface Conditions of Humus and Soil.* Any changes that have taken place in the surface conditions of humus and soil since the last measurement (see Sample Plot Form No. 2c or 2b) will be recorded.

A soil pit will only be dug at a remeasurement when considerable changes appear to have taken place in the condition of the soil.

(11) *Soil Vegetation.* Any changes in density, species, or frequency of species of the ground vegetation since the last measurement (see Sample Plot Form No. 2a or 2b), will be recorded, together with the revised density

index and list of species. If no change has taken place, the fact will be noted.

(12) *Condition of Crop Before and After Thinning.* Notes will be made on the condition of the crop before and after thinning, under the same headings as those for establishment (para. 36 (20)). If only minor changes have taken place in the condition of the crop since the last measurement, it may not be necessary to make entries under all the headings.

(13) *Remarks.* Under this heading will be recorded :

(*a*) Points of interest for which no appropriate headings are given.

(*b*) Departures from standard sample plot or silvicultural practice, giving reason.

(*c*) Inspection notes by visiting forest officers of the Forestry Commission and observations by other professional visitors.

Chapter 4

MEASUREMENTS AND MAINTENANCE

General

(39) The procedure outlined below refers to plots of a single species. In mixtures (see para. 36 (1)), this procedure will be applied to each species. The procedure to be used for subsidiary species occurring in the plot in insufficient numbers for the plot to be classed as a mixture is given in para. 73.

(40) As stated in para. 6, a distinction is made between measurements at which the whole procedure is applied (*full measurements*) and measurements at which only part of the procedure is applied (*intermediate measurements*). The first *full measurement* normally takes place when the main crop trees in a plot are first numbered (para. 27) and thereafter at intervals of 9 to 12 years. A *full measurement* is required at shorter intervals if there are obvious indications of a change in the rate of growth.

(41) The intermediate measuring procedure will be applied to all un-numbered plots and to numbered plots at those thinnings at which a *full measurement* is not required. At *intermediate measurements* the main differences in procedure are as follows :

(*a*) The tree classification is not applied to the main crop in single plots ; it is, however, applied to the main crop in thinning series and to the thinnings in all plots (see para. 50).

(*b*) Heights will be measured in all un-numbered plots (para. 64), and in numbered plots only at those intermediate measurements between the first full measurement (i.e. when the crop is first numbered) and the second full measurement. Thereafter heights will *not* be measured unless, in the opinion of the Mensuration Officer or the party leader, there is a special need for them.

(*c*) No sample trees will be measured for determining the volume of the standing crop, which will be estimated by the method considered to be most appropriate by the party leader (see para. 114 (*h*)).

(*d*) No bark measurements will be taken on thinnings.

Girthing

(42) All trees, both main crop and thinnings, with a girth of 4 inches or more, will be girthed with a steel tape at the girthing band (i.e. 4 feet 3 inches above ground level). In plots where the main crop has not been numbered, each tree should be marked with timber chalk or other clearly visible but temporary marking as it is girthed ; the object is to prevent trees being missed or girthed twice. Girths will be recorded to the nearest half-inch. Girths falling exactly on a quarter-inch will be rounded up or down to the nearest whole number, e.g. 13¼ inches will be recorded as 13 inches, 13¾ inches as 14 inches. Trees with girths below 4 inches will *not* be girthed but will be counted and recorded in the space provided on the Girthing Sheet (Sample Plot Form No. 3a).

(43) Where by reason of a swelling at 4 feet 3 inches, two bands have been painted on the stem (see para. 24) the girth will be measured at each band and the arithmetic mean of these two measurements recorded as the girth.

(44) All girths recorded will be those shown on the tape, irrespective of fluting, buttressing, or abnormal thickening at the girthing point. When the plot is numbered, the presence of any abnormalities will be recorded in the remarks column of the General Register (Sample Plot Form No. 3) (see paras. 46 and 47).

(45) In plots where the main crop has not been numbered, the number of trees in both main crop and thinnings will be classified by half-inch classes into *gates of five* on the Girthing Sheet (Sample Plot Form No. 3a) as is shown in Table 1 below and in Appendix IX.

TABLE 1

Girth Class (inches)	Number of Trees		Total	
	Main Crop	Thinnings	Main Crop	Thinnings
12½	𝍸 ||	||	7	2
13	|||	𝍸	3	5
13½	𝍸 𝍸 |	||	11	2
14	𝍸 |	|||	6	3
				etc.

Where more than one species occurs in the plot, each species will be recorded separately and additional forms used if necessary.

(46) When the main crop is first numbered, the girths of the main crop trees will be entered directly into the General Register (Sample Plot Form No. 3) whence they will be transferred to the Girthing Sheet. When there is more than one species in the plot, the trees may be recorded in the General Register in numerical order irrespective of species, or by species, irrespective of numerical order, whichever is more convenient. The most appropriate method will be decided at the time. The thinnings, which at that measurement are still unnumbered, will be recorded into half-inch classes, by gates of five, directly onto the Girthing Sheet (Sample Plot Form No. 3a). In order to avoid confusion, it will be best if the girthing of the main crop and thinnings is done as two separate operations.

(47) At subsequent measurements of numbered plots, the girths of both main crop and thinnings will be recorded against the appropriate tree number in the General Register. From there the girths will be transferred to the Girthing Sheet (Sample Plot Form No. 3a) and recorded by half-inch classes. On this form, the actual *tree numbers* will be entered, thinnings being distinguished from main crop trees by being *circled*, e.g. (31). Any thinnings marked after the girths have been transferred to the Girthing Sheet will be distinguished by a *square*, e.g. [13] around the tree number in place of a circle. Table 2 below illustrates the procedure.

Tree Classification

(48) Tree classification will normally be applied only to even-aged forest, and all trees 4 inches in girth and over will be classified. In two-storied high forest, the classification will normally be applied to the upper canopy only ; if classification of the under storey is required, the lower canopy will be treated independently of the upper. The tree classification is described in Appendix II.

(49) The dominance classification of a tree is relative to those trees immediately surrounding it. Tree classification is necessarily subjective, but the same standard of classification should be applied to all plots, irrespective of species or thinning grade ; it would for example, be wrong to apply a stricter criterion of what constitutes good stem form in a plot of Norway spruce where the majority of the trees are straight, than in an exposed plot of Japanese larch, where even the best stems have some deformity.

TABLE 2

Girth Class (inches)	Number of Trees*	Total	
		Main Crop	Thinning
15½	7, 12, (31), 42, 50.	4	1
16	56, 71, 82, (111), 125.	4	1
16½	6, (22), 33, 46, 66, (99).	4	2
17	19, 165.	2	—
17½	[13], 41, 92, (118), 189, 190, 193.	5	2
18	2, 16, [48].	2	1
18½	98.	1	—
			etc.

Note. As explained in para. 47, the figures in the above table in the column headed " Number of Trees " relate to the serial number of each individual tree as recorded in the General Register. For ease of printing, brackets have been used instead of circles and squares to denote thinnings; round brackets denote normal thinnings, while square brackets indicate thinnings marked *after* the girths have been transferred to the girthing sheet.

(50) The trees of the main crop will be classified when a plot is first numbered (but not before) and, subsequently, at *full measurements*. In thinning series, but not in single plots, the classification will also be applied at *intermediate measurements*. The tree classes will be recorded directly into the General Register (Sample Plot Form No. 3).

(51) Thinnings will be classified at establishment and at each subsequent remeasurement, whether *full* or *intermediate*. When thinnings have not been numbered, their tree classes will be recorded directly on the Tree Classification Form (Sample Plot Form No. 3b); but when the thinnings are numbered the tree classes will first be recorded in the General Register (Sample Plot Form No. 3).

Felling of Thinnings

(52) Thinnings can be felled once the plot has been girthed and classified. (See para. 21.)

Sampling of Thinnings

(53) All thinnings of 8½ inches girth and over will be measured for volume provided that they number less than 40. If there are 40 of them or more a sample of approximately 30 may be measured, if sampling will save time. Measurement is easier if the sample thinnings are felled and measured before the other thinnings are felled, but this may not always be practicable.

(54) In plots where the thinnings have not been numbered every *n*th tree, working systematically backwards and forwards along the planting rows or contours, excluding trees under 8½ inches girth, will be measured. "*N*" is determined by dividing the number of thinnings of 8½ inches girth and over in the plot by 30. Counting from one corner of the plot, the first tree to be measured will be determined by dividing the quotient "*n*" by two, subsequent trees will be selected at intervals of the quotient. For example, if there are 120 measurable thinnings in the plot, every *fourth* tree will be measured, commencing with the second tree from the corner, then the sixth, tenth and so on. If the quotient is an odd number, it should be increased to the next even number before dividing it by two.

(55) In plots where the thinnings are numbered the procedure is similar except that the sample is chosen from the half-inch girth classes on the Girthing Sheet (Sample Plot Form No. 3a). Sampling starts from the smallest girth class (8½ inches or above) and continues in ascending order of girth.

Measurement of Thinnings

(56) All lengths will be measured from the breast-height girth band. If timber height is above this band, 4 feet 3 inches will be added to give the length from ground level; if timber height is below the band, the length will be subtracted from 4 feet 3 inches. If the stems are badly bowed, the lengths will be measured along the curvature of the stem. Lengths will be measured to the nearest inch and recorded to the nearest foot; over-bark and under-bark girths will be recorded to the nearest half-inch.

(57) The following measurements will be taken, after felling, on all thinnings selected for volume measurement, and the data will be recorded on the Measurement of Thinnings Form (Sample Plot Form No. 4a):

(*a*) Length to the tip of the tree or to the tip of the longest fork (i.e. effective length from ground level).

(*b*) Length to 9½ inches girth over-bark, or to the point above which no main stem can be distinguished, whichever comes first (i.e. effective length from ground level to timber height).

(*c*) The over-bark girths at the mid-points of 10-foot sections, up to timber height. If, however, there is a "stop" (i.e. a point on the stem where there is a sudden marked change in girth), the length of the section immediately below it will be increased to coincide with it, and the points for mid-girth measurement will be adjusted accordingly. Similarly, the length of the last section below timber point will be increased to be between 10 and 19 feet, e.g. if a tree has a length to timber point of 48 feet, there will be three sections 10 feet long and one section of 18 feet, and the tree will be girthed at 5, 15, 25 and 39 feet from the butt; i.e. at 9 inches, 10 feet 9 inches, 20 feet 9 inches and 34 feet 9 inches from the breast-height girth mark. The mid-girth of a section will be measured at exactly the mid-point of the measured length except where a deformity of the stem makes it necessary to take the mean of two girths at equal distances above and below this point.

(*d*) At full measurements, bark thickness will be measured on all thinnings, if all have been measured, or on the trees forming the sample, if a sample has been measured. No measurements of bark thickness will be made at *intermediate measurements*.

(*e*) Bark thickness will be measured with a Swedish Mattson bark gauge (which reads in millimetres) at the points of girthing. Under-bark girth is found by deducting half an inch from the over-bark girth for every two millimetres thickness of bark, and will be recorded to the nearest half-inch. If the reading of bark

thickness falls exactly on an odd millimetre, the bark thickness will be rounded up or down to the nearest inch, e.g. 2 mm. is recorded as ½-inch thickness of bark, 3 mm., 4 mm. and 5 mm. as 1 inch, 6 mm. as 1½ inches, 7 mm., 8 mm. and 9 mm. as 2 inches, 10 mm. as 2½ inches, etc.

(58) If a thinning (either coniferous or broadleaved) is forked, all measurable volume, i.e. volume to the point on each fork where the over-bark girth is 9½ inches (3 inches diameter), will be measured and reckoned as stem wood. Sometimes there may be difficulty in deciding whether to treat a tree as being forked, i.e. as having two stems from the point of forking, or whether to regard the smaller and possibly less straight prong of the fork merely as a branch. The smaller prong will only be treated as stemwood if the minimum straight length exceeds 10 feet to the point on the stem where the over-bark girth is 9½ inches ; otherwise it will be treated as branchwood.

(59) In coniferous thinnings branchwood will be ignored ; but in broadleaved thinnings, each branch will be measured in one length to the point where the over-bark girth is 9½ inches, and be recorded separately from the stem wood. (See Appendix IX.) No measurement of bark thickness will be made on branchwood.

Wind-Blown Trees

(60) Where the basal area of the wind-blown trees in a plot is more than five per cent of the basal area of the standing crop before the windblow occurred, details of the damage will be recorded on the special form provided. The form will be completed in duplicate ; one copy will be placed in the relevant sample plot file, and the other will be sent to the Mensuration Officer. The form is shown in Appendix IX.

(61) Windblown trees will be measured in the same way as thinnings (paras. 57–59). They will be measured and recorded separately from them when their basal area is more than five per cent of the basal area of the standing crop before windblow occurred, and a separate entry will be made on the Final Summary Sheet (Sample Plot Form No. 7 : Record of Periodical Measurements per Acre). In all other instances they will be combined with the thinnings, and will not have a separate entry on the Final Summary Sheet, except where windblow occurs between measurements.

Measurement of Trees for Height Analysis

(62) The height growth of three thinnings will be analysed at the establishment of a plot or at the first subsequent measurement at which suitable trees are available. Height analysis will not normally be done more than once in the same plot.

The three trees for height analysis will be chosen subjectively from thinnings which conform to the following specifications :

(*a*) The trees must have been dominants or co-dominants and should have heights similar to the top height of the plot.

(*b*) They must not be forked.

Where only a sample of the thinnings has been measured, the trees for height analysis should be chosen from the sample, if possible.

(63) The measurements for each tree will be recorded on the Height Analysis of Sample Trees Form (Sample Plot Form No. 5) and the procedure is as follows :

(*a*) Holding the 4 feet 3 inches mark on the tape against the breast-height girth band, measure and record the present height of the tree and its height 3, 6, 9, etc., years ago, down to the point on the stem where shoot growth becomes indistinct, recording the heights to the nearest foot.

(*b*) Cross-cut the stem at this point, and cut the remainder of the log into sections of from 5 to 12 feet long, depending on local utilisation requirements. Record, at each cut, the height above ground level and the number of annual rings.

(*c*) The age at each cut is found by subtracting the number of rings counted from the *age of the crop*. There may be a difference between the number of rings counted at the butt, and the age of the crop, because of the age of the plants at the time of planting.

Selection of Trees for Height Measurement

(64) The heights of about 40 trees will be measured in all *un-numbered* and in *numbered* plots at all full measurements, and at certain specified intermediate measurements (see para. 41). The procedure for selecting these trees is described in paras. 65 and 66 below. The heights will be measured by either rods or hypsometer, and recorded to the nearest foot in the height column on the Girthing Sheet (Sample Plot Form No. 3a), the entry being made on the appropriate line for girth. The height recorded will be the vertical distance between the base of the tree and its tip. It may, however, be more convenient to record the height measurements on a rough sheet in the first instance, especially when an Abney level is used, or in wet weather, and to transfer them later to the Girthing Sheet. If this is done, the rough sheet will not be destroyed until the next measurement of heights in the sample plot.

(65) In plots where the main crop trees have not been numbered, every *n*th tree, working systematically backwards and forwards along the planting rows or contours, excluding thinnings, will be measured. "*n*" is determined by dividing the number of main crop trees (i.e. excluding thinnings) of 4 inches girth and over by 40. Counting from one corner of the plot, the first tree to be measured will be determined by dividing the quotient "*n*" by two, subsequent trees will be selected at intervals of the quotient. For example, if there are 328 trees of the main crop of 4 inches girth and over in the plot, the quotient is $328 \div 40 = 8{\cdot}2$, which is taken as 8, and the heights of the 4th, 12th, 20th, 28th tree etc., will be measured. If the quotient is an odd number, it should be increased to the next even number before dividing it by two.

(66) In plots where the main crop trees have been numbered, the sample will be chosen from the half-inch classes on the Girthing Sheet (Sample Plot Form No. 3a). Sampling starts from the smallest girth class represented, and continues in ascending order of girth. The trees to be measured will be underlined as shown in the example in Appendix IX, and the heights will be recorded in the height column so that they refer to the selected trees. The principle of sampling is similar to that used in un-numbered plots, except that the sample of approximately 40 trees is chosen in a way which ensures that a fairly high proportion of the largest girthed trees in the plot are included ; this is to facilitate the determination of the top height. The sampling fraction is determined by dividing the number of main crop trees of 4 inches girth and over by *30*, and the quotient "*n*" determines the interval at which samples will be taken. Counting from the smallest girthed tree on the Girthing Sheet, the first tree to be measured will be determined by dividing the quotient "*n*" by two, subsequent trees will be selected at intervals of the quotient. In addition to these trees, the heights of the *ten* largest girthed trees in the plot will also be measured, these may include trees already selected for measurement in the systematic sample of 30.

Selection and Measurement of Sample Trees for Determining the Main Crop Volume

(67) As explained in paragraphs 40 and 41, the volume of the standing crop will normally only be determined in plots where the main crop trees have been numbered. Only in exceptional cases will it be asked for in other plots but, in either case, the method of selecting the sample trees will be the same.

(68) In *numbered* plots the ten sample trees for volume assessment will be chosen from the systematic sample of 30 trees measured for height. The first volume sample tree will be the second tree measured for height, and every third tree thereafter (excluding any of the ten largest girthed trees if they were not included in the sample of 30). If the first volume sample tree, by this method, has a girth of less than 8½ inches, the first tree measured for height in the 8½-inch girth class or above will then become the first volume sample tree, and the interval between sample trees adjusted so as to get a sample of ten. Where there are less than 30 trees in a plot, the sampling fraction will be increased to give at least ten sample trees. Thinnings are excluded from height measurement and will therefore also be excluded as sample trees. No sample tree will be rejected on account of its size or form, but if a sample tree is either very much better or worse than the majority of trees in the plot, a remark to this effect should be made on the Measurement of Sample Trees Form (Sample Plot Form No. 4).

(69) Sample trees will be measured to timber height either by climbing or by the use of a dendrometer. A dendrometer will be used where it will save time or where climbing is unsafe. When a dendrometer is not available, the sample trees will be climbed as far as it is safe and practicable to do so. The measuring and recording procedure will vary according to which method is used (paras. 70, 71 and 72).

(70) Where sample trees are climbed to timber point, measurements will be recorded on the Measurement of Sample Trees Form (Sample Plot Form No. 4) as follows :

(*a*) *Heights* recorded to the nearest foot (all heights will be measured from the breast-height girth mark and 4 feet 3 inches added).

(i) Total height (by hypsometer or rods).
(ii) Timber height.
(iii) Lower Crown.
(iv) Upper Crown.

(*b*) *Crown diameter* measured to the nearest foot. The points to which measurements are taken are judged by eye.

(*c*) *Girths* measured over-bark to the nearest half-inch at the mid-points of the sections to timber height. The sections will normally be 10 feet, but as in the case of thinnings, the lengths of sections will be increased if there are "stops" or odd lengths below timber point (see para. 57 (*c*)). The only difference between the measurement of thinnings and of sample trees is that branchwood is not measured on broad-leaved sample trees.

(*d*) *Bark thickness* will be measured at the points of girthing of the sections (as is explained in

para. 57 (*e*)) on all species *except* Scots pine, Corsican pine, European larch, Japanese larch, Norway spruce, Sitka spruce and Douglas fir. (These species are omitted because sufficient data has already been collected.)

(71) Where sample trees are climbed to a point below timber height, measurements will be taken and recorded on the Measurement of Sample Tree Form (Sample Plot Form No. 4) as follows :

(*a*) *Heights*, as in para. 70, except that the position of timber point will be estimated ; the height to this point, and also to upper crown and lower crown, if not reached by climbing, will be measured by hypsometer or rods and recorded to the nearest foot.

(*b*) *Crown diameter*, as given in para. 70.

(*c*) *Girths*, measured over bark to the nearest half-inch at 5-foot intervals from ground level, i.e. at 5, 10, 15, 20, etc. feet as far as measurement is safe and practicable (see example, Appendix V). The estimated girth at timber point will be recorded if it exceeds 9½ inches.

(*d*) No bark measurements will be taken.

(72) Where sample trees are measured by dendrometer instead of by climbing, measurements will be recorded on Measurement of Sample Trees by Dendrometer Form (Sample Plot Form No. 4b).

The measurements will be similar to those given in para. 70 except that under the dendrometer procedure no bark measurements will be taken, and the sections will not be of equal length (see Appendix IV). (The heights of lower and upper crowns may be measured by height rods, hypsometer or dendrometer, and will be recorded to the nearest foot. These measurements and also crown diameter will be recorded on Sample Plot Form No. 4.)

Subsidiary Species

(73) Where subsidiary species occur in a plot in insufficient numbers for the crop to be classed as a mixture, they will be girthed and classified, and all thinnings will be measured in accordance with the procedure given in paras. 42–59. In addition, it may be necessary to measure all, or a sample, of the subsidiary species for height and/or volume. If a sample is measured, the methods of selecting the trees and measuring them will follow those outlined in paras. 64–72 ; but the actual size of the sample will be left to the discretion of the party leader. The sample trees used to estimate the volume of the subsidiary species will only be measured over bark. Alternative methods for calculating the volume of the subsidiary species by means other than measuring sample trees are given in paras. 108, 109 and 110. The volume of subsidiary species will only be calculated when the volume of the main species is calculated, i.e. at *full measurements*.

Pruning

(74) Selected trees in sample plots will be pruned if the average breast-height girth of the 100 largest trees per acre in the plot is less than 18 inches. Dead or moribund branches only will be pruned, and branches will be cut as close as possible to the stem and at right angles to it. Trees will not normally be pruned in sample plots thinned to a B grade. Except in those plots for which special instructions have been issued (e.g. sample plots in spacing experiments), pruning in both conifer and hardwood sample plots will be as follows :

First pruning : about 200 stems per acre pruned to 14 feet at a top height of 30–35 feet.

Second pruning : about 150 stems per acre pruned to 20–24 feet at a top height of 40–45 feet. These stems will be selected from those already pruned.

At subsequent measurements any epicormic shoots growing on the pruned stems will be removed, and their frequency and the fact that they have been removed will be recorded.

Pruning in sample plots will not normally be taken beyond 24 feet and no pruning will normally be done after the crop has reached a top height of 45 feet.

The fact that a tree has been pruned will be recorded in the remarks column of the General Register (Sample Plot Form No. 3). The height to which pruning has been done, and the number of trees pruned per acre, will be recorded on the Description Sheet (Sample Plot Form No. 2a or 2b).

Plot Maintenance

(75) When the prescribed silvicultural treatment has been applied, and the plot has been measured, any other necessary maintenance work such as the clearing of drains will be done.

Final Check

(76) When all the field work has been completed, a check will be made to ensure that no item has been omitted and that all the data are complete, correct and legible. In particular will it be necessary to see that the number of standing trees in the plot tallies with that recorded in the General Register and the Girthing Sheet.

Chapter 5

COMPUTATIONS AND RECORDS

Calculation of Basal Area and Mean Girths

(77) In *un-numbered* plots, girths will have been recorded directly on to the Girthing Sheet (Sample Plot Form No. 3a), while in *numbered* plots, they will have been first recorded in the General Register (Sample Plot Form No. 3) and thence transferred to the Girthing Sheet for counting the number of trees in each half-inch girth class. (See para. 45 and 47.)

Where the Girthing Sheet has become too soiled to be kept as part of the permanent record, and has to be copied, it will only be necessary in *un-numbered* plots to copy the total number of standing trees and thinnings in each girth class on to the new form. In *numbered* plots, the numbers of the individual trees will be re-copied, this may be done in pencil, but the totals, basal areas and tree heights will be recorded in ink.

(78) At *full measurements*, the calculation of the main crop basal area will be made on the Volume Calculation Sheet (Sample Plot Form No. 6), the number of trees in each girth class being transferred from the Girthing Sheet to the Volume Calculation Sheet and recorded in ascending order of girth. No entries will be made in the main crop basal area column on the Girthing Sheet. At *intermediate measurements*, the calculation of the main crop basal area will be made in the column provided on the Girthing Sheet and the Volume Calculation Sheet will not be used.

(79) In order to keep a separate record of the 100 largest girthed trees per acre (for example in a plot of 0·354 acre there will be 35 trees in that group), it may be necessary to split one of the girth classes. The beginning of the group of the 100 largest trees per acre will be indicated on the Girthing Sheet by an oblique stroke, and, on the Volume Calculation Sheet, by leaving a space of two lines immediately above the group. This group should never occur on two forms, and, if necessary, should be placed on a separate sheet.

(80) The total basal area of the trees in each girth class of 4 inches and over will be obtained from decimal hoppus tables, using the Commission's Research Branch edition, in order to enable the basal areas to be recorded to three places of decimals. It will be entered in the appropriate column on either the Volume Calculation Sheet or the Girthing Sheet, depending on whether the measurement is *full* or *intermediate*. The basal areas will be recorded correct to three places of decimals.

(81) The total basal area of the plot is found by adding together the basal areas in all the girth classes. The mean basal area of the plot will be calculated correct to *three* places of decimals and will be obtained by dividing the total basal area of the plot by the number of trees of 4 inches girth and above. The girth corresponding to this mean basal area (i.e. the mean girth of the plot) will be recorded correct to the nearest half-inch. At *full measurements*, it is necessary to calculate separately the mean basal area of all trees of $8\frac{1}{2}$ inches girth and over, for purposes of volume calculation (see para. 105).

(82) In addition to the above calculations, the total basal area, mean basal area and the mean girth (to the nearest half-inch) of the 100 largest girthed trees per acre will be calculated. At *full measurements* they will be recorded in the space provided on the volume calculation sheet. At *intermediate measurements* they will be recorded on the Girthing Sheet either on the front of the form if there is room or, if not, on the reverse of the form.

(83) The total basal area, mean basal area and mean girth (to the nearest half-inch) of the thinnings will be calculated on the Girthing Sheet (Sample Plot Form No. 3a) in the same way as for the main crop (paras. 79–80) and transferred to the summary made on the Thinning Sheet (Sample Plot Form No. 4a). (See para. 90.) Where a sample of thinnings is measured, it will be necessary to calculate separately the total basal area of all trees of $8\frac{1}{2}$ inches girth and over for purposes of volume calculation (see para. 88).

Tree Classification

(84) A table will be prepared on Sample Plot Form No. 3b, showing the number and percentage of trees in each canopy, stem and crown class before thinning, removed in thinning, and main crop after thinning. Percentages will be recorded to the nearest whole number. At *intermediate measurements* this will only be prepared for thinnings, except in thinning series where both main crop trees and thinnings are classified.

Calculation of Thinning Volumes

(85) The following information for each thinning will have been recorded in the appropriate columns on Sample Plot Form No. 4a :

Tree number ;

Breast-height girth ;

Total height ;

Timber height ;

Lengths of sections (normally 10 feet except for the last section).

Girth overbark at the mid-points of these sections. At *full measurements*, but not at *intermediate measurements*, the under-bark girth will also have been measured.

Where all the thinnings are numbered they will be recorded in numerical order.

(86) The volume of each thinning will be calculated by sections, the sectional volumes being determined from decimal hoppus tables (Research Branch edition). Volumes will be recorded correct to two decimal places. The total volume of each tree is the sum of the sectional volumes. In thinnings where " stops " occur, the volume of the butt length is always shown first and the total volume of each log length will be shown separately for each tree as well as the total stem-wood volume (see example in part B of Appendix IX, page 89). The volume of branchwood in hardwoods may be calculated in the Remarks column of Sample Plot Form 4a as shown in this example, or if more convenient it may be calculated on a separate sheet.

(87) In plots where *all the thinnings* have been measured, the total thinning volume will be the sum of the over-bark volumes of the individual thinnings. The volume of branchwood in hardwoods will be shown separately and will not be included in the stem-wood volume of the thinnings.

(88) In plots where *only a sample of the thinnings* has been measured, the total volume of thinnings will be estimated by a proportional basal area calculation as follows :

(*a*) The total basal area of the sample thinnings will be calculated.

(*b*) The total over-bark volume of the sample thinnings will be calculated.

(*c*) The total basal area of all the thinnings in the plot of 8½ inches girth and over will be obtained from the Girthing Sheet (Sample Plot Form 3a). (See para. 83.)

(*d*) The estimated over-bark volume of thinnings in the plot is then :

$$V_t = \frac{v_t \times G_t}{g_t}$$

Where V_t = Estimated over-bark volume of all the thinnings.

v_t = Volume of the sample thinnings.

G_t = Basal area of all thinnings of 8½ inches girth and over.

g_t = Basal area of the sample thinnings.

This calculation will be shown on the Thinning Sheet (Sample Plot Form No. 4a).

(89) At *full measurements* the under-bark volumes of the thinnings will also be calculated and totalled, and the average bark per cent determined as follows :

Average bark per cent of thinnings =

$$\frac{\text{Total over-bark vol.} - \text{Total under-bark vol.}}{\text{Total over-bark volume}} \times 100$$

Calculated correct to the nearest *half* per cent.

(90) A summary will be made on the thinning sheet giving the following information :

(*a*) *Where all the thinnings are measured*, record :—

Total number of thinnings, of 4 inches girth and over, obtained from the Girthing Sheet (Sample Plot Form No. 3a).

Total volume over bark.

Total volume under bark (at *full measurements* only).

Bark per cent.

Total basal area, Average basal area, Average girth } Transferred from the Girthing Sheet. (See para. 83.)

In addition, in hardwood plots the total volume of branchwood will be shown separately from the stem-wood volume.

(*b*) *Where only a sample of the thinnings is measured*, the summary is as in para. (*a*) above except :

Total number of thinnings, from the Girthing Sheet (Sample Plot Form No. 3a). To avoid confusion the number of thinnings in the sample should not be recorded in the summary.

Total estimated volume over-bark (from the calculation given in para. 88 (*d*) above).

Total volume of sample thinnings over bark.
Total volume of sample thinnings under bark (at *full measurements only*). } Record at foot of appropriate columns on the thinning sheet.

(91) The mean height of the thinnings will not normally be calculated, but when it is required, the arithmetic mean height of all the thinnings measured will be calculated.

Height

(92) In *un-numbered plots*, the mean height will be the arithmetic mean height of the 40 measured trees. The mean height will be recorded to the nearest *half-foot*.

Top height will be calculated from the mean height by the following formula :

$$h_{dom} = \left(\frac{\bar{x}' \times w}{4 \cdot 32}\right) + \bar{h}$$

Where h_{dom} is the top height.

w is the range of measured heights.

$\bar{h}$ is the mean height, and

$\bar{x}'$ is the value read from Table 3 below, with interpolation where necessary, corresponding to :

$$\frac{100}{\text{No. of main crop trees per acre}}$$

TABLE 3

$\frac{100}{\text{No. of main crop trees per acre}}$	$\bar{x}'$
·500	0·79
·460	0·85
·421	0·92
·382	0·99
·345	1·06
·309	1·13
·274	1·20
·242	1·28
·212	1·35
·184	1·43
·159	1·51
·136	1·59
·115	1·67
·097	1·75
·080	1·83
·067	1·91
·055	1·99
·045	2·07
·036	2·16

e.g. Mean height = 25 feet. Range of heights = 35·5 − 17 = 18·5 feet.

No. of main crop trees per acre = 1,197.

$$\therefore \frac{100}{1{,}197} = \cdot 084.$$

From Table 3, $\bar{x}'$ corresponding to ·084 = 1·81.

$$\therefore \text{ top height} = \left(1 \cdot 81 \times \frac{18 \cdot 5}{4 \cdot 32}\right) + 25 = 33 \text{ feet.}$$

(The above formula is derived from probability tables of the normal distribution, the standard deviation being estimated from the standard deviation/range ratio for 40 trees.)

(93) In *numbered* plots the heights of the 40 trees will be plotted over their basal areas, and a mean line drawn through the points. Where the points are very scattered, so that it is difficult to draw the line, the heights may be grouped, and the mean height and mean basal area of each group plotted. Normally, there will be five trees in each group, but all the trees in any one girth class must be placed into the same group. The points representing the *group means* will be differentiated on the graph by using a different symbol from the one used for the *individual trees* ; the number of trees in each group will be recorded to enable the weighting of the points to be taken into account in drawing the line.

(94) In *numbered plots*, the mean height of the plot is the height corresponding to the mean basal area of the plot, as read from the graph ; and the top height is the height corresponding to the mean basal area of the 100 *largest* trees per acre. These heights will be recorded on the Volume Calculation Sheet (Sample Plot Form No. 6) at *full measurements* ; at those *intermediate measurements* at which heights are measured they will be recorded directly into their respective columns on the Final Summary Sheet (Sample Plot Form No. 7). Both top height and mean height will be recorded to the nearest *half-foot*. At the first *full measurement* of a plot that was previously *un-numbered*, the graphical mean height of the *previous* measurement will be obtained in the manner explained above, and entered in brackets above the arithmetic mean height on the Final Summary Sheet (Sample Plot Form No. 7).

Height Analysis Graph

(95) The data recorded on the Height Analysis of Sample Trees Sheet (Sample Plot Form No. 5) will be plotted on to a height-age graph. The points for each tree will be joined by straight lines and coloured inks will be used to differentiate between the three trees.

On a separate graph, the mean line will be drawn by determining the mean height of these three trees at five yearly intervals. The final point on the graph should correspond to the top height of the crop, if the trees have been chosen correctly. If it does not, the mean line will be extended to the height corresponding to the top height of the crop, by a dotted line.

Volume Calculation of Sample Trees

(96) The method of calculating the volume of each sample tree depends on which of the methods of measurement described in paras. 69 to 72 was used.

(*a*) *Sample trees climbed to timber point.* The volume of each sample tree will be calculated by sections, the sectional volumes being determined from decimal hoppus tables

(Research Branch edition) and recorded to two decimal places as has been described for thinnings in para. 86.

(*b*) *Sample trees climbed to a point below timber point.* The volume of each sample tree will be calculated in ten-foot sections as far as measurements are available. The sectional areas in the upper portion of the stem, which has not been climbed, will be estimated by the method described in Appendix V.

(*c*) *Sample trees measured by Dendrometer.* The volume of each tree will be calculated on Sample Plot Form No. 4b by the method described in Appendix IV, and the total volume of each tree will be transferred to Sample Plot Form No. 4.

Other Calculations on Sample Trees

(97) The calculations in paras. 98 and 102 will be made on all sample trees ; the calculation in para. 101, however, is only applicable when the sample trees have been climbed to timber point and then only on certain species (see para. 70 (*d*)). The resulting percentages and form factors will be recorded in the appropriate columns of the Measurement of Sample Tree Sheet (Sample Plot Form No. 4).

(98) The crown per cent of each sample tree =

$$\frac{\text{Total height} - \frac{1}{2}\,(\text{lower crown height} + \text{upper crown height})}{\text{Total height}} \times 100$$

Calculated correct to the nearest *one* per cent.

(99) The average crown per cent of all the sample trees =

$$\frac{\text{Sum of the crown per cents of the sample trees}}{\text{Number of sample trees}}$$

Calculated correct to the nearest *one* per cent.

(100) The bark per cent of each sample tree =

$$\frac{\text{Volume over bark} - \text{Volume under bark}}{\text{Volume over bark}} \times 100$$

Only applicable when the sample trees have been measured both over bark and under bark ; it is not calculated for sample trees climbed to a point below timber point or for those measured by dendrometer. Calculated correct to the nearest *half* per cent.

(101) The average bark per cent =

$$\frac{\text{Total volume, sample trees over bark} - \text{Total volume, sample trees under bark}}{\text{Total volume of sample trees over bark}} \times 100$$

Calculated correct to the nearest *half* per cent.

(102) The form factor of each sample tree will be calculated irrespective of the method of measurement used. The form factor of each sample tree =

$$\frac{\text{Total volume over bark}}{\text{Sectional area at breast height} \times \text{total height}}$$

Calculated correct to three places of decimals.

(103) The average crown per cent and average bark per cent of the sample trees, as described in paras. 99 and 101 above, will be accepted as the average crown and average bark percentages of the crop. The average form factor of the crop will, however, be calculated in a different manner which is explained in para. 106 below.

Calculation of Main Crop Volume

(104) The over-bark volumes of the ten sample trees will be plotted against their respective basal areas, and the linear regression line will be drawn through these points by Keen's method which is described in Appendix VI. When the regression line drawn by Keen's method does not, by inspection, appear to fit the plotted points, the regression line will be calculated by the method of least squares. In such cases, the data may be referred to the Mensuration Officer at Alice Holt or Edinburgh where the computation can be done mechanically.

(105) The volume corresponding to the mean basal area of all trees of 8½ inches girth and over will be read from the graph and recorded correct to 0·01 hoppus feet in the appropriate space on the Volume Calculation Sheet (Sample Plot Form No. 6). This volume multiplied by the number of trees in the plot, of 8½ inches girth and above, will give the total volume of the plot.

Calculation of Main Crop Form Factor

(106) The main crop form factor (i.e. the average form factor of the standing crop) =

$$\frac{\text{Total main crop volume over bark}}{\text{Mean height of main crop} \times \text{total basal area of main crop (all trees over 4 inches)}}$$

Calculated correct to three places of decimals.

Calculation of Volume of Missing Trees

(107) If on remeasuring a plot, it is found that there are trees missing, e.g. windblown trees removed without the knowledge of the Research Branch, the procedure will vary according to whether the measurement is "*full*" or "*intermediate*".

(*a*) *Full measurement :* the volume of each tree missing at a *full measurement* will be estimated from the current main crop volume-basal area graph, using the last recorded girth of each missing tree.

(*b*) *Intermediate measurement :* the volume of trees missing at an *intermediate measurement* will be estimated either :

(i) by using a proportional basal area calculation, i.e. Estimated volume of missing trees =

$$\frac{\text{Total over-bark volume of thinnings} \times \text{Total basal area of missing trees}}{\text{Total basal area of thinnings}}$$

or (ii) by estimated the volume of each missing tree from the previous main crop volume/basal area graph.

The choice between the methods *b* (i) and *b* (ii) is left to the discretion of the party leader, as the suitability of each method depends on circumstances such as the number of trees that are missing, the number of years since the last full measurement, and the rate of growth of the crop.

Subsidiary Species

(108) The basal areas and mean girths of the subsidiary species will be calculated in the same way as for the main species, paras. 78, 80, 81 and 83 and the volume of thinnings as in paras. 86–88.

(109) The height and volume of the subsidiary species remaining in the standing crop may be estimated by one of five methods. The choice of method will depend on the number and importance of the subsidiary species, and it will be left to the discretion of the party leader to use the one he considers most appropriate. Where the subsidiary species are of minor importance only, and comprise small trees likely to be removed in the next two or three thinnings, *no* estimate will be made of their height or volume. The method used will be stated on the Description Sheet (Sample Plot Form No. 2a or 2b).

(110) The methods can conveniently be placed in two sections.

Using standing sample trees of the subsidiary species. The over-bark volumes of these trees will be calculated in the same way as those of the main species (para. 96).

(i) All standing trees will be measured for volume and height. The volume of the subsidiary species will be the sum of the volumes of the individual trees ; the average height will be the arithmetic mean of the heights.

(ii) The volume of the subsidiary species will be estimated by proportional basal area adjustment using the formula :

$$V_s = \frac{v_s \times G_s}{g_s}$$

Where V_s = Estimated standing volume of subsidiary species.
v_s = Volume of standing sample trees.
G_s = Basal area of the standing trees of the subsidiary species of $8\frac{1}{2}$ inches girth and over.
g_s = Basal area of the sample trees.

The average height will be the arithmetic mean height of the sample trees.

(iii) The volume and mean height of the subsidiary species will be obtained graphically in the same way as the main species (see paras. 93, 94, 104 and 105).

Not using standing sample trees of the subsidiary species. With these methods no estimate is made of the height of the subsidiary species.

(iv) The volume will be estimated from the volume/basal area graph of the main species.

(v) The volume will be estimated by a proportional basal area calculation, using all the thinnings of the species as sample trees. The formula to be used is the same as the one given in (ii) above, substituting thinnings in the place of the standing sample trees.

Record of Periodical Measurements

(111) A summary of all measurements will be recorded on Sample Plot Form No. 7, in which all plot totals are converted to their *per acre* equivalents. The headings to this form, plot number, species, thinning grade and acreage are all self-explanatory, and the details for these headings will be transferred from the Description Sheet (Sample Plot Form No. 2a or 2b). Any alteration to the thinning grade or plot area will be shown under these headings, and the date of the change recorded. The heading relating to quality class will be completed only for those species for which British yield tables have been prepared.

(112) In mixtures and under-planted plots, a separate sheet will be used for each species, and an additional Summary Sheet prepared giving the total number of stems, basal areas and volumes for all species combined. Where subsidiary species occur in a plot in insufficient numbers for it to be classed as a mixture, they will be recorded on the same sheet as the main species but on separate lines, and at each measurement the totals of the main and subsidiary species will be given.

(113) Where, on establishment of a sample plot, it is found that the crop has been previously thinned, the information on these early thinnings will normally be available from local records and will already have been recorded on the Pre-establishment Form (Sample Plot Form No. 2). The total volume per acre of all these previous thinnings, the number of trees and years in which the thinnings were carried out, will be entered in the appropriate columns on the Summary Sheet.

If the crop has been thinned, but no details of the volume are available, the fact that the crop has been previously thinned will be entered on the Summary Sheet, giving the years when the thinnings were made, if known.

The basal area and volume of these past thinnings will be estimated by measuring stump diameters if there is good reason to assume that the stumps of the previous felled trees, together with the trees standing in the plot, represented the complete stocking before any thinnings were made. This estimate will only be made if the majority of stumps are sufficiently sound to enable reliable diameter measurements to be made. The full procedure is given in Appendix VII. These entries will be made on the first line or lines of the Summary Sheet before the entry for the first measurement of the sample plot.

(114) The items recorded in the summary are given below ; the per acre figures are obtained by dividing the relevant plot data by the plot area.

(*a*) *Month and year of measurement.*

(*b*) *Age of crop :* copied from the Description Sheet (Sample Plot Form 2a or 2b) (see paras. 36 (15) and 38 (3)).

Main Crop (including the 100 largest trees per acre).

(*c*) *Number of trees per acre :* calculated from the total number of trees in the plot as shown on either the Volume Calculation Sheet (Sample Plot Form No. 6) at *full measurements* or the Girthing Sheet (Sample Plot Form No. 3a) at *intermediate measurements.* The number of trees are recorded correct to the nearest *one tree per acre.* The sum of the number of stems per acre of the main crop and the number of thinnings removed since the last measurement, should equal the number of main crop trees at the previous measurement.

(*d*) *Average height of 100 largest trees per acre (top height) and average height of main crop :* these will be copied from the Volume Calculation Sheet (Sample Plot Form No. 6) at *full measurements.* If heights have been measured at intermediate measurements they will be entered into their respective columns directly from the graph (para. 94), or if the plot was un-numbered, from the calculations given in para. 92. Both top height and mean height will be recorded correct to the nearest *half-foot.*

(*e*) *Average girth of 100 largest trees per acre and average girth of main crop :* these will be copied from the Volume Calculation Sheet at *full measurements* and from the Girthing Sheet at *intermediate measurements.* The average girths are recorded correct to the nearest *half-inch.*

(*f*) *Basal area per acre :* calculated from the total basal area of the plot shown on the Volume Calculation Sheet at *full measurements* and on the Girthing Sheet at *intermediate measurements.* Basal area per acre is calculated correct to one place of decimals.

(*g*) *Form factor :* copied from the Volume Calculation Sheet and recorded to three places of decimals.

(*h*) *Volume per acre (over bark) :* calculated from the total volume of the plot as shown on the Volume Calculation Sheet and recorded correct to the nearest hoppus foot.

At *intermediate measurements* an estimate of the main crop volume will be made and recorded in *pencil.* The choice of method will be left to the discretion of the party leader, who will use whichever of the following three methods appears most appropriate.

(*a*) Multiply the product of the present mean height and basal area per acre by the previous form factor.

(*b*) Multiply the present basal area per acre by the previous form factor and the *estimated* mean height at the current measurement.

(*c*) Use the tariff number applicable to the thinnings to obtain an estimate of the present standing volume.

Note : The previous form factors should not be used to estimate the volume if the top height of the crop at the previous measurement was less than 40 feet.

(*i*) *Crown per cent :* } The average crown and bark per cent of the sample trees copied from the Measurement of Sample Trees Sheet (Sample Plot Form No. 4).

(*j*) *Bark per cent :* }

Thinnings

The following data are all copied or calculated from the summary on the Thinning Sheet (Sample Plot Form No. 4a) :

(*k*) *Number of trees :* calculated correct to the nearest tree per acre.

(*l*) *Average girth :* recorded correct to the nearest *half-inch.*

(*m*) *Basal area per acre :* calculated correct to one place of decimals.

(*n*) *Volume per acre (over bark) :* calculated correct to one hoppus foot.

Total Crop

(*o*) *Total basal area production :* the sum of the main crop basal area and the cumulative total of all thinning basal areas to date, recorded to one decimal place.

(*p*) *Total volume production :* the sum of the main crop volume and the cumulative total of all thinning volumes to date, recorded to one hoppus foot.

At *intermediate measurements* this volume will be entered in *pencil* because the main crop volume will have been estimated.

Increment

(*q*) *Periodic annual basal area increment :* the total crop basal area at the present measurement, less the total crop basal area at the previous measurement, divided by the difference in age (in whole years), and recorded correct to one place of decimals.

(*r*) *Periodic annual volume increment :* the total crop volume at the present measurement, less the total crop volume at the previous measurement, divided by the difference in age (in whole years), and recorded correct to one hoppus foot.

At *intermediate measurements* the periodic annual volume increment will be calculated over the period since the last *full measurement* and will be recorded in pencil.

(*s*) *Mean annual volume increment :* the total volume production to date divided by the age of the crop (in whole years), and recorded correct to one hoppus foot. This will only be calculated when the volume of all thinnings removed to date is known. At *intermediate measurements* it will be entered in pencil.

Records

(115) The records relating to each plot will be kept in a separate file.

(116) The sequence of forms in each file will be as follows :

(*a*) *Route maps* (see para. 20).

(*b*) *Plan of plot*, Sample Plot Form No. 1.

(*c*) *Pre-establishment data*, Sample Plot Form No. 2.

(*d*) *Description on establishment*, Sample Plot Form No. 2a, and any detailed treatment instructions.

(*e*) *Soil description*, Sample Plot Form No. 2c : the soil description on establishment, plus any subsequent detailed descriptions.

(*f*) *Description at remeasurement*, Sample Plot Form No. 2b : the first description after establishment, and all subsequent descriptions for which a separate Form 2b is used.

(*g*) *General Register*, Sample Plot Form No. 3. The original general register and any subsequent registers that are required.

(*h*) After the General Register, the Sample Plot Forms Nos. 3a–6 and the graphs relating to any one remeasurement will be kept together, the forms being in their numerical sequence with the graphs following after Form 6.

(*i*) *Record of Periodical Measurements per Acre*, Sample Plot Form No. 7. This form will be kept right at the back of the file, following the data for the last measurement.

(117) As explained in paras. 36 (21) and 38 (13) inspection notes will be entered under remarks in the current Description Sheet. If, however, there are lengthy inspection notes, correspondence relating to disease or treatment, etc., these will be filed with the Description Sheets in front of the file.

Appendix I

LIST OF EQUIPMENT

This list of equipment is based on the requirements of a sample plot party of three members :

Item	Number	Item	Number
Hypsometer	1	Axes	2
Tapes, linen, 100 feet	2	Slasher	1
Tapes, linen, 50 feet	3	Hooks, bill	2
Tapes, steel, girthing	3	Saws, bow	1
Gauges, bark	2	Saws, cross cut	1
Compass, prismatic	1	Saws, pruning	2
Rule, steel, 12 inches	1	Spade	1
Rule, slide, circular	1	Belts, climbing	1 or 2
Rule, slide, flat	1	*Dendrometer	1
Rule, flexible, 18 inches	1	*Ladders	20–50 feet
Protractor	1	*Rods, height	40–50 feet
		*Tape, steel, surveying, 100 feet, scaled in feet and links	1
Maps, scale 1/625,000 (10 miles to 1 inch) :		*Chain, surveyors (Gunter's), 66 feet	1
Rainfall	1	*Arrows, surveyors	10
Geology	1	*Rods, ranging	4
Books :		*Box sextant	1
A Handbook of British Flora	1		
Study of the Soil in the Field by G. R. Clark	1	*Consumable Stores*	
Handbook of Grasses	1	Rule, glass	1
Cases, brief or attaché	1	Stones, carborundum	2
First Aid Kit	1	Files, saw	1
Boxes, tool	1	Timber chalk	†
Haversack	1	Paint, white titanium	†

Notes

* The items marked with an asterisk may not be available in sufficient numbers to be issued permanently to each party, but will be supplied when they are required.

† Quantities as required.

Additional items of equipment, such as timber sword, mattock, cant hook, etc., which may be needed on occasion, can be obtained from the Research Station.

Appendix II

TREE CLASSIFICATION

The object of tree classification is to facilitate precise description of thinning grades and to show how trees change in respect of the characteristics included in the classification as they grow older. The tree classification will usually be applied only to even-aged forest. In two-storied high forest the classification will normally be applied to the upper canopy only ; if classification of the understorey is required it will be treated independently of the upper. Although the classifications are necessarily subjective, as far as possible, the same criteria are applied irrespective of species or grade of thinning. The dominance classification of a tree is relative to those trees immediately surrounding it.

Five systems of tree classification have been used in sample plot work since 1919. The system in current use was introduced in 1932 and is presented first. The other four systems follow, commencing with the first one adopted. They are included in this Appendix as a source of reference and so that the development of the present system can be traced.

(1) PRESENT SYSTEM

(A modification of Schädelin's system, in use 1931–32.)

The present system is a fully numerical system of classification. In it, dead and dying trees have a different classification from living trees. For both living trees and dead and dying trees four canopy and three stem classes are recognized, but crown classification is restricted to living trees. Leaning or diseased trees are placed in their appropriate canopy, stem or crown class and the nature of the defect is recorded in the remarks column of the General Register (Sample Plot Form No. 3). The separate classification for " whips " is no longer used, they are now shown as having bad crowns.

Living Trees

Living trees are classified as follows :

1st digit ..	1, 2, 3 or 4 to denote position in canopy.
2nd digit ..	1, 2 or 3 to denote stem quality.
3rd digit ..	1, 2 or 3 to denote crown shape and size.

The four canopy classes are :

1. Dominant trees.
2. Co-dominant trees.
3. Sub-dominant trees.
4. Suppressed trees.

The three stem classes are :

1. Good stem.
2. Slightly defective stem.
3. Very defective stem.

The three crown classes are :

1. Good crown.
2. Slightly defective crown.
3. Very defective crown.

Class 1. Dominant Trees

These are the tallest and, with the exception of whips, the most vigorous trees in the crop, and usually have a large proportion of their crowns free.

There are nine sub-classes :

111. Trees with good stems and good crowns.
112. Trees with good stems and slightly defective crowns.
113. Trees with good stems and very defective crowns.
121. Trees with slightly defective stems and good crowns.
122. Trees with slightly defective stems and crowns.
123. Trees with slightly defective stems and bad crowns.
131. Trees with very defective stems and good crowns.
132. Trees with very defective stems and slightly defective crowns.
133. Trees with very defective stems and crowns.

Class 2. Co-dominant Trees

These are trees in the upper canopy which they help to complete, but they are below the crown level of the dominants. Some of the better stems will be used to fill up gaps in the canopy.

There are nine sub-classes as for Class 1, i.e. 211, 212, 213, 221, etc.

" Whips ", which are simply shown as having bad crowns may be 113, 123, 133, 213, 223, 233.

TABLE 4

Canopy	1. Dominants			2. Co-dominants			3. Sub-dominants			4. Suppressed			5. Dead and Dying				
Stem ..	1	2	3	1	2	3	1	2	3	1	2	3	Canopy ..	1	2	3	4
Crown ..	123	123	123	123	123	123	123	123	123	123	123	123	Stem	123	123	123	123

Class 3. Sub-dominant Trees

These trees are not in the upper canopy but their leaders still have free access to the light.

There are again nine sub-classes, i.e. 311, 312, 313, 321, etc.

Class 4. Suppressed Trees

These are trees whose leaders have no direct access to light and stand beneath the crowns of adjacent trees.

There are again nine sub-classes, i.e. 411, 412, 413, 421, etc.

Dead and Dying Trees

A dying tree is a tree which, owing to disease or suppression, is unlikely to survive for more than three to five years. These trees are cut out at the first available opportunity as they are liable to harbour insect pests and fungal diseases.

Dead and dying trees are classified differently from living trees because their crowns are ignored in the classification. The classification is as follows :

1st digit .. 5, denotes dead or dying.
2nd digit .. 1, 2, 3, 4, denotes position in the canopy
3rd digit .. 1, 2, 3, denotes stem quality.

There are 12 sub-classes, i.e. 511, 512, 513, 521, etc.

The complete classification for both living and dead trees is given in Table 4.

This present system of classification forms the basis for all other more detailed classifications of stem or crown carried out by other sections of the Research Branch. Additional digits are added to the basic numerals to record any special characteristics such as fluting, spiral grain, stem persistence, crown depth etc. ; each of these special characteristics being split into three or four classes. The division of dominance, stem and crown normally being separated by an oblique stroke when such additional classifications are used.

For sample plot work, the classification of trees is confined to the basic numerals.

PREVIOUS SYSTEMS

(2) The International System (1919–1923)

This system was adopted by the Forestry Commission in 1919, partly on account of its simplicity and partly because it was more generally in use in European research stations. Only two main classes were recognized, the dominant and the dominated trees ; Class 2 of the dominant trees being sub-divided to show the nature of the defect. The classification is shown in full in Table 5.

TABLE 5

I. Dominants and Co-dominants						II. Sub-dominants and Suppressed		
1	2 (Abnormal crown or poor stem)					3	4	5
	a	*b*	*c*	*d*	*e*			
Normal Crown and good stem	Crown adpressed	Deformed top	Crooked stem (especially forked)	Whip	Diseased	Sub-dominants	Suppressed	Dead or Dying

TABLE 6

1. Dominants				2. Co-dominants				3. Sub-dominants		4. Suppressed	5. Dead and Dying	6. Diseased	
a	*b*	*c*	*d*	*a*	*b*	*c*	*d*	*a*	*b*			*a*	*b*
Normal crown and good stem	Slightly defective stem or crown	Very defective stem or crown	Whips	Normal crown and good stem	Slightly defective stem or crown	Very defective stem or crown	Whips	Normal crown and good stem	Defective stem or crown	Suppressed	Dead, Dying bent and Leaning	Dominants and Co-dominants	Sub-dominant and Suppressed

After this classification had been in use for some time it was found that the sub-division into two canopy classes led to much difficulty in placing borderline trees. Schotte (1912) evolved a modified system of classification which recognized four canopy classes, each of which was sub-divided into seven sub-classes founded upon the characters of crown and stem. After several tests, a new system of classification was adopted in 1923.

(3) A Modification of Schotte's System (1923–1927)

This system followed the Swedish system in the division of the canopy into four classes, but differed from it in having fewer sub-classes and also in using separate classes for dead and dying, and for diseased trees.

The full classification is shown in Table 6.

(4) Modification of System No. 3 (1927–1931)

In 1927, a further modification to Schotte's system was introduced by which Classes 1b, 1c, 2b and 2c were subdivided so that the nature of the defect to stem or to crown could be classified. This system was in use to 1931. The full classification is given in Table 7.

(5) An Adaptation of Schädelin's System (1931–1932)

The only differences between this system and the previous one is the further sub-division of the upper canopy layers, Classes 1 and 2. The classification of whips is now related to the stem form and dominance class of the tree instead of forming a separate class related only to dominance.

The full classification is given in Table 8.

This system was only in use for about two years and led to the development of the system in current use.

TABLE 7

1. Dominants								2. Co-dominants								3. Sub-dominants		4. Suppressed	5. Dead and Dying	6. Diseased	
a	*b*			*c*			*d*	*a*	*b*			*c*			*d*						
	1	2	3	1	2	3			1	2	3	1	2	3		*a*	*b*			*a*	*b*
Normal crown and good stem	Slight defect in stem only	Slight defect in crown only	Defects in stem and crown	Slight defect in stem only	Slight defect in crown only	Defects in stem and crown	Whips	Normal crown and good stem	Slight defect in stem only	Slight defect in crown only	Defects in stem and crown	Slight defect in stem only	Slight defect in crown only	Defects in stem and crown	Whips			(Classified as in System No. 3)			

TABLE 8

1. Dominants												2. Co-Dominants												3. Sub-dominants		4. Suppressed	5. Dead and Dying	6. Diseased	
1				2				3				1				2				3									
1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	*a*	*b*			*a*	*b*
Good stem and good crown	Good stem and slightly defective crown	Good stem and very defective crown	Whip. Good stem	Slightly defective stem and good crown	Slightly defective stem and crown	Slighuly defective stem and bad crown	Whip. Slightly defective stem	Very defective stem and good crown	Very defective stem and slightly defective crown	Very defective stem and crown	Whip. Very defective stem	(Classification as for dominants)												(Classified as in System No. 3)					

REFERENCES

FORESTRY COMMISSION (1928). *Growth and Yield of Conifers in Great Britain.* Forestry Commission Bulletin No. 10. H.M.S.O. (Out of print.)

IRVINE, T. W. (1948). *Modifications of Sample Plot Procedure since 1931.* (Unpublished.)

MACDONALD, J. (1931). Sample Plot Methods in Great Britain. *Empire Forestry Review*, Vol. X, No. 2, 1931.

SCHÄDELIN, W. (1931). Uber Klasseneinteilung und Qualifikation der Waldbäume. *Schweizerische Zeitschrift für Forstwesen.* January, 1931.

SCHOTTE, G. (1912). Om gallringsförsök. *Medd. f. Statens Skogsförsöksånstalt*, Hft. 9, pp. 211–269. Stockholm, 1912.

Appendix III

GRADES OF THINNING

Eight grades of thinnings are now recognized in sample plot procedure. Six are classed as low thinnings and two as crown thinnings. These are further described below in this Appendix.

Other types of thinning, such as selection thinning, free thinning and mechanical thinning are not normally used in Sample Plot work and, therefore, have not been described in detail in this appendix, but these three are briefly defined in Appendix XIV.

I. LOW THINNING

(1) **A Grade. Very light low thinning.**

Remove dead and dying trees only. This grade is very rarely used in practice.

(2) **B Grade. Light low thinning.**

Remove diseased, dead and dying, badly-leaning and suppressed trees ; also whips and some sub-dominants below the standard of 311. A plot thinned to this grade is normally used as a control in comparative thinning series.

(3) **C Grade. Moderate low thinning.**

Remove trees as for a B Grade and, in addition, gradually remove all trees of Classes 311 to 333, 221 to 233, together with part of 211 to 213, 113, 123, 131, 132, 133, i.e. gradually remove all sub-dominants, the majority of the defective co-dominants together with part of the good co-dominants and the worst formed of the dominants.

(4) **C/D Grade. Moderately heavy to heavy low thinning.**

Intermediate between a C Grade and a D Grade, this has become the standard thinning grade for single plots in all coniferous species except the larches.

Remove trees as for C Grade and, in addition, an occasional well shaped dominant where dominants are crowded.

(5) **D Grade. Heavy low thinning.**

Remove trees as for a C Grade and gradually, in addition, as many trees as possible in Classes 211, 121, 112, 122, together with some trees in Class 111, i.e., as many as possible of the well shaped co-dominants and defective dominants, together with some of the well shaped dominants. Under this grade there should remain ultimately only trees with normal crown development and well shaped boles distributed as regularly as possible over the ground.

D Grade is the standard thinning grade for single larch sample plots.

(6) **E Grade. Very heavy low thinning.**

This is an exceptionally heavy thinning, introduced in 1947, to be applied to young stands where the canopy has only recently closed. Its purpose is to try and obtain results comparable with those obtained by Craib in South Africa.

The stocking is reduced to about two-thirds of that in a D Grade. The use of the E Grade is at present confined to a limited number of comparative thinning experiments.

With regard to all the above grades, the rule is laid down that the thinning must not be so heavy at any time as to prevent the closing over of the gaps in the canopy within a period of five or at most ten years from the date of the thinning ; suppressed or sub-dominant trees may be left to cover a gap caused by the removal of a tree in the upper canopy classes.

II. CROWN THINNINGS

(1) **L.C. Grade. Light Crown Thinning.**

This is the standard thinning grade for hardwoods with the exception of ash and poplars.

Remove all diseased, dead, dying and leaning trees, all whips, most of the very defective dominants (113, 123, 131, 132, 133), some of the well formed dominants (111) where they are grouped and part of the co-dominants (211 to 233). Most of the suppressed trees (Class 4) and sub-dominants (Class 3) are retained, but the worst stems in these classes may be cut out in order to favour the best. The removal of dominant trees with poor stems or defective crowns may have to be spread over several thinnings to prevent too extensive a breaking of the upper canopy.

(2) **H.C. Grade. Heavy Crown Thinning.**

This grade aims at the rapid development of certain stems ; the best dominants which are to form the main part of the final crop.

Remove trees as for L.C. Grade and, in addition, all other trees in the upper canopy classes which hinder the development of the crowns of the best dominant trees.

TABLE 9

Index of Stocking	Number of stems per acre at height of :					Corresponding Thinning Grade
	30 feet	50 feet	70 feet	90 feet	110 feet	
0·5	605	218	111	67	45	E Grade
0·75	908	326	166	100	68	D Grade
Standard 1·0	1,210	435	222	134	90	C/D Grade
1·5	1,815	652	333	201	135	C Grade

The paragraphs below give certain guides which may be of assistance in the application of the above prescriptions. These are A, basal area and B, numerical guides.

A. BASAL AREA

The basal area remaining after thinning in C/D and L.C. grade plots of all species except the larches should normally be within 10 per cent of the appropriate yield table basal area. The basal area in a D grade should be 20 per cent less. In larch plots, the yield table basal area is the standard for D grades.

For species for which there are no yield tables, and for thinning grades other than those mentioned above, there is as yet no fixed basal area guide. Generally speaking the basal area per acre after thinning should not be lower than the basal area left after the previous thinning, except where early thinnings have been delayed or where for some other reason a change from a lighter grade to a heavier grade of thinning has been prescribed. In the lighter thinning grades, the basal area per acre tends to increase more rapidly than in the heavier grades where, on occasion, there may be no increase at all.

B. NUMERICAL GUIDES

The eight grades of thinning defined above have all been described in terms of tree classes to be removed, and for certain of them, some indication has been given of the basal area of the standing crop after thinning. The following numerical indices may be used as additional guides to supplement, but NOT to replace, the above definitions.

(*a*) Height/spacing ratio

This index is based on the average spacing between trees after thinning expressed as a percentage of top height. For simplicity the indices for the various thinning grades are expressed as fractions of the " standard ", in which the average spacing between trees after thinning is 20 per cent of the top height. The C/D Grade is taken as the " standard ", the number of stems per acre in the C, D and E Grades are respectively 1·5, 0·75 and 0·5 of the " standard "; in terms of percentages the average spacing between trees after thinning is 16, 23 and 28 per cent of the top height respectively. No numerical guide is given for a B Grade, as this grade is used as a control to give the maximum number of trees that can be kept alive in a stand ; no similar numerical guide is as yet available for use with crown thinnings.

Table 9 gives the approximate number of stems per acre that should be reached after thinning for C, C/D, D and E Grades. These are also shown graphically in Figure 1 ; F. G. Wilson, who first recommended the use of the logarithmic stand density sheet (Wilson 1955), has kindly consented to his method of presentation being used.

(*b*) Bole Area (Stand Density Index)

This index is the product of top height, average true girth at breast height and the number of stems per acre, and it gives a measure of the cambial surface or bole area of a stand. It is desirable to divide the product of these three factors by 1,000,000 to obtain a convenient range of values which have been found to range from 0·25 for heavily thinned stands of young larch to 1·2 in lightly thinned stands of shade-bearing species such as spruce. An approximate range of values for each thinning grade is given in Table 10 below.

TABLE 10

Thinning Grade		Bole Area
Low Thinnings	B Grade	1·0–0·8
	C Grade	0·8–0·6
	C/D Grade	0·7–0·5
	D Grade	0·6–0·4
	E Grade	0·4–0·2
Crown Thinnings.. ..	L.C. Grade	0·8–0·6
	H.C. Grade	0·6–0·4

The bole area is used in some thinning experiments in conjunction with the tree classification, for example in spacing experiments, so that a large number of plots, forming one experiment scattered throughout Britain, may be thinned to the same grade and be as closely comparable with each other as possible. The figures for bole area in crown thinnings must be considered as provisional.

REFERENCE

WILSON, F. G. (1955). Evaluation of Three Thinnings at Star Lake. *Forest Science*. Vol. 1, No. 3, September, 1955.

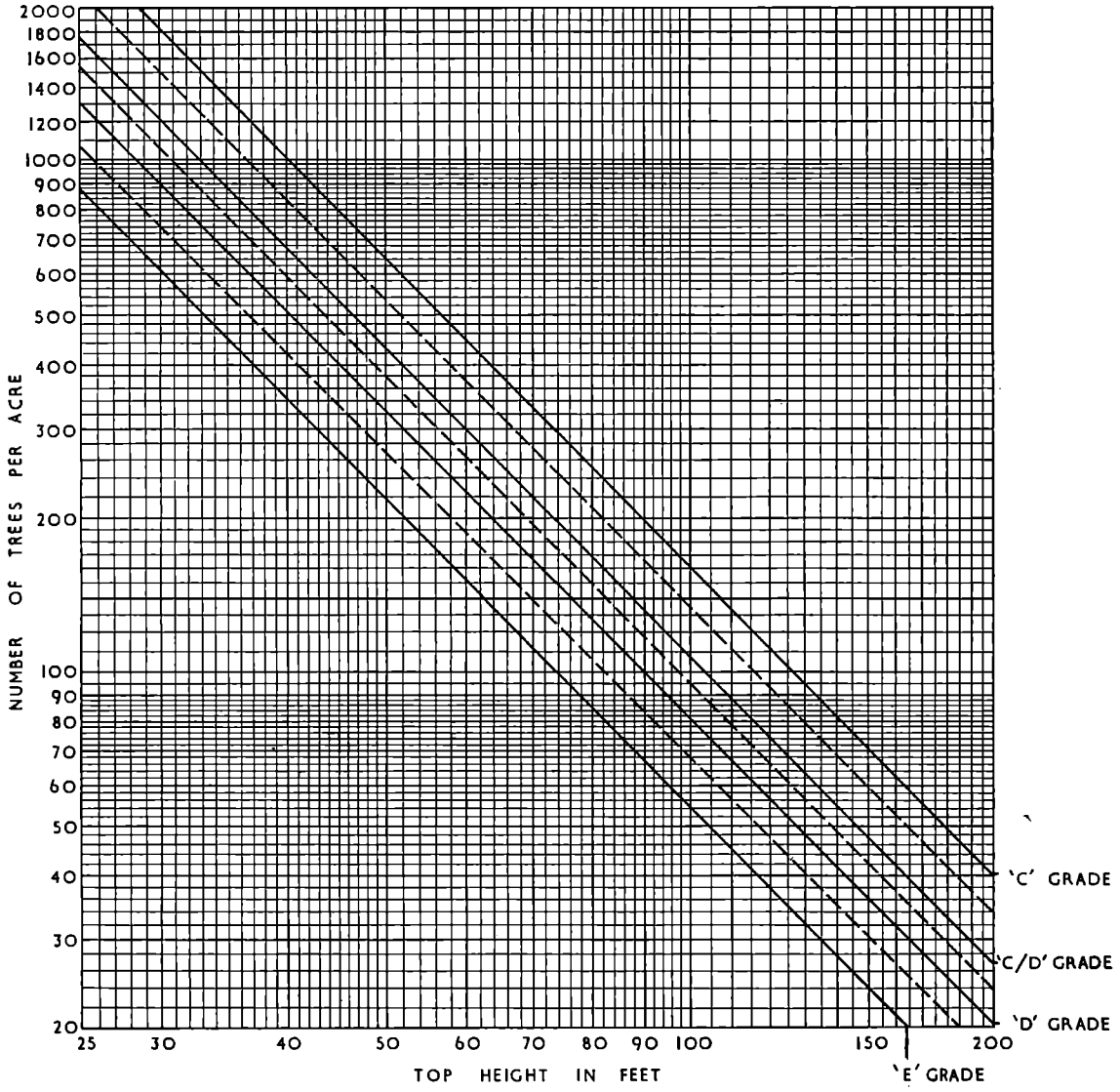

FIGURE 1.

Approximate number of stems per acre after thinning at given top heights for C, C/D, D and E Grades.

Appendix IV

USE OF DENDROMETER FOR MEASURING VOLUMES OF STANDING TREES

The following method has been evolved for using the Barr & Stroud Dendrometer, Type F.P.7 or Type F.P.9.

The tree is measured in sections of unequal length from timber height, i.e. the point on the stem where the over-bark diameter is 3 inches ($9\frac{1}{2}$ inches girth), to the base ; the volume of each section, except the butt section, being calculated by Smalian's formula :

$$\text{Volume} = \frac{S_1 + S_2}{2} \times L$$

where S_1 and S_2 are the sectional areas at the end of each section, and L is the length of the section.

The volume of the butt section is calculated by Huber's formula, i.e. mid-sectional area multiplied by the length.

The observer will take all measurements from a position from which the whole length of the tree from base to timber point is visible. When this is not possible, the observer should choose a position from which he can see the greatest length of stem from the base upwards. The height to timber point and total height will then be measured from another position.

The tree to be measured should be clearly visible and preferably with no other tree behind it or immediately beside it. This is to ensure that the stem is well defined and that the readings taken will be accurate.

There is a slight difference in the two models ; Type F.P.7, the prototype, has no angle of depression, but Type F.P.9 has an angle of depression of 25 degrees. Because of this, the instructions given below, although generally applicable to both models, may have to be modified slightly for the prototype.

For both models the maximum angle of elevation is 45 degrees and the horizontal distance between the observer and the tree should be at least 12 yards. It is also advisable for eye level to be above the base of the tree and for the instrument to be supported, for example on a forked stick.

Two examples are given, the first is applicable for the prototype and the second for Type F.P.9.

Measurements

The following measurements will be taken from the chosen position in the stand and recorded on Measurement of Sample Trees by Dendrometer Form (Sample Plot Form No. 4b).

(1) Record in column 1 the tree number and breast height girth.

(2) Set the micrometer head on the Dendrometer to zero and find the point on the tree corresponding to eye level. Measure this height on the tree with rods to the nearest *half-foot* and record the height in column 7 opposite to a sine reading of zero in column 4.

(3) Sight the Dendrometer to the tip of the tree and record the first reading in column 2 and the sine in column 4.

(4) Estimate the timber point by eye, i.e. the position on the stem where the diameter is 3 inches or the point above which no main stem can be distinguished. At this point on the stem, take first and second readings recording them in columns 2 and 3 ; read the sine of elevation and record in column 4. If the timber point is obscured by the crown, take readings as near to timber point as possible ; and then measure the height of timber point from another position after all subsequent readings have been recorded.

(5) Take first and second readings at points on the stem to which the sine values of the angles of elevation from the observer are multiples of 0·1, e.g. 0·6, 0·5, 0·4, etc. ; the first reading is taken at the multiple which is between 0·05 and 0·15 below the sine value at timber point. For example, if the sine reading at timber point is 0·563, the next readings will be at 0·500, then 0·400, etc., if it is 0·549, the next readings will be at 0·400, then 0·300, etc.

If the diameter readings by this method fall on a whorl, the readings should be taken just below the whorl and the sine reading at this point recorded.

(6) Continue to take readings at the prescribed sine values to the point on the tree from which

the butt log can conveniently be measured directly, i.e. by measuring the mid girth or diameter by tape or caliper and the length by rods. The length of the butt log should not normally exceed 15 feet. The height and girth (or diameter) of the butt section will be recorded in columns 11 and 6 respectively.

Height readings of the butt section, and to eye level (para. (2)) will be measured from the breast height girth band, and 4 feet 3 inches added in order to give the effective height from ground level.

Calculation of Volume

(7) *Distance in feet* (column 5). These are the distances (ranges) from the Dendrometer to the points on the tree at which the diameters were measured. These ranges are obtained from the first readings at each point as shown in the table provided with the instrument. Interpolate between the nearest range readings given in the table to obtain the range, correct to one decimal place of a foot.

(8) *Diameter in inches* (column 6). These diameters are obtained from the first and second range readings at each point and are read from the tables provided. Interpolate between the nearest values given in the table to get the observed diameter correct to one decimal place.

(9) *Height in feet* (column 7). This is the height at which the diameter was measured ; it is the distance (range) given in column 5 multiplied by the sine in column 4. If the sine measures an angle of elevation the height to the point on the tree corresponding to eye level is added to the calculated height, if the sine measures an angle of depression the calculated height is subtracted from the height corresponding to eye level. Heights are recorded correct to the nearest *half-foot.*

(10) *Sectional area* (column 8). These are the sectional areas corresponding to the diameters given in column 6.

(11) *Sums* (column 9). These are the sums of the two successive sectional areas recorded in column 8.

(12) *Half sums* (column 10). These are half of the sums given in column 9. The entries in columns 9 and 10 represent the totals and means of the two end sectional areas of each log.

(13) *Difference in Height* (column 11). The difference in height between two successive values given in column 7 ; these differences are the lengths of each section.

(14) *Volume* (column 12). In this column are entered the volumes of each section, which are obtained by multiplying the mean sectional area (column 10) by the length of each section (column 11).

(15) *The volume of the butt section* is calculated by multiplying the mid-sectional area (column 8) by the length (column 11).

(16) *The total volume of tree* is the sum of all the sectional volumes.

(17) Small divergences from a diameter of 3 inches may be ignored as they have only a very small effect on the total volume of the tree. If the uppermost diameter read by the dendrometer is considerably greater than three inches, and the tree is not forked at this point, an allowance will be made for the additional length of stem to the three inch diameter point, as described in Appendix V.

Sample Plot Form No. 4b

MEASUREMENT OF SAMPLE TREES BY DENDROMETER

Plot No. ..... Species ..... Initials .....

Date of Measurement ..... Location Checked by .....

1	2	3	4	5	6	7	8	9	10	11	12	13
Tree No. and Girth (inches)	Readings			From Tables		Calculations						
	1st	2nd	Sine	Distance (feet)	Diameter (inches)	Height (feet)	Sectional Area (square feet q.g.)	Sums	Half Sums	Difference in Height (ft.)	Volume (hoppus ft.)	Remarks
	47·8	—	+·642	83·9	—	69						(Example using Dendrometer Type F.P.7)
A/33	46·4	53·4	+·476	78·2	2·9	52	·036					
	45·0	57·0	+·4	73·3	4·7	44½	·095	·131	·066	7½	·50	
	43·8	61·0	+·3	69·6	6·5	36	·181	·276	·138	8½	1·17	
	43·0	63·5	+·2	67·5	7·6	28½	·247	·428	·214	7½	1·60	
	43·0	64·9	+·1	67·5	8·2	22	·288	·535	·268	6½	1·74	
	42·8	65·6	0	66·9	8·4	15	·302	·590	·295	7	2·06	
Butt section ..					31 inches girth		·417			15	6·26	
Total											13·33	
	50·6	—	+·558	98·9	—	76						Forked tree
B/50	49·6	57·4	+·489	92·9	4·0	66½	·069					
	48·7	62·9	+·4	88·15	7·1	56½	·216	·285	·142	10	1·42	
	48·5	65·9	+·3	87·2	8·7	47	·324	·540	·270	9½	2·57	(Example using Dendrometer Type F.P.9)
	48·0	69·0	+·2	84·8	10·4	38	·463	·787	·394	9	3·55	
	47·6	70·7	+·1	83·0	11·3	29½	·547	1·010	·505	8½	4·29	
	46·8	72·3	0	—	12·0	21	·617	1·164	·582	8½	4·95	
	47·6	74·8	−·1	83·0	13·7	12½	·804	1·421	·710	8½	6·04	
Butt section ..					48½ inches girth		1·021			12½	12·76	
Total											35·58	

Appendix V

CALCULATION OF VOLUME OF PARTIALLY CLIMBED SAMPLE TREES

Where it is not possible to climb a sample tree to timber point, and a Dendrometer is not available, the tree should be climbed as far as is safe and practicable. The method outlined below is derived from that described by Gray (1956). It is simpler to use than the form quotient method, which has been discontinued for estimating girths in the unclimbed portion of the tree ; it is, however, like form quotients, inaccurate when used on trees with forks or other abnormalities.

Total height, lower crown, upper crown and crown diameter will be measured and recorded on the Measurement of Sample Trees Form (Sample Plot Form No. 4) ; in addition the position of timber point will be estimated and its height recorded. If the girth at timber point is greater than 9½ inches because of forking, its girth will be estimated and recorded. The tree will also be girthed at intervals of five feet, from ground level to as far up the stem as possible.

From these measurements the volume of the tree will be calculated using the following method :

(1) From decimal hoppus tables (Research Branch edition) read the sectional area corresponding to the girth at each point on the stem at which measurements were taken (i.e. at 5, 10, 15, etc., feet).

(2) Plot on a height/sectional area graph the following :

(i) the sectional areas at 5, 10, 15, etc., feet as far as the girths were measured ;

(ii) the estimated height of timber point at a sectional area of 0·039 square feet (i.e. the sectional area corresponding to 9½ inches girth or 3 inches diameter), or the sectional area corresponding to the girth at timber point if estimated to be greater than 9½ inches ;

(iii) the total height of the tree at a sectional area of zero.

(3) Draw a line through these points to timber point, ignoring the first and possibly the second points from the base of the tree which may, because of butt swelling, be away from the trend indicated by the remainder of the points. The line through the points is usually straight, although it may be curved. (Figure 2.)

(4) The volume of each tree will be calculated in the usual way by ten-foot sections. Actual measurements of the girths at the mid points of each section will be used as far as the tree has been climbed ; while in the unclimbed portion of the tree the mid-sectional areas will be read from the graph and multiplied by the length of the section to obtain the volume. The girths corresponding to these sectional areas need not be recorded.

TABLE 11

Measurements taken in the Field

Tree No.	Girth (inches)	Total Height (feet)	Timber Height (feet)	Section (feet)	Girth over bark (inches)	Sectional Area (square feet q.g.)
1	27	56	48	5	27	·316
				10	23½	·240
				15	21½	·201
				20	20	·174
				25	19	·157
				48	9½	·039

(5) If, however, the length of stem between timber point and the point of the last measurement does not exceed 19 feet, the volume of this section will be calculated by Smalian's formula, and the remainder of the stem in ten-foot sections as before. In this case there will be no need to determine from a graph the mid-sectional area of the unclimbed portion of the stem.

The following is an example of the method of calculating the volume of a partially climbed tree. In Table 11 opposite, the actual measurements for a single tree taken in the field are shown, together with the sectional areas at each point of girthing; the graph is shown in Figure 2; the calculation of the tree volume (on Sample Plot Form No. 4) in Table 11a.

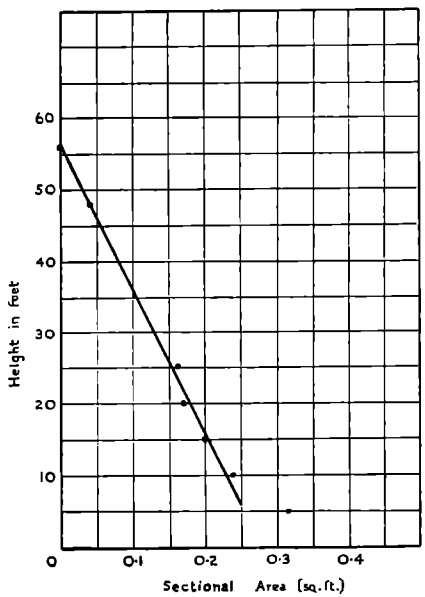

FIGURE 2.
Graph of taper line derived from the measurements given in Table 11.

TABLE 11a

COMPUTATION OF VOLUME OF PARTIALLY CLIMBED TREE

F.C. Sample Plot Form No. 4

MEASUREMENT OF SAMPLE TREES

Sample Plot No. *W.T21/54* Species : *Thuja plicata*

Tree No.	Girth at 4 ft. 3 in. inches	Total Height feet	Timber Height feet	½ T.H. Girth, O.B. inches	½ T.H. Girth, U.B. inches	Volume O.B. hoppus ft.	Volume U.B. hoppus ft.	Lower Crown feet	Upper Crown feet	Crown per cent	Crown Width feet
1	*27*	*56*	*48*					*26*	*30*	*46½*	*6*

Tree No.	Basal Area	Length of Section feet	Girth O.B. inches	*[Girth U.B.] Sectional Area sq. ft. q.g. [inches]*	Volume O.B. hoppus ft.	Volume U.B. hoppus ft.	Bark per cent	Form Factor O.B.	Remarks
1	*·316*	*10* *10* *10* *18*	*27* *21½* *19*	*·084*	*3·16* *2·01* *1·57* *1·51*				
					8·25			*·466*	

* *Note.* The deletion of the normal heading to this column of the form is denoted by square brackets [ ], and the substituted heading is shown in *italics*.

REFERENCE

GRAY, H. R. (1956). *The form and taper of forest tree stems.* Institute Paper, Imperial Forestry Institute, Oxford, No. 32.

Appendix VI

KEEN'S METHOD OF ESTIMATING LINEAR REGRESSION

This method of estimating the regression between two variables was devised by Joan Keen and D. J. Page and was published in the *Incorporated Statistician*, Vol. 4, No. 2, August, 1953. It is reproduced here by kind permission of the authors and editor.

The method is demonstrated by an example of the fitting of the regression of volume on basal area. See Figure 3 (a, b, c and d).

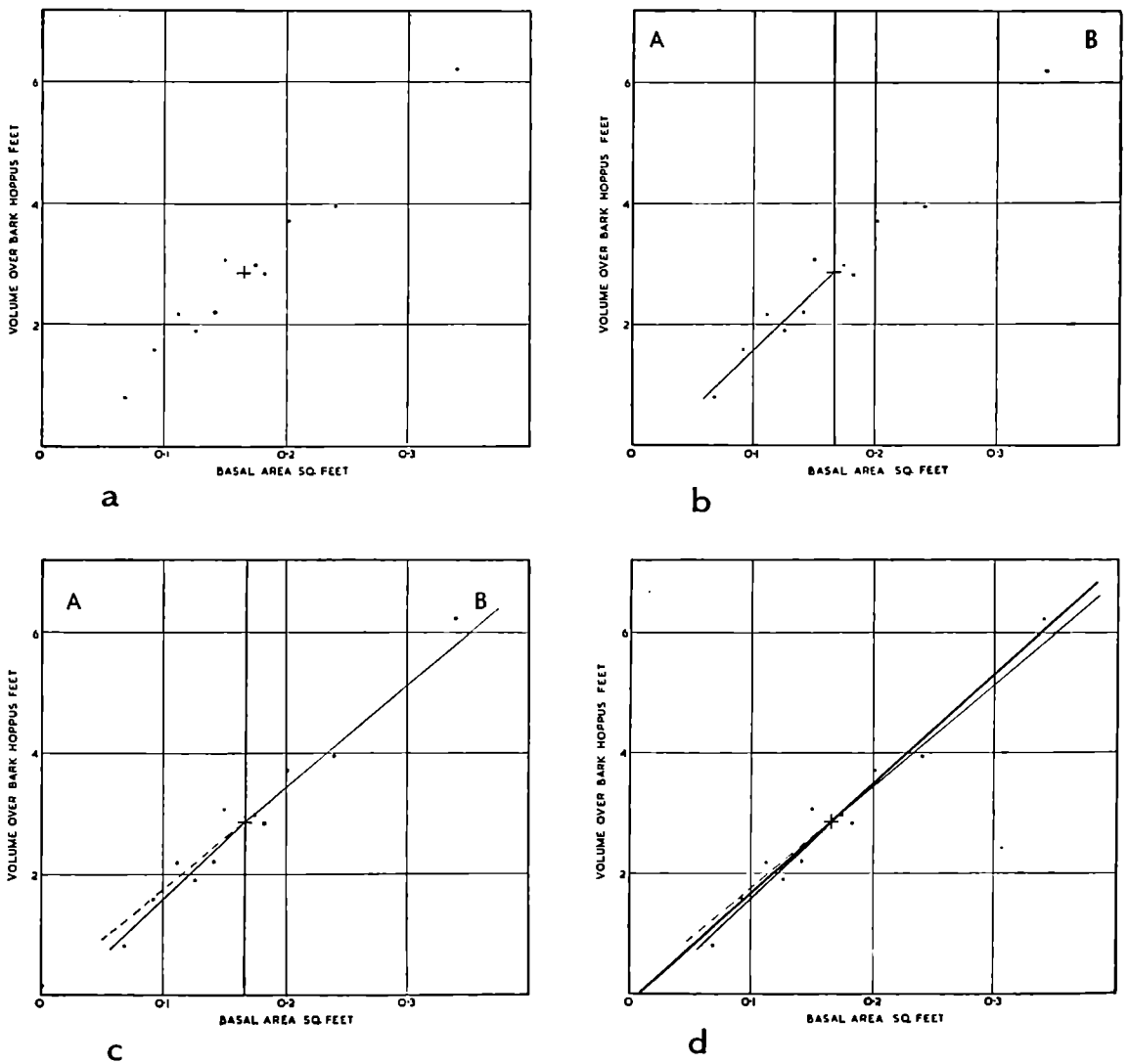

FIGURE 3 (*a, b, c, d*).
Stages in the estimation of the regression line by the method described by Keen & Page.

The volumes and basal areas of 11 sample trees were :

X Basal Area Square Feet q.g.	Y Volume Hoppus Feet
·340	6·11
·240	3·96
·201	3·72
·182	2·84
·174	2·98
·149	3·08
·141	2·21
·125	1·90
·111	2·18
·091	1·59
·068	0·80

Step 1

The volume of each sample tree is plotted against basal area on a graph, as in Figure 3 (*a*), arranging the scales so that the slope of the line suggested by these points is approximately 45 degrees.

Step 2

The average basal area ($\bar{x}$), and the average volume ($\bar{y}$) are computed, and the average point ($\bar{x}$, $\bar{y}$) plotted on the graph as a cross. Divide the graph into two sectors, A and B, by drawing a line parallel to the Y axis, through the average point.

Step 3

With the average point ($\bar{x}$, $\bar{y}$) as a pivot, draw a line through the points in sector A so that the number of points above and below the line are equal. (A transparent ruler is desirable, but not essential, for this step.) When the number of points is odd, the line passes through the median point ; when the number of points is even, the line passes between the two median points, and should be drawn so that the vertical distances from these two points to the line are the same. (Figure 3 (*b*).)

A plotted point coinciding with the average of the independent variable ($\bar{x}$) should be regarded as falling in sector A if its volume is less than ($\bar{y}$) and as falling in sector B if its volume is greater than ($\bar{y}$).

Step 4

Again using the average point ($\bar{x}$, $\bar{y}$) as a pivot, a line is drawn through the points in sector B (Figure 3 (*c*)), in the same way as in Step 3. This line is extended into sector A.

Step 5

A line is drawn to bisect the small angle between the two lines that have been drawn in Steps 3 and 4 ; this line automatically passes through the point ($\bar{x}$, $\bar{y}$). (Figure 3 (*d*).)

Step 6

The volume corresponding to any given basal area, within the range of the plotted basal areas, is read from the line drawn in Step 5.

When the regression line, drawn by Keen's method, does not, by inspection, appear to fit the plotted points, the regression line will be calculated by the method of least squares. (See para. 104.)

REFERENCE

KEEN, J. and PAGE, D. J. (1953.) Correlation for the non-mathematician. *The Incorporated Statistician.* Vol. 4, No. 2 August, 1953, pages 55–65.

Appendix VII

DETERMINATION OF VOLUME OF PREVIOUS THINNINGS FROM STUMP DIAMETERS

In stands where there are no records of past thinning yields, it may be necessary to make an estimate of the volume removed in previous thinnings at the establishment of a sample plot. This estimate can be obtained by measuring the diameters of the stumps of the previous thinnings and estimating their breast height girths from the relationship of stump diameter to breast height girth found in the thinnings being currently removed. This method should only be used when the stumps of the previous thinnings are sound enough for accurate diameter measurements to be made and when it is reasonable to assume that the number of stumps represents the total number of trees removed in previous thinnings. The procedure, which is illustrated by a worked example is as follows :

Field Work

(1) Before any thinnings are felled, measure and record in part B of the special form (see worked example) the under bark stump diameters of all the previous thinnings by half-inch diameter classes. The diameter to be recorded for each stump is the mean of the maximum and minimum under-bark diameters.

(2) After the thinnings are felled, measure and record in part A of the special form the under-bark stump diameters of the thinnings against their breast height girths.

Office Work

(3) Plot the breast height girths (B.H.G.) of the thinnings, recorded in part A, against their stump diameters and draw the regression line through the points (Figure 4). This relationship is normally linear.

(4) In part B, first total the number of stumps in each half-inch diameter class. From the graph (Figure 4) read the breast height girth corresponding to each diameter recorded; from these girths calculate the total basal area for each stump diameter class, the total basal area of the previous thinnings, and their mean girth.

(5) The volume of the previous thinnings may be estimated from either the *tariff** applicable to the trees removed in the current thinning or the current volume graph for the standing crop. As previously explained (paras. 81, 88 and 105) only trees with girths of 8½ inches and above are considered to contain measurable volume. If, therefore, the previous thinnings are estimated to have contained trees with girths of less than 8½ inches, a separate total and mean basal area and mean girths must be calculated before their volume can be estimated.

In part C, record in column 1, the tariff number of the current thinnings if this method is used; in column 2 record the average volume corresponding to the mean girth or basal area of the previous thinnings of 8½ inches girth and above (part B); in column 3, record the total volume of the previous thinnings. This is obtained by multiplying the average volume (column 2) by the number of previous thinnings of 8½ inches and over (part B).

(6) The number of trees, mean girth, basal area and volume of previous thinnings are recorded on the final Summary Sheet (Sample Plot Form No. 7) before the entry relating to the first measurement of the sample plot.

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* *Note.* A tariff is one of a series of volume tables based on breast height girth alone; the use of tariff tables is explained in Forestry Commission Forest Record No. 31.

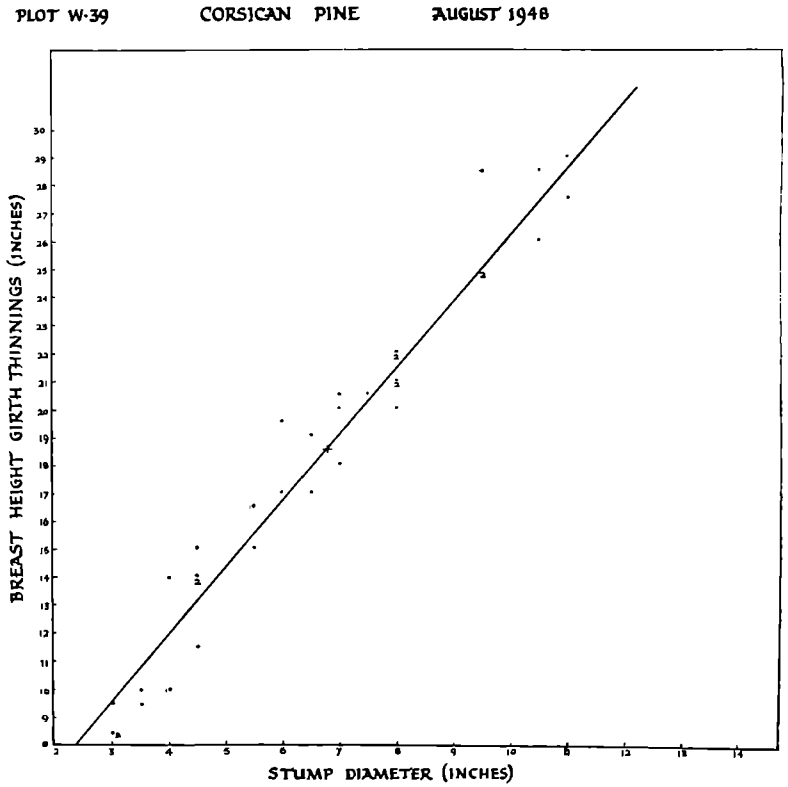


FIGURE 4.

Regression of the breast-height girth of thinnings to stump diameter from the measurements given in part A of sample form.

ESTIMATION OF VOLUME OF PREVIOUS THINNINGS BY STUMP DIAMETERS

Plot No. : *W.39* Location : *Gwydyr.*

Species : *Corsican pine.* Date : *August, 1948.*

A. THINNINGS

Breast-height Girth of Thinnings (Inches)	Stump Diameters of Thinnings in Inches																			
	3	3½	4	4½	5	5½	6	6½	7	7½	8	8½	9	9½	10	10½	11	12	13	13½
8½	II																			
9	I	I																		
10		I	I																	
11				I																
12																				
13																				
14			I	II																
15				I		I I														
16						I														
17							I	I												
18									I											
19							I	I												
20									I I	I	I									
21											II									
22											II									
23																				
24																				
25														II						
26																I				
27½																	I			I
28½														I		I				
29																	I			

B. STUMPS

Stump Diameter (inches)	No. of Stumps	Total	B.H.G. (inches)	Basal Area (square feet q.g.)
2	𝍸 𝍸 𝍸 ||	17	7	·362
½	𝍸 ||||	9	8½	·282
3	𝍸 𝍸 𝍸	15	9½	·588
½	𝍸 𝍸 ||	12	11	·630
4	𝍸 𝍸 𝍸 𝍸 ||	22	12	1·375
½	𝍸 ||	7	13	·513
5	𝍸 ||||	9	14½	·821
½	𝍸 ||	7	15½	·730
6	𝍸 ||||	9	16½	1·063
½	||	2	18	·281
7	𝍸 𝍸	10	19	1·567
½	|||	3	20	·521
8	||	2	21½	·401
½	||	2	22½	·439
9	||	2	23½	·479
½	|	1	25	·271
	Totals	129	—	10·323
	Means		13½	0·080

C. VOLUME

Tariff Number of Thinnings	Average over-bark volume per tree (hoppus feet)	Total Volume over bark (hoppus feet)
—	·51	57·12

No. of trees 8½ inches girth and over = 112.
Total basal area = 9·961 square feet q.g.
Average basal area = 0·089 square feet q.g.
Average girth = 14½ inches.

Note. In practice, Parts A, B and C above appear on one foolscap sheet.

Appendix VIII

SUMMARIES OF WORK

The work necessary in a sample plot has, for convenience, been summarized in this Appendix, with references to the relevant instructions in the code. The Appendix is divided into three sections :

(1) Summary of work at plot establishment ;
(2) Summary of work at a full measurement ;
(3) Summary of work at an intermediate measurement.

Each of these sections is subdivided to give a summary of the work necessary in a *numbered* plot and in an *un-numbered* plot. The summaries relate only to the *field work* and to that part of the *other work* which is essential to the completion of the field work. They do not include the subsequent computations which may be done later. The sequence of work given in the summaries is that in which the work is normally done, but it need not be followed rigidly.

1. SUMMARY OF WORK AT PLOT ESTABLISHMENT

(a) Numbered Plot, i.e. a plot in which 90 per cent or more of the trees are of 8½ inches girth or over, or one in which the height is 40 feet or more (para. 27).

Field Work	Other Work
1. Survey plantation in which plot or plots are required and select exact site of plot.	
2. Survey plot, marking corners with white posts and the limits of the surround with letters painted on dominant trees (paras. 10–17).	Calculate area of plot (paras. 18–19 and Appendix X).
3. Brash plot and its surround, if not already done.	
4. Mark thinning in plot and its surround (para. 21).	
5. Paint bands at 4 feet 3 inches on all trees of 4 inches breast-height girth and above (paras. 22–25).	
6. Number all trees in the main crop that have a breast-height girth of 4 inches or more (paras. 28–30).	
7. Girth and classify main crop, recording measurements in General Register (paras. 42–44, 46, 48–50).	Transfer girths from General Register to Girthing Sheet (Form 3a) (para. 47).
8. Girth and classify thinnings, recording measurements on the Girthing Sheet (Form 3a) and classifications on Form 3b, using in both cases gates of five (paras. 46 and 51).	Transfer tree classification from General Register to Form 3b and calculate percentages of main crop and thinnings in each canopy, stem and crown class (para. 84).
9. Describe crop, flora and soil (paras. 35–37).	Determine sampling fraction for thinnings, if measuring only a sample (paras. 53 and 54).
10. Fell and measure thinnings. If a sample of thinnings is to be measured these should be felled and measured if possible before the other thinnings are felled (paras. 52, 56–59).	Select trees which may be suitable for height analysis (para. 62).
	Select from the Girthing Sheet trees for height measurement (para. 66).

Field Work	Other Work
11. Measure heights of standing trees (para. 64).	
12. Measure trees selected for height analysis (para. 63).	Select sample trees (para. 68).
13. Measure sample trees (para. 69–72).	
14. Check main crop trees to ensure that no tree supposed to be standing has been felled, and that no thinning remains standing (para. 76).	
15. Prune plot (para. 74).	
16. Describe plot after thinning (para. 36 (20)).	
17. Paint plot legend (para. 34).	Make sure the data are complete, correct and legible before leaving locality (para. 76).

(b) **Un-numbered Plot,** i.e. a plot in which less than about 90 per cent of the trees are of $8\frac{1}{2}$ inches girth or over, or one in which the top height is less than 40 feet.

Field Work	Other Work
1–5. As for Numbered Plot (para. (a)).	As for Numbered Plot.
6. Girth main crop and thinnings and record in gates of five on the Girthing Sheet, Form 3a (paras. 42–45).	
7. Classify thinnings and record in gates of five on Form 3b (para. 51).	Calculate percentage in each canopy, stem and crown class (para. 84).
8. Describe crop, flora and soil (paras. 35–37).	Determine sampling fraction for thinnings if measuring only a sample (paras. 53 and 54).
9. Fell and measure thinnings. If a sample of thinnings is to be measured, these should be felled and measured, if possible, before the other thinnings are felled (paras. 52, 56–59).	Select trees which may be suitable for height analysis (para. 62).
	Determine sampling fraction for trees for height measurement (para. 65).
10. Measure heights of standing trees (para. 64).	
11. Measure trees selected for height analysis (para. 63).	
12. Prune plot (para. 74).	
13. Describe plot after thinning (para. 36 (20)).	
14. Paint plot legend (para. 34).	Make sure the data are complete, correct and legible, before leaving locality (para. 76).

2. SUMMARY OF WORK AT A FULL MEASUREMENT

(a) Plot which was **un-numbered** *at previous measurement.*

Field Work	Other Work
1. Mark thinnings in plot and its surround (para. 21).	
2. Repaint bands and the surround symbols, if necessary (paras. 26 and 31).	
3. Number all trees in the main crop that have a breast-height girth of 4 inches or more (para. 28–30).	
4. Girth and classify main crop, recording measurements in General Register (paras. 42–44, 46, 48–50).	Transfer girths from General Register to Girthing Sheet, Form 3a (para. 47).
5. Girth and classify thinnings, recording measurements on the Girthing Sheet (Form 3a) and classifications on Form 3b ; using in both cases gates of five (paras. 46 and 51).	Transfer tree classification from General Register to Form 3b, and calculate percentages of main crop and thinnings in each canopy, stem and crown class (para. 84).
6. Describe plot, and record any changes in flora, and depth of leaf litter and humus since last measurement on Form 2b (para. 38).	
	Determine sampling fraction for thinnings if measuring only a sample (paras. 53 and 54).
7. Fell and measure thinnings. If a sample of thinnings is to be measured, these should be felled and measured, if possible, before the other thinnings are felled (paras. 52, 56–59).	If height analysis was not done previously, select any trees which may be suitable (para. 62).
	Select from Girthing Sheet trees for height measurement (para. 66).
8. Measure heights of standing trees (para. 64).	
9. Measure trees selected for height analysis, if no heights were analysed at a previous measurement (para. 63).	
	Select sample trees (para. 68).
10. Measure sample trees (paras. 69–72).	
11. Check main crop trees to ensure that no tree supposed to be standing has been felled and no thinning has been left standing (para. 76).	
12. Prune plot (para. 74).	
13. Describe plot after thinning (para. 38 (12)).	
14. Repaint plot legend if necessary (para. 34).	Make sure the data are complete, correct and legible, before leaving locality (para. 76).

(*b*) *Plot which was* **numbered** *at previous measurement.*

Field Work	Other Work
1. Mark thinnings in plot and its surround (para. 21).	
2. Repaint bands, numbers and surround symbols if necessary (paras. 26 and 31).	
3. Paint numbers on any trees which have been recruited into the 4-inch girth class or above (para. 32).	Note position of these trees in relation to nearest numbered tree, in the remarks column of the General Register (para. 32).
4. Girth and classify main crop and thinnings, recording measurements in General Register (paras. 42–44, 47, 48–50).	Transfer girths from General Register to Girthing Sheet, Form 3a (para. 47). Transfer tree classification from General Register to Form 3b, and calculate percentage of main crop and thinnings in each canopy, stem and crown class (para. 84).
5. Describe plot and record any changes in flora, and depth of leaf litter and humus since last measurement, on Form 2b (para. 38).	Select sample thinnings from Girthing Sheet if measuring only a sample (paras. 53 and 55).
6. Fell and measure thinnings. If a sample of thinnings is to be measured, these should be felled and measured, if possible, before the other thinnings are felled (paras. 52, 56–59).	If height analysis was not done previously, select any trees which may be suitable (para. 62). Select from Girthing Sheet trees for height measurement (para. 66).
7. Measure heights of standing trees (para. 64).	
8. Measure trees selected for height analysis if no heights were analysed at a previous measurement (para. 63).	Select sample trees (para. 68).
9. Measure sample trees (paras. 69–72).	
10. Check main crop trees to ensure that no tree supposed to be standing has been felled and no thinning has been left standing (para. 76).	
11. Prune plot (para. 74).	
12. Describe plot after thinning (para. 38 (12)).	
13. Repaint legend if necessary (para. 34).	Make sure all data are complete, correct and legible, before leaving locality (para. 76).

3. SUMMARY OF WORK AT AN INTERMEDIATE MEASUREMENT

(a) Plot which was **un-numbered** *at previous measurement.*

Field Work	Other Work
1. Mark thinnings in plot and its surround (para. 21).	
2. Repaint bands and the surround symbols if necessary (paras. 26 and 31).	
3. Girth main crop and thinnings and record in gates of five on the Girthing Sheet Form 3a (para. 45).	
4. Classify thinnings and record in gates of five on Form 3b (para. 51).	Calculate percentage in each canopy, stem and crown class (para. 84).
5. Describe plot and record any changes in flora and depth of leaf litter and humus since last measurement on Form 2b (para. 38).	
	Determine sampling fraction for thinnings if measuring only a sample (paras. 53 and 54).
6. Fell and measure thinnings. If a sample of thinnings is to be measured, these should be felled and measured, if possible, before the other thinnings are felled (paras. 52, 56–59).	If height analysis was not done previously, select any trees which may prove suitable (para. 62).
	Determine sampling fraction for trees for height measurement (para. 65).
7. Measure heights of standing trees (para. 64).	
8. Measure trees selected for height analysis if no heights were analysed at a previous measurement (para. 63).	
9. Prune plot (para. 74).	
10. Describe plot after thinning (para. 38 (12)).	
11. Repaint plot legend if necessary (para. 34).	Make sure all data are complete, correct and legible, before leaving locality (para. 76).

(*b*) *Plot which was* **numbered** *at previous measurement.*

Field Work	Other Work
1. Mark thinning in plot and its surround (para. 21).	
2. Repaint bands, numbers and surround symbols if necessary (paras. 26 and 31).	
3. Paint numbers on any trees which have been recruited into the 4-inch girth class and above (para. 32).	Note position of these trees in relation to nearest numbered tree, in the remarks column of the General Register (para. 32).
4. Girth all trees (main crop and thinnings) and classify thinnings; in comparative thinning series classify main crop also (paras. 41, 42–44, 46, 48 and 50).	Calculate percentage in each canopy, stem and crown class (para. 84).
5. Describe plot and record any changes in flora and depth of leaf litter and humus, since last measurement on Form 2b (para. 38).	
	Select sample thinnings from Girthing Sheet if measuring only a sample (paras. 53–55).
6. Fell and measure thinnings. If a sample of thinnings is to be measured these should be felled and measured, if possible, before the other thinnings are felled (paras. 52, 56–59).	If height analysis was not done previously, select any trees which may be suitable (para. 62).
	Select from Girthing Sheet trees for height measurement if heights of standing crop are to be measured (paras. 41 (*b*), 66).
7. Measure heights of standing trees if appropriate (para. 64).	
8. Measure trees selected for height analysis if no heights were analysed at a previous measurement (para. 63).	
9. Prune plot (para. 74).	
10. Describe plot after thinning (para. 38 (12)).	
11. Repaint legend if necessary (para. 34).	Make sure all data are complete, correct and legible, before leaving locality (para. 76).

Appendix IX

WORKED EXAMPLES FROM SAMPLE PLOT FILES

Note. Throughout this appendix *italic* type is used to indicate manuscript entries on printed forms. Where a column on a form has been used for recording entries other than those for which it was originally intended, the original heading has been deleted (indicated by [ ]) and the new heading is shown in italic type.

The two examples which follow have been taken from sample plot records. Where necessary, these records have been re-calculated using the new procedure. This Appendix also gives (on page 91) an example of the special form to be used for recording details of damage caused by wind (see para. 60).

The first example, part A of this Appendix (starting on page 50), is of a single sample plot established in a crop of *Abies grandis* at Gwydyr Forest in 1948. The plot received an *intermediate measurement* in 1951, a *full measurement* in 1954, and a *second intermediate measurement* in 1957. The pages of the worked exemple are arranged as follows :

First to Seventh Pages : the forms normally completed at the establishment of a sample plot.

Eighth to Ninth Pages : the description of the plot at each subsequent measurement, although the actual data are not included for the 1951 and 1954 measurements.

Tenth to Fifteenth Pages : the general register.

Sixteenth to Thirtieth Pages : the procedure for a full measurement at the plot establishment in 1948, when the volume of the thinnings was determined by measuring a sample of them.

Thirty-first to Thirty-eighth Pages : the procedure for the intermediate measurement made in 1957, when no heights of the main crop were measured.

Thirty-ninth Page : the complete Final Summary of all measurements to date ; this shows the procedure for recording the volume of thinnings removed before the establishment of the sample plot and also of windblown trees.

The forms are arranged in the order in which they are kept in the file for each sample plot and references are given at the top of each page to the relevant instructions in this code.

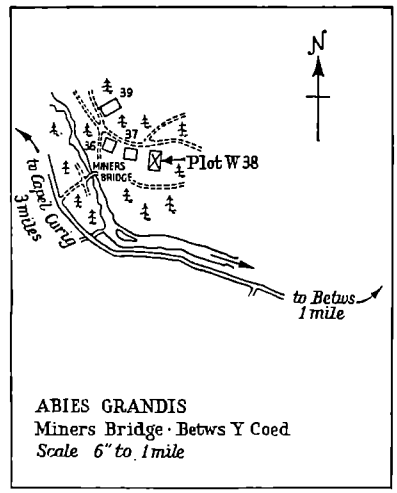
The second example, part B (starting on page 89), illustrates the method of recording measurements of thinnings when there are "*stops*". This is particularly applicable to broadleaved species, and the example has been taken from an oak sample plot. The measurements and calculations of branchwood volume may be recorded in the remarks column of Form 4a as shown in the example, or if more convenient on a separate form. As explained in para. 59, measurement of branchwood is restricted to broadleaved species. Standing sample trees in sample plots in broadleaved species are recorded on Sample Plot Form No. 4, the method being the same as for thinnings except that branchwood is not measured.

P. C. Sample Plot Form No. 1

Map of Permanent Sample Plot No. *W 38* Initials *P.M.*

Ordnance Sheet 1" No. *New Popular Edition 107* Checked *J.N.R.*

" " 6" No. *Caernarvon XIX SW*



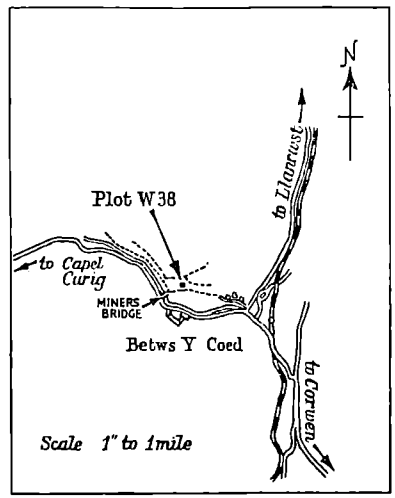


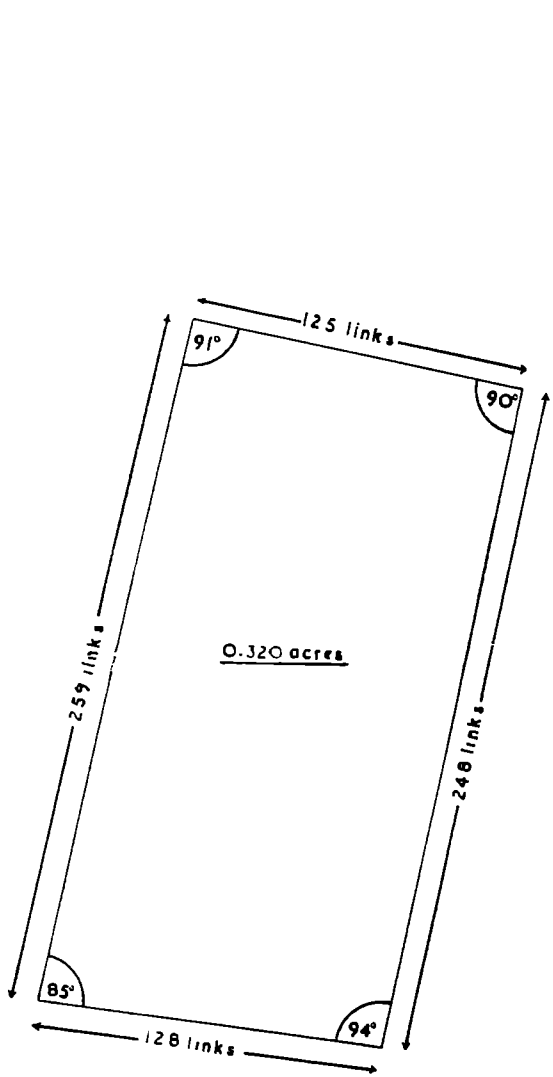
FIGURE 5. Worked Example A : First Page.
(See para. 20, page 5.)

F. C. Sample Plot Form No. 1

Map of Permanent Sample Plot No. W 38 Initials. T.R.T.

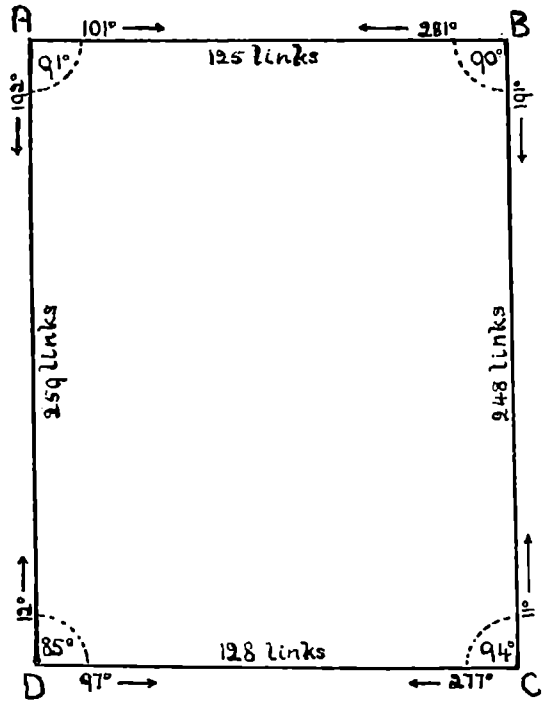
Ordnance Sheet 1″ No. Checked. R.S.

„ „ 6″ No.



Scale: 1 cm. to 20 links

FIGURE 6. Worked Example A : Second Page.
(See para. 18, page 5.)



$$\text{Area} = \tfrac{1}{2}\, BC \times AB \times \text{Sine } 90°$$
$$= 124 \times 125 \times 1 \qquad = 0{\cdot}1550 \text{ acres}$$
$$\tfrac{1}{2}\, DC \times AD \times \text{Sine } 85°$$
$$= 64 \times 259 \times {\cdot}9962 \qquad = 0{\cdot}1651 \text{ acres}$$
$$0{\cdot}3201 \text{ acres}$$

$$\text{Area} = \tfrac{1}{2}\, AB \times AD \times \text{Sine } 91°$$
$$= 62{\cdot}5 \times 259 \times {\cdot}9998 \qquad = 0{\cdot}1618 \text{ acres}$$
$$\tfrac{1}{2}\, CD \times BC \times \text{Sine } 94°$$
$$= 64 \times 248 \times {\cdot}9976 \qquad = 0{\cdot}1583 \text{ acres}$$
$$0{\cdot}3201 \text{ acres}$$

FIGURE 7. Worked Example A : Third Page.
(Reverse of Form 1)
(See para. 19, page 5, and Appendix X, page 93.)

F.C. Sample Plot Form No. 2

PRE-ESTABLISHMENT DATA

Plot No. *W.38*

Date and initials : *August, 1948. J.N.R.J.*

Species : *Abies grandis*

Forest : *Gwydyr*

Compartment No. *75*

Vegetation prior to planting : *No Record*

Ident. No. or seed source : *No Record*

Ex (*Unknown*) Nursery

Method of Planting : *Mattock*

Planted P.*27* at *6* × *6* feet

Age and size of plants used : *No Record*

Year of sowing : *Not applicable*

Natural Regeneration : *Not applicable*

Particulars of Beating Up : *Not available*

Year and month of Brashing : *1945*

Year/s of Thinning and volumes per acre removed : *1947—350 hoppus feet (310 trees per acre).*

Damage (wind, animals, insects, fungi, etc.) : *None*

Remarks :

F. C. Sample Plot Form No. 2a.

DESCRIPTION ON ESTABLISHMENT

Sample Plot No. *W.38* Date : *August, 1948*

1. Species : *Abies grandis* 2. Area : *0·320 acres.*
3. Situation : *Cpt. 75, Gwydyr Forest. 23/782569.*
   The plot is on the left bank of the river Llugwy opposity Miners Bridge—1½ miles north-west of Betws-y-Coed and 1¾ miles from the Swallow Falls.
4. Ownership and address of owner or agent : *Forestry Commission, North Wales Conservancy.*
5. Objects of Sample Plot, with details of Treatment to be applied : *Established to provide data on the growth and increment of Abies grandis and for comparison with the sample plots of other North-Western American species in this valley. Thinned to a C/D grade, this treatment to be continued.*
6. Interval at which Plot is to be Measured and Thinned : *Three years.*
7. Height above sea-level : *250 feet.*
8. Relative elevation : *The valley of the river Conway (50 feet) is two miles to the south-east.*
9. Aspect : *South.*
10. Exposure : *Moderately exposed.*
11. Slope : *10°, irregular.*
12. Topography within the Plot : *Occasional small rock outcrops.*
13. Geology. *Ordovician : Bala and Caradoc Series, Shales.*
14. Climate : *Mean Annual Rainfall, 60–80 inches. (10 miles to 1 inch—Rainfall Map).*
15. Age of crop at first Measurement, and how ascertained : *22 years. Records P.27, confirmed by ring counts.*
16. Date of first Measurement : *August, 1948.*
17. Numbering of Main Crop trees : *Plot fully numbered.*
18. Method of Measurement : *Full measurement, sample trees climbed to timber point.*

(Reverse of Form 2a)

19. Ground Vegetation. *NIL. Very occasional weak oak scrub and coppice.*

20. Condition of Crop. (Stocking, Distribution, Canopy, Crowns, Branching, Stem-form, Uniformity as regards girth and height, Damage or Disease). *Before this present thinning, canopy had not completely closed, following a previous thinning in 1947. After thinning, stocking was full for grade, and distribution regular, except for a few gaps caused by the removal of large " wolf " trees. The canopy is rather irregular, 0·6–0·7, but the holes should close rapidly. The crowns are deep, extending to half of the stem length, and are not much damaged laterally by competition. Branching is moderately heavy and persistant down to the brashed height of 6 to 7 feet. Stem form is very good and there is only slight waviness and little or no forking. The plot is uniform in both height and girth growth. Annual shoots average 3 to 4 feet. There are no signs of any damage or disease.*

21. Remarks. *There has been a tendency towards natural thinning in this plot, and the dominants are regularly spaced.*

J.N.R.J.
August, 1948.

WORKED EXAMPLE A : SEVENTH PAGE (See para. 37, page 9)

FIELD SOIL DESCRIPTION SHEET

Sample Plot Form No. 2 (c).

Date : *26/7/48*	Locality : *Miners Bridge, Gwydyr.* 1-inch O.S. map ref. *23/782569* (Sheet 107)	Series. — Type. —	Gen. Group : *Brown Earth.*
Elevation : *250 feet* Slope/Aspect : *10°/South* Relief { Macroscopic : *Lower Valley Side* Microscopic : *Irregular*	Drainage — Profile : *Free* Site : *Satisfactory*	Parent rock material : *Ordovician. Bala and Caradoc Series. Shales.*	Vegetation : *Abies grandis.* (*W.38*) *No ground vegetation.*
Weather conditions { Prior to / at } Sampling { *Fairly dry* / *some drizzle*		Climatic data : Rainfall. *60 to 80 inches* (*Rainfall Map*).	Temp.

Layer depth and clarity	Colour and disposal	Texture	Mineral skeleton (stones)	Structure	Visible Porosity	Handling Consistency	Organic matter	Roots	Water conditions	Secreted chemicals and minerals	Fauna	CO_3	pH
L.	*Thin cover, loose, recent needles.*				—	—	—	—	—	—			
F. ..	*Fibrous decomposing needles.*				—	—	—	—	—	—			
H. ..	*Greyish humus-soil mixture*				—	—	—	*well rooted*	*just moist*	—	—	—	—
0 to 2 inches ..	*medium grey-brown*	*loam*	*slightly stony shale 1 inch to 2 inches*	*small crumb*	*porous*	*loose and mellow*	*stained intimate o.m.*	*many live roots < 1 inch*	*just moist*				
Merging 2 inches to 9 inches ..	*medium brown*	*loam*	*slightly stony shale 1 inch to 2 inches*	*small crumb*	*porous*	*loose and mellow*	*little or none*	*many live roots < 1 inch*	*just moist*				
Merging 9 inches to 35 inches+ ..	*reddish brown*	*heavy loam*	*very stony shale 2 inches to 4 inches*	*crumb*	*porous*	*crumbling and easy to dig*	*nil*	*roots extend to 23 inches*	*moist*				
	Becoming increasingly stony with depth												

J.N.R.J.
26/7/48

F. C. Sample Plot Form No. 2b*.

DESCRIPTION ON REMEASUREMENT

Sample Plot No. *W.38* 1.Species : *Abies grandis.*

2. Date and Initials	*7/1951 D.E.E.*	*10/1954 E.H.*	*1/1957 E.H.*	
3. Age of Crop	*25 years*	*28 years*	*30 years*	
4. No. of times Crop has been (*a*) thinned	*3*	*4*	*5*	
(*b*) measured ..	*2*	*3*	*4*	
5. Grade of thinning applied	*C/D*	*C/D*	*C/D*	
6. Future thinning treatment to be applied ..	*C/D*	*C/D*	*C/D*	
7. Proposed Year for next thinning and measurement	*1954*	*1956 or 1957*	*1960*	
8. Year of numbering ..	*1948*			
9. Method of Measurement	*Intermediate*	*Full Measurement. Sample trees climbed to timber point.*	*Intermediate*	

Date and Initials	10. Surface Conditions of Humus, Soil, etc.
7/1951 D.E.E.	*No change since 1948.*
10/1954 E.H.	*No change.*
1/1957 E.H.	*No change since plot establishment.*
	11. Soil Vegetation
7/1951 D.E.E.	*Nil.*
10/1954 E.H.	*Nil.*
1/1957 E.H.	*Nil.*

Notes. * Although numbered " 2b ", this page actually follows 2c in the series.
C/D = Moderately Heavy Thinning Grade. See Appendix III, page 28.

WORKED EXAMPLE A : NINTH PAGE (See para. 38 (12) to (13), page 10)
(Reverse of Form 2b)

Date and Initials	
7/1951 D.E.E.	12. Condition of crop before and after thinning. *Stocking is full and distribution is regular. Crowns are symmetrical and spire-like, with regular whorls of branches 3 feet to 4 feet apart, tending to make the canopy rather light. Canopy 0·75, opened up by the thinning but still complete in places : there are occasional gaps where badly shaped trees were removed. Stem form is excellent, but some trees have spiral scars ascending the trunk between whorls : these may have been caused by either frost or drought.*
10/1954 E.H.	*Before thinning, canopy 0·9, opened up to 0·7 by the present thinning. Stocking is fairly even but the largest trees tend to occur in groups. Crowns are large, stems are clean and straight and very cylindrical. Branches persist to brashed height on unpruned stems. In the past three years the top height of the crop has increased by 10½ feet. The butts of the thinnings showed no signs of decay, although fructifications of Armillaria mellea are present in the plot. Spiral scars caused by drought crack persist.*
1/1957 E.H.	*Before thinning, canopy was 0·9. It was opened to 0·7 by present thinning. A gap remains where the largest tree in the plot was blown in 1954. In recent years a number of the leading shoots have been damaged. Scars caused by drought-cracks (?) remain pronounced : fresh cracks have appeared this year. Armillaria mellea is still present : only one thinning showed stain : otherwise the trees appear to be unaffected by it.*

Date and Initials	
	13. Remarks.
7/1951 D.E.E.	*Approximately 130 selected stems per acre were pruned to a height of 30 feet.*
10/1954 E.H.	*In order to avoid possible extraction damage, the thinnings were removed under the supervision of the sample plot party. This plot should be visited in 1956, when plots W.33, 35 and 39 are due to be inspected.*
12/1954 E.H.	*The plot was inspected following the recent heavy gales and it was found that one tree, the largest in the plot, was broken off at 30 feet. The tree was felled and measured.*
1/1957 E.H.	*This degree of thinning is not suppressing the side branches. Loading bays have been excavated on the road near the plot and spoil from these has enroached into the surround.*

WORKED EXAMPLE A : TENTH PAGE

(See paras. 42, 44, 46, 48–51, pages 10 to 12, and Appendix II, page 24)

F.C. Sample Plot Form No. 3.

GENERAL REGISTER

Sheet I

Sample Plot No. *W.38*
Species : *Abies grandis*

Date of Measurement :	Initials
1. *August, 1948*	*P.M.*
2. *June, 1951*	*D.H.*
3. *September, 1954*	*C.A.*
4. *January, 1957*	*E.H.*
5.	

Tree No.	Tree Class					Girth (inches)					Remarks *P = pruned to 30 feet.*				
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
1	121		121			24	27½	31½	33½			P			
2	211	212				22½	24½					Thinning			
3	111		222			20½	22½	26	27½			P			
4	212	223				16	17½					Thinning			
5	111					23½					Thinning				
6	121		132			22	24	26½	28			P			
7	121		121			23	26	29	31						
8	111		111			21½	23½	26	27½			P			
9	212		212	213		17½	19½	23½	25					Thinning	
10	223		323			15	16	18	20						
11	111		122			22½	25	29½					Thinning		
12	111		111			30	32½	37½	40½			P			
13	121	121				23½	24½					Thinning			
14	112		112	212		20½	23	27	29					Thinning	
15	121		111			23	25½	30	32½			P			
16	121		111			28½	32	36	38½						
17	313	413				11	12					Thinning			
18	222		313			14	15½	17½	18½						
19	212	312				14½	16					Thinning			
20	121	222				22½	25					Thinning			
21	112		212			18½	21½	25	26½						
22	111					22½					Thinning				
23	111					19½					Thinning				
24	313					10½					Thinning				
25	212	212				16½	17½					Thinning			
26	112		212	312		17	19	23	24½					Thinning	
27	111		111			23½	25½	29½	31½			P			
28	112		212			17	19½	22					Thinning		
29	322		323	323		16½	17½	18½	19					Thinning	
30	111	122				26½	28½					Thinning			
31	111		112			16½	21½	22½	24½						

WORKED EXAMPLE A : ELEVENTH PAGE

(Reverse of Form 3, Sheet I)

GENERAL REGISTER

Tree No.	Tree Class					Girth (inches)					Remarks				
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
32	111		111			21	24	28	30			P			
33	111	111				22½	24					Thinning			
34	111		111			24	27	31½	33			P			
35	111		111			23	26	30	32½						
36	212		212			18	20	23					Thinning		
37	122		112			19½	21½	25	27						
38	111		112			22	25½	30½	33						
39	313	313				12	12					Thinning			
40	323	423				9	9					Thinning			
41	112	212				19½	21½					Thinning			
42	111		222			20½	23	25½					Thinning		
43	111		111			25	28	32	34			P			
44	222	222				18	20					Thinning			
45	323					10½					Thinning				
46	121		121			19	22	27	29						
47	111		111			27½	30	34	36			P			
48	121		121			26½	29	32	33½			P			
49	111		112			20½	23	26	28						
50	212	313				16	16½					Thinning			
51	212	313				16	16½					Thinning			
52	413					6					Thinning				
53	112		112			19	21	24½	26						
54	111					24					Thinning				
55	122		213			18	20½	23½					Thinning		
56	111	111				23	24					Thinning			
57	111		111			31½	34½	38½	40½			P			
58	111		112			20½	24	29	31½						
59	111		111			25	28	33	34			P			
60	121		122			24	26½	30	31½						
61	542					6½					Thinning				
62	223	223				13	13½					Thinning			
63	121		111	112		23	25½	30½	32					Thinning	
64	111	111				23½	26½					Thinning			
65	121		112	112		21	24	28	30					Thinning	
66	323	323				11½	12					Thinning			
67	111		111	112		20½	24	28	30½					Thinning	

F.C. Sample Plot Form No. 3

GENERAL REGISTER

Sheet II

Sample Plot No. *W.38*
Species : *Abies grandis*

Date of Measurement : Initials
1. *August, 1948* *P.M.*
2. *June, 1951* *D.H.*
3. *September, 1954* *C.A.*
4. *January, 1957* *E.H.*
5. .....

Tree No.	Tree Class					Girth (inches)					Remarks *P = pruned to 30 feet*				
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
68	111		111			24	27	31	32½						
69	111		111			24½	27	30	31½			P			
70	111		111			23½	27	32	34½						
71	313	313				9	9½					Thinning			
72	112		212			15½	17½	20	21						
73	121	223				19	20½					Thinning			
74	111		111			19	21½	25	27						
75	222	323				14	14½					Thinning			
76	111		111	112		23	25½	29½	31					Thinning	
77	121	122				19	21					Thinning			
78	222	222				15½	16½					Thinning			
79	111		111			23	26	29½	31			P			
80	111	212				15½	17					Thinning			
81	111		212	313		16	17½	19½	20½					Thinning	
82	111		111			27½	30½	36	38½						
83	111		212	322		19	20½	23	24					Thinning	
84	221	221				19	20					Thinning			
85	222		313	413		13	14	14½	15½					Thinning	
86	111		112	222		19½	21½	23½	24½					Thinning	
87	111		111			25½	29	32½	34			P			
88	121		111			26	28½	32½	34½			P			
89	111		111			25	27	31½	33½			P			
90	121		121			25½	28½	33½					Thinning		
91	121	122				22½	24					Thinning			
92	212	212				17	19					Thinning			
93	111		111			26½	29½	33	35			P			
94	111		112			19½	22	25½	27						
95	212		112			18	20½	24	26						
96	222		212			16	18	22					Thinning		
97	111		111			27	30	35½	37½			P			
98	213	213				14½	16					Thinning			

WORKED EXAMPLE A : THIRTEENTH PAGE

(Reverse of Form 3, Sheet II)

GENERAL REGISTER

Tree No.	Tree Class					Girth (inches)					Remarks				
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
99	111		111			21	23½	27½	29						
100	121	121				24½	25½					Thinning			
101	111		112			23½	26	29	30½						
102	111		111			27	30½	34	36			P			
103	211	211				20	21					Thinning			
104	111		121			28½	31½	37	39			P			
105	212	313				14	14½								
106	111		111			28½	32	37	39½			P			
107	111		111			34	37	42	44			P			
108	111		112	122		21½	24	27	29					Thinning	
109	121		121			30	32	35					Thinning		
110	212		212	322		16	17	18½	19½					Thinning	
111	222		213			16½	19	22½	24						
112	112	222				17½	18½					Thinning			
113	222		212			17	18	19½	20½						
114	111		111			28	31	34½	36			P			
115	212	212				16	17½					Thinning			
116	122		122			18½	21	22½	23						
117	122					16½					Thinning				
118	111		111			23½	26	30	32			P			
119	212		212			17	19½	21½					Thinning		
120	121	132				20½	22½					Thinning			
121	111	212				20½	21½					Thinning			
122	112		212			17	19	21	22						
123	111		111	112		26½	28½	30	31					Thinning	
124	212	313				14	14½					Thinning			
125	111		111			25	27	30½					Thinning		
126	211		222			18	20	22½	24						
127	111		111			28	30½	34½	36			P			
128	111		111			22	24	26½	27½						
129	121	222				22½	25					Thinning			
130	112	212				17½	18½					Thinning			
131	111	112				25½	27½					Thinning			
132	111		111			27	30	34½	36½			P			
133	211		112	322		19½	21½	23	23½					Thinning	
134	121	121				30½	33					Thinning			

F.C. Sample Plot Form No. 3

GENERAL REGISTER

Sheet III

Sample Plot No. *W.38*
Species : *Abies grandis*

Date of Measurement :	Initials
1. *August, 1948*	*P.M.*
2. *June, 1951*	*D.H.*
3. *September, 1954*	*C.A.*
4. *January, 1957*	*E.H.*
5.	

Tree No.	Tree Class					Girth (inches)					Remarks *P = pruned to 30 feet*				
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
135	111		112			29	31½	35	37			P			
136	121	122				21	22					Thinning			
137	121		121			29	31½	35	37			P			
138	111		111			27	29½	33	35			P			
139	121		121			25½	28½	32½					Thinning		
140	111		111			22	25½	31½	33½			P			
141	121	121				21½	23					Thinning			
142	212		313			15½	17	18½	19						
143	111		111			34½	39½	44½	44½			P		Blown 12/1954	
144	122		223			19	22	23½					Thinning		
145	213	213				13	13½					Thinning			
146	111		111			30	34	38½	41			P			
147	111		111			29½	32½	36½	38½			P			
148	221	221				20½	22					Thinning			
149	122	122				20	23					Thinning			
150	112		212	212		18½	20½	23½	25					Thinning	
151	223		213	313		16½	17½	19	20					Thinning	
152	111		112			22½	25	28½	30						
153	212		112			20	22½	25½	27						
154	221		222			19½	23	25					Thinning		
155	111		111			28½	32½	37	39			P			
156	111		111			21½	24½	27½	29½						
157	111		111			34	36½	40	42			P			
158	111		111			26½	29	31½					Thinning		
159	111		111			28½	31½	35	36½			P			
160	212		313	423		17	18	18½	19					Thinning	
161	112		112			18½	21	24					Thinning		
162	212		313	413		12½	13	14	14½					Thinning	
163	112	112				20	22					Thinning			
164	213					11½					Thinning				
165	211		213	313		18	19½	21	22					Thinning	

WORKED EXAMPLE A : FIFTEENTH PAGE

(Reverse of Form 3, Sheet III)

GENERAL REGISTER

Tree No.	Tree Class					Girth (inches)					Remarks				
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
166	*111*		*111*			*27*	*30*	*35*	*38*			*P*			
167	*112*	*112*				*19½*	*21*					*Thinning*			
168	*111*		*111*			*32*	*35½*	*41*	*43½*						
169	*212*		*212*			*15*	*16½*	*18*					*Thinning*		
170	*111*		*112*			*22*	*24½*	*27*	*28½*						
171	*111*		*111*			*25½*	*29½*	*35½*	*38½*						
172	*111*		*111*			*26*	*30*	*34*	*36*			*P*			
173	*212*					*13*					*Thinning*				
174	*313*	*323*				*8½*	*9*					*Thinning*			
175	*333*	*333*				*9*	*9*					*Thinning*			
176	*121*		*112*			*19*	*23*	*27*	*29*						
177	*423*	*423*				*7*	*7*					*Thinning*			
178	*111*		*121*			*25*	*28½*	*32*	*33½*			*P*			

(See paras. 46, 47, page 11 ; paras. 64, 66, 68, pages 13 & 14 ; paras. 77, 83, page 16)

F.C. Sample Plot Form No. 3a.

GIRTHING SHEET

Sheet I

Plot No. : *W.38* Area : *0·320 acres* Location : *Cpt. 75 Gwydyr*

Species : *Abies grandis* Date : *August, 1948*

Initials : *P.M.* Checked by : *J.N.R.J.*

Girth Class (inches)	Number of Trees		Total		Basal Area (square feet q.g.)		Main Crop Heights (feet)
	Main Crop	*Thinnings*	Main Crop	Thinnings	Main Crop	Thinnings	
Trees under 4 inches					—	—	
6 ½	[52] [61]			1 1		·016 ·018	
7 ½	177		1				
8 ½	174		1				
9 ½	40, 71, 175	I III	3	1 3		·035 ·118	39
10 ½	[24] [45]	II I		2 3		·087 ·144	
11 ½	17 66, [164]	I	1 1	1 1		·053 ·057	
12 ½	39 162	IIII III	1 1	4 3		·250 ·203	41
13 ½	62, 85, 145, [173]	II IIII I	3	3 6		·220 ·475	
14 ½	18, 75, 105, 124 19, 98	III II	4 2	3 2		·255 ·183	40
15 ½	10, 169 72, 78, 80, 142	IIII I I	2 4	6 1		·586 ·104	45
16 ½	4, 50, 51, 81, 96, 110, 115 25, 29, 31, 111, [117], 151	IIII II III	7 5	7 4		·778 ·473	40 44
17 ½	26, 28, 92, 113, 119, 122, 160 9, 112, 130	II II	7 3	2 2		·251 ·266	47 44
18 ½	36, 44, 55, 95, 126, 165 21, 116, 150, 161	IIII I	6 4	4 1		·563 ·149	46
19 ½	46, 53, 73, 74, 77, 83, 84, 144, 176 [23], 37, 41, 86, 94, 133, 154, 167	II	9 7	2 1		·313 ·165	45, 48 49
20 ½	103, 149, 153, 163 3, 14, 42, 49, 58, 67, 120, 121, 148	I	4 9	1		·174	48 48
21 ½	32, 65, 99, 136 8, 108, 141, 156	I	4 4	1		·191	50 49
22 ½	6, 38, 128, 140, 170 2, 11, 20, [22], 33, 91, 129, 152	I	5 7	1 1		·210 ·220	51, 49
23 ½	7, 15, 35, 56, 63, 76, 79 [5], 13, 27, 64, 70, 101, 118	III III	7 6	3 4		·689 ·959	52 52
	Totals : *Carried fwd.*		118	75		8·205	
	Average Basal Area :				—	—	
	Average Girth :				—	—	

F.C. Sample Plot Form No. 3a;

GIRTHING SHEET

Sheet II

Plot No. : *W.38* Area : *0·320 acres* Location : *Cpt. 75 Gwydyr*
Species : *Abies grandis* Date : *August 1948*
Initials : *P.M.* Checked by : *J.N.R.J.*

Girth Class (inches)	Number of Trees: Main Crop	Number of Trees: Thinnings	Total: Main Crop	Total: Thinnings	Basal Area (square feet q.g.): Main Crop	Basal Area (square feet q.g.): Thinnings	Main Crop Heights (feet)
Trees under 4 inches		*Brought fwd.*	*118*	*75*	—	— *8·205*	
24 ½	*1, 34, [54], 60, 68* *69, 100*		*4* *2*	*1*		*·250*	*51*
25 ½	*43, 59, 89, 125, 178* *87, 90, 131, 139, 171*	*1* *1*	*5* *5*	*1* *1*		*·271* *·282*	*53*
26 ½	*88, [172* *30, 48, 93, 123, 158*		*2* *5*				*52* *53*
27 ½	*97, 102, 132, 138, 166* *47, 82*	*11* *1*	*5* *2*	*2* *1*		*·633* *·328*	*55*
28 ½	*114, 127* *16, 104, 106, 155, 159*		*2* *5*				*58*
29 ½	*137, 135* *147*		*2* *1*				*52*
30 ½	*12, 109, 146* *134*		*3* *1*				*54, 53, 55* *56*
31 ½	*57*	*1*	*1*	*1*		*·417*	*55*
32 ½	*168*		*1*				*58*
33 ½							
34 ½	*107, 157* *143*		*2* *1*				*50, 52 (fk, top)* *58*
	Totals :		*167*	*82*		*10·386*	*(10·352 8½ inches and over)*
	Average Basal Area :					*·127*	
	Average Girth :					*17*	

NOTE :

The tree numbers underlined once are the sample of 30 trees selected for height measurement ; the 10 largest girthed trees in the plot, which are also measured for height, have *not* been underlined except where they form part of the sample of 30 trees.

The tree numbers underlined twice are the ten trees which comprise the sample for volume measurement.

Any trees which were removed as thinnings after the trees in the plot had been numbered and the other thinnings felled are indicated by a square [ ] bracket around the tree number.

The commencement of the group containing the 100 largest girthed trees per acre is indicated by a single large square bracket sign—[172. (See paragraph 79, page 16, and also Worked Example A, thirty-second page. p. 81.)

WORKED EXAMPLE A : EIGHTEENTH PAGE

(See para. 51, page 12 ; para. 84, page 16)

F.C. Sample Plot Form 3b.

Plot No. : *W.38* Location : *Cpt. 75 Gwydyr* Initials : *P.M.*

Species : *Abies grandis* Date : *August, 1948* Checked by : *S.A.D.*

TREE CLASSIFICATION

Stem and Crown	Canopy 1	Per cent	2	Per cent	3	Per cent	4	Per cent	Dead Trees Canopy and Stem	5	Per cent
1^1	*82*	*33*	*7*	*3*					1^1		
1^2	*14*	*6*	*35*	*14*	*1*	—			1^2		
1^3			*4*	*2*	*10*	*4*	*1*	—	1^3		
2^1	*35*	*14*	*3*	*1*					2^1		
2^2	*8*	*3*	*23*	*9*	*4*	*2*			2^2		
2^3			*11*	*4*	*5*	*2*	*1*	—	2^3		
3^1									3^1		
3^2									3^2		
3^3					*3*	*1*	*1*	—	3^3		
—									4^1		
—									4^2	*1*	—
—									4^3		
	139	*56*	*83*	*33*	*23*	*9*	*3*	—		*1*	—

2 per cent

Before Thinning *249*

Stem and Crown	Canopy 1	Per cent	2	Per cent	3	Per cent	4	Per cent	Dead Trees Canopy and Stem	5	Per cent
1^1	𝍸 𝍸 10	*12*	11 2	*2*					1^1		
1^2			𝍸 𝍸 𝍸 𝍸 15	*19*	1 1	*1*			1^2		
1^3			11 2	*2*	𝍸 11 7	*8*	1 1	*1*	1^3		
2^1	𝍸 111 8	*10*							2^1		
2^2	111 3	*4*	𝍸 𝍸 𝍸 𝍸 15	*19*	111 3	*4*			2^2		
2^3			𝍸 111 8	*10*	111 3	*4*			2^3		
3^1									3^1		
3^2									3^2		
3^3					11 2	*2*	1 1	*1*	3^3		
—									4^1		
—									4^2	1 1	*1*
—									4^3		
	21	*26*	*42*	*52*	*16*	*19*	*2*	*2*		*1*	*1*

Thinnings *82*

F.C. Sample Plot Form 3b—*continued*

Stem and Crown	Canopy 1	Per cent	2	Per cent	3	Per cent	4	Per cent
1^1	*71*	*42*	*5*	*3*				
1^2	*14*	*8*	*20*	*12*				
1^3			*2*	*1*	*4*	*2*		
2^1	*27*	*16*	*3*	*2*				
2^2	*5*	*3*	*8*	*5*	*1*	*1*		
2^3			*3*	*2*	*2*	*1*	*1*	*1*
3^1								
3^2								
3^3					*1*	*1*		
	117	*69*	*41*	*25*	*8*	*5*	*1*	*1*

Main Crop *167*

Note. All parts of Form 3b normally fall on one page.

WORKED EXAMPLE A : TWENTIETH PAGE

(See paras. 69, 70, page 14 ; paras. 96a, 97, 102, pages 18 & 19)

F.C. Sample Plot Form No. 4.

MEASUREMENTS OF SAMPLE TREES

Sample Plot No. : *W.38* Species : *Abies grandis* Initials : *D.E.E.*
Checked by : *S.A.D.* Date : *July, 1948*

Tree No.	Girth at 4ft. 3ins. inches	Total Height feet	Timber Height feet	½ T.H. Girth, O.B. inches	½ T.H. Girth, U.B. inches	Volume O.B. hoppus feet	Volume U.B. hoppus feet	Lower Crown feet	Upper Crown feet	Crown %	Crown Width feet
162	*12½*	*41*	*20*					*14*	*17*	*62*	*5*
51	*16*	*40*	*26*					*15*	*18*	*59*	*7*
112	*17½*	*44*	*32*					*17*	*20*	*58*	*6*
84	*19*	*48*	*33*					*15*	*19*	*65*	*7*
58	*20½*	*48*	*32*					*12*	*16*	*71*	*8*

Basal Area (square feet q.g.)	Tree No.	Length of Section feet	Girth O.B. inches	Girth U.B. inches	Volume O.B. hoppus feet	Volume U.B. hoppus feet	Bark %	Form Factor O.B.	Remarks
	162	*20 10*	*12½*	*12*	*·68*	*·63*			
		10	*11*	*10½*	*·53*	*·48*			
·068					*1·21*	*1·11*	*8½*	*·434*	
	51	*26 10*	*15½*	*14½*	*1·04*	*·91*			
		16	*12½*	*12*	*1·09*	*1·00*			
·111					*2·13*	*1·91*	*10½*	*·480*	
	112	*32 10*	*17½*	*16½*	*1·33*	*1·18*			
		10	*15*	*14*	*·98*	*·85*			
		12	*12*	*11*	*·75*	*·63*			
·133					*3·06*	*2·66*	*13*	*·523*	
	84	*33 10*	*18½*	*17½*	*1·49*	*1·33*			
		10	*15½*	*14½*	*1·04*	*·91*			
		13	*12½*	*12*	*·88*	*·81*			
·157					*3·41*	*3·05*	*10½*	*·452*	
	58	*32 10*	*20*	*19*	*1·74*	*1·57*			*Crooked stem*
		10	*17*	*16*	*1·25*	*1·11*			
		12	*13*	*12*	*·88*	*·75*			
·182					*3·87*	*3·43*	*11½*	*·443*	
				Average Crown % = 65 *Average Bark % = 10*					

WORKED EXAMPLE A : TWENTY-FIRST PAGE

(Reverse of Form 4)

Tree No.	Girth at 4ft. 3ins. inches	Total Height feet	Timber Height feet	½ T.H. Girth, O.B. inches	½ T.H. Girth, U.B. inches	Volume O.B. hoppus feet	Volume U.B. hoppus feet	Lower Crown feet	Upper Crown feet	Crown %	Crown Width feet
2	22½	51	38					14	18	69	8
101	23½	52	36					16	19	66	8
88	26	52	39					16	20	65	7
106	28½	58	41					15	20	70	9
107	34	50	38					14	21	65	10

Basal Area (square feet q.g.)	Tree No.	Length of Section feet	Girth O.B. inches	Girth U.B. inches	Volume O.B. hoppus feet	Volume U.B. hoppus feet	Bark %	Form Factor O.B.	Remarks
	2	38 10	22	21	2·10	1·91			
		10	19	18	1·57	1·41			
		18	13½	12½	1·42	1·22			
·220					5·09	4·54	11	·454	
	101	36 10	23	22	2·30	2·10			
		10	19	18	1·57	1·41			
		16	14	13½	1·36	1·27			
·240					5·23	4·78	8½	·419	
	88	39 10	25½	24	2·82	2·50			
		10	21½	20½	2·01	1·82			
		19	14½	13½	1·73	1·50			
·293					6·56	5·82	11½	·431	
	106	41 10	28	27	3·40	3·16			
		10	23	22	2·30	2·10			
		10	18½	17½	1·49	1·33			
		11	12½	12	·75	·69			
·353					7·94	7·28	8½	·388	
	107	38 10	33½	32	4·87	4·44			
		10	27	26	3·16	2·93			
		18	15½	14½	1·88	1·64			
·502					9·91	9·01	9	·395	
Totals 2·259					48·41	43·59			
Means ·226					4·84				

(See paras. 53, 54, 58, pages 12 & 13 ; paras. 85, 86, 88, 90, page 17)

Sample Plot Form No. 4a.

MEASUREMENTS OF THINNINGS

SAMPLE

Sheet I

Sample Plot No. : *W.38* Species : *Abies grandis* Initials : *R.L.*

Date : *August, 1948* Checked by : *P.M.*

[Tree No.] *Basal Area square feet q.g.*	Girth at 4ft. 3ins. inches	Total Height feet	Timber Height feet	½ Ti.H. Girth O.B. inches	½ Ti.H. Girth U.B. inches	Volume O.B. hoppus feet	Volume U.B. hoppus feet	Remarks *C.S. = crooked stem*
·230	23	50	35 10	22½	21½	2·20	2·01	
			10	18½	17½	1·49	1·33	
			15	13½	13	1·19 4·88	1·10 4·44	
·111	16	43	23 10	15½	14½	1·04	·91	
			13	12	11½	·81 1·85	·75 1·66	
·174	20	46	35 10	20	19	1·74	1·57	
			10	17½	17	1·33	1·25	
			15	12½	12	1·02 4·09	·94 3·76	
·063	12	40	19	11½	11	1·09	1·00	
·191	21	48	31 10	20½	19½	1·82	1·65	
			10	16½	15½	1·18	1·04	
			11	12½	12	·75 3·75	·69 3·38	
·043	10	33	5	10½	10	·24	·22	
·079	13½	40	18	12	11½	1·13	1·03	
·141	18	46	30 10	17½	16½	1·33	1·18	
			10	15½	14½	1·04	·91	
			10	12	11½	·63 3·00	·57 2·66	
·079	13½	43	25 10	13	12	·73	·63	
			15	11	10½	·79 1·52	·72 1·35	
·098	15	43	22 10	15	14	·98	·85	
			12	12	11½	·75 1·73	·69 1·54	
·210	22	45	30 10	21½	20½	2·01	1·82	C.S.
			10	18	17	1·41	1·25	
			10	14	13½	·85 4·27	·79 3·86	

WORKED EXAMPLE A : TWENTY-THIRD PAGE

(Reverse of Sample Plot Form No. 4a, Sheet I)

[Tree No.] *Basal Area square feet q.g.*	Girth at 4ft. 3ins inches	Total Height feet	Timber Height feet	½ Ti.H. Girth O.B. inches	½ Ti.H. Girth U.B. inches	Volume O.B. hoppus feet	Volume U.B. hoppus feet	Remarks
·271	25	45	32 10	24	23	2·50	2·30	
			10	19½	18½	1·65	1·49	
			12	14	13½	1·02 5·17	·95 4·74	
·125	17	50	32 10	17	16	1·25	1·11	
			10	15	14	·98	·85	
			12	12	11½	·75 2·98	·69 2·65	
·068	12½	36	16	12	11½	1·00	·92	
·068	12½	36	16	12	11½	1·00	·92	
·063	12	41	17	11½	11	·98	·89	
·104	15½	45	28 10	15½	14½	1·04	·91	C.S.
			18	13	12½	1·32 2·36	1·22 2·13	
·282	25½	53	39 10	25½	24	2·82	2·50	C.S.
			10	21½	20½	2·01	1·82	Stain
			19	15	14	1·86 6·69	1·62 5·94	
·048	10½	36	9	10½	10	·43	·39	C.S.
·141	18	47	28 10	17½	16½	1·33	1·18	
			18	13½	13	1·42 2·75	1·32 2·50	
·098	15	42	25 10	15	14	·98	·85	Damaged top
			15	12	11½	·94 1·92	·86 1·71	
·085	14	44	22 10	14	13½	·85	·79	
			12	12	11½	·75 1·60	·69 1·48	
·118	16½	50	32 10	16½	15½	1·18	1·04	Stain
			10	15	14	·98	·85	
			12	12	11½	·75 2·91	·69 2·58	
·230	23	44	35 10	22½	21½	2·20	2·01	C.S.
			10	19½	18½	1·65	1·49	
			15	15	14½	1·47 5·32	1·37 4·87	
·053	11	17	6	12½	12	·41	·38	

Sample Plot Form No. 4a.

MEASUREMENTS OF THINNINGS

SAMPLE

Sheet II

Sample Plot No. : *W.38* Species : *Abies Grandis* Initials : *R.L.*

Date : *August, 1948* Checked by : *P.M.*

[Tree No.] *Basal Area square feet q.g.*	Girth at 4ft. 3ins. inches	Total Height feet	Timber Height feet	½ Ti.H. Girth O.B. inches	½ Ti.H. Girth U.B. inches	Volume O.B. hoppus feet	Volume U.B. hoppus feet	Remarks
·111	16	40	26 10	15½	14½	1·04	·91	
			16	12½	12	1·09 2·13	1·00 1·91	
·091	14½	43	26 10	14½	13½	·91	·79	
			16	11½	11	·92 1·83	·84 1·63	
·039	9½	30	4	11	10½	·21	·19	
·316	27	52	40 10	26½	25½	3·05	2·82	
			10	22½	21½	2·20	2·01	
			10	18½	17½	1·49	1·33	
			10	12½	12	·68 7·42	·63 6·79	
Totals 3·730						74·66	67·52	

Total volume of thinnings = $\frac{74 \cdot 66 \times 10 \cdot 352}{3 \cdot 730}$

= *207·21 hoppus feet O.B.*

Total number of thinnings = *82*

Total volume over bark = *207·21 hoppus feet.*

Bark per cent = *9½*

Total basal area = *10·386 square feet q.g.*

Average basal area = *·127 square feet q.g.*

Average girth = *17 inches.*

F.C. Sample Plot Form No. 5.

HEIGHT ANALYSES OF SAMPLE TREES

Sample Plot No. : *W.38* Species : *Abies grandis* Date : *7 August, 1948*
Initials : *R.L.* Checked by : *S.A.D.*

Sample Tree No. *A* ..... Girth (inches) *27*

Height	*0*	*8*	*16*	*24*	*32*	*40*	*48*	*55*	
No. of Rings	*22*	*18*	*15*	*12*	*9*	*6*	*3*	*0*	
Age	*0*	*4*	*7*	*10*	*13*	*16*	*19*	*22*	

Length (in inches) of Leading Shoots .....

Sample Tree No. *B* (*Tree No. 22*) ..... Girth (inches) *22½*

Height	*0*	*8*	*16*	*24*	*32*	*40*	*48*	*54*	
No. of Rings	*22*	*18*	*15*	*12*	*9*	*6*	*3*	*0*	
Age	*0*	*4*	*7*	*10*	*13*	*16*	*19*	*22*	

Length (in inches) of Leading Shoots .....

Sample Tree No. *C* ..... Girth (inches) *25½*

Height	*0*	*8*	*16*	*24*	*32*	*40*	*48*	*53*	
No. of Rings	*22*	*16*	*13*	*11*	*8*	*5*	*3*	*0*	
Age	*0*	*6*	*9*	*11*	*14*	*17*	*19*	*22*	

Length (in inches) of Leading Shoots .....

Sample Tree No. .....

Height									
No. of Rings									
Age									

Length (in inches) of Leading Shoots .....

(See paras. 78, 82, page 16 ; para. 94, page 18 ; paras. 105, 106, pages 19 & 20)

F.C. Sample Plot Form No. 6.

VOLUME CALCULATION

Sheet I

Sample Plot No. *W.38* Date : *August, 1948*

Initials : *P.M.* Checked by : *J.N.R.J.*

Girth Class	By Girth Classes		By Groups							
	Number of Trees	Basal Area	Number of Trees	Basal Area	Mean Basal Area	Mean Girth	Mean Height	Mean Volume Over Bark	Total Volume Over Bark	Form Factor
Inches		square feet q.g.		square feet q.g.	square feet q.g.	Inches	Feet	hoppus feet	hoppus feet	
Trees under 4 inches : Recruitment :										
7	*1*	*·021*	*1*	*·021*						
8½	*1*	*·031*								
9	*3*	*·105*								
11	*1*	*·053*								
11½	*1*	*·057*								
12	*1*	*·063*								
12½	*1*	*·068*								
13	*3*	*·220*								
14	*4*	*·340*								
14½	*2*	*·183*								
15	*2*	*·195*								
15½	*4*	*·417*								
16	*7*	*·778*								
16½	*5*	*·591*								
17	*7*	*·878*								
17½	*3*	*·399*								
18	*6*	*·844*								
18½	*4*	*·594*								
19	*9*	*1·410*								
19½	*7*	*1·155*								
20	*4*	*·694*								
20½	*9*	*1·642*								
21	*4*	*·766*								
21½	*4*	*·803*								
Total and means of trees 8½ inches and over : Total and means of plot : Total and means of 100 largest girthed trees per acre :										

F.C. Sample Plot Form No. 6.

VOLUME CALCULATION

Sheet II

Sample Plot No. : *W.38* Date : *August, 1948*

Initials : *P.M.* Checked by : *J.N.R.J.*

Girth Class Inches	By Girth Classes: Number of Trees	By Girth Classes: Basal Area square feet q.g.	By Groups: Number of Trees	By Groups: Basal Area square feet q.g.	By Groups: Mean Basal Area square feet q.g.	By Groups: Mean Girth Inches	By Groups: Mean Height Feet	By Groups: Mean Volume Over Bark hoppus feet	By Groups: Total Volume Over Bark hoppus feet	Form Factor
Trees under 4 inches : Recruitment :										
22	*5*	*1·050*								
22½	*7*	*1·538*								
23	*7*	*1·607*								
23½	*6*	*1·438*								
24	*4*	*1·000*								
24½	*2*	*·521*								
25	*5*	*1·356*								
25½	*5*	*1·411*								
26	*1*	*·293*	*134*	*22·500*						
*										
26	*1*	*·293*								
26½	*5*	*1·524*								
27	*5*	*1·582*								
27½	*2*	*·656*								
28	*2*	*·681*								
28½	*5*	*1·763*								
29	*2*	*·730*								
29½	*1*	*·378*								
30	*3*	*1·172*								
30½	*1*	*·404*								
31½	*1*	*·431*								
32	*1*	*·444*								
34	*2*	*1·003*								
34½	*1*	*·517*	*32*	*11·578*						
Total and means of trees *8½* inches and over :			*166*	*34·078*	*·250*	*21½*	—	*4·45*	*738·70*	—
Total and means of plot :			*167*	*34·099*	*·204*	*21½*	*50*	—	*738·70*	*·433*
Total and means of 100 largest girthed trees per acre :			*32*	*11·578*	*·362*	*29*	*54*	—	—	—

* *Note.* These two lines have been left blank to indicate the commencement of the group containing the 100 largest girthed trees per acre. (See para. 79, page 16.)

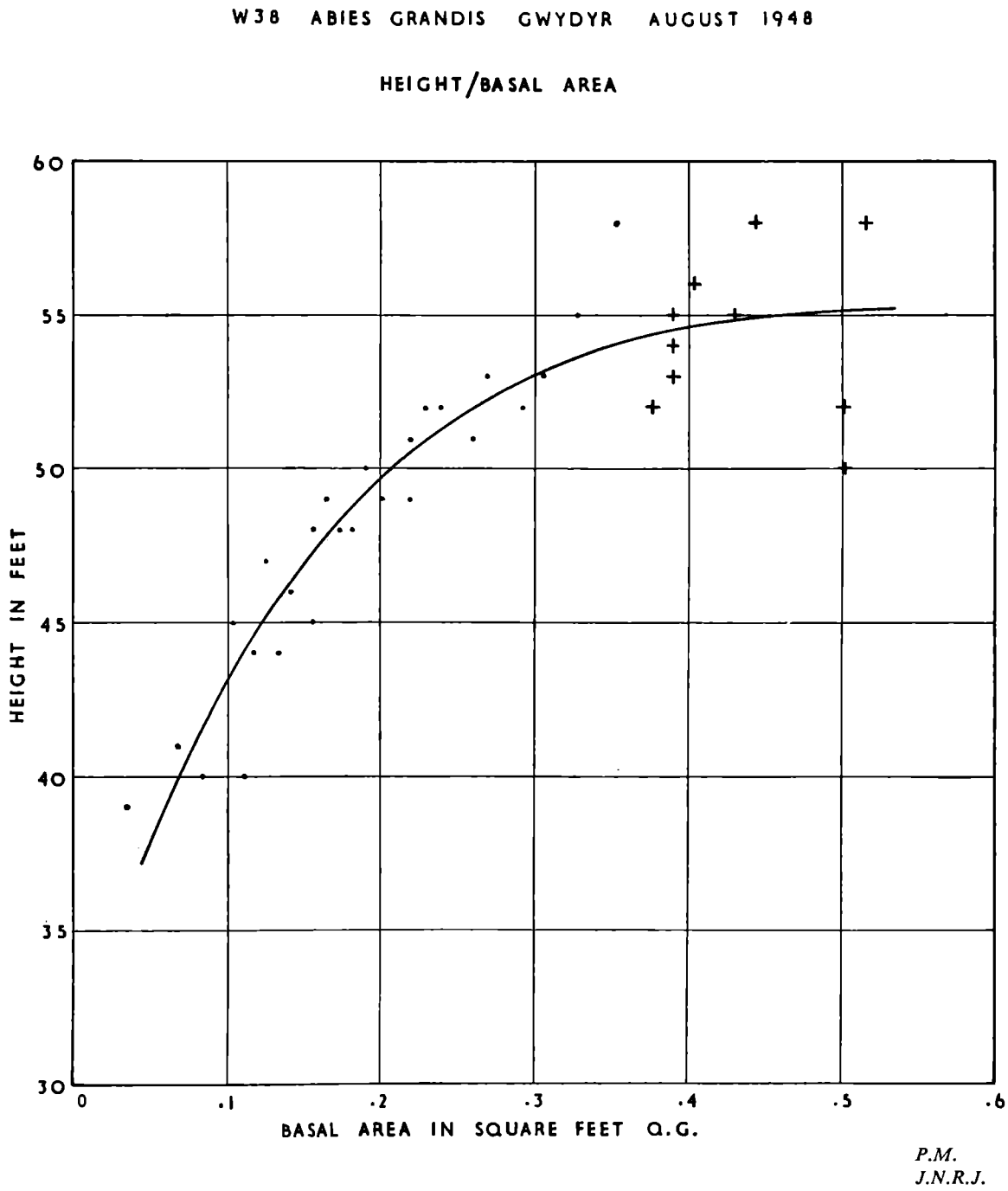
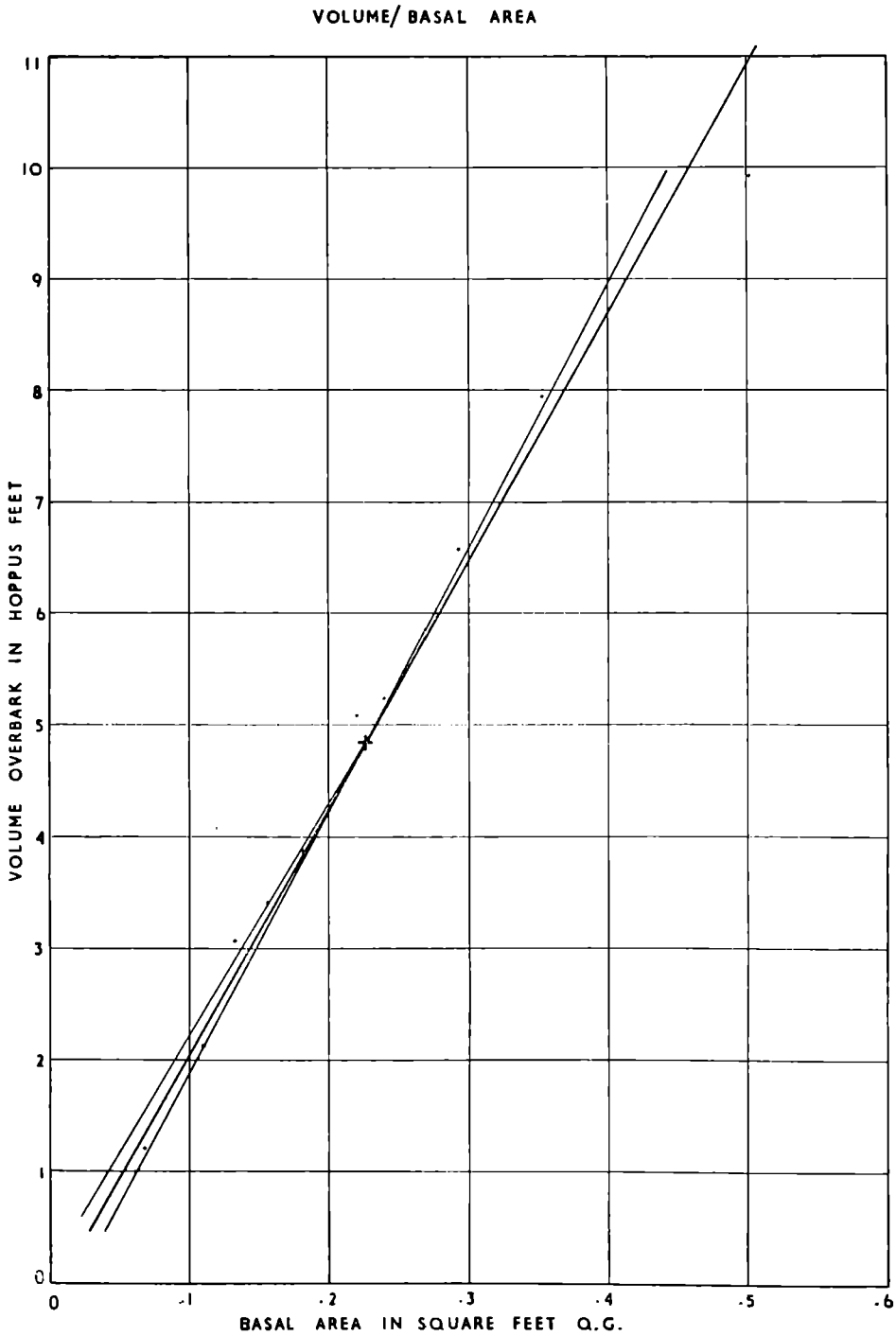


FIGURE 8. Worked Example A : Twenty-eighth page. (See para. 93, page 18.)

WORKED EXAMPLE A : TWENTY-NINTH PAGE

W38 ABIES GRANDIS GWYDYR AUGUST 1948



P.M.
J.N.R.J.

FIGURE 9. Worked Example A : Twenty-ninth page. (See para. 104, page 19 ; and Appendix VI, page 37.)

WORKED EXAMPLE A : THIRTIETH PAGE

W38 ABIES GRANDIS GWYDYR AUGUST 1948

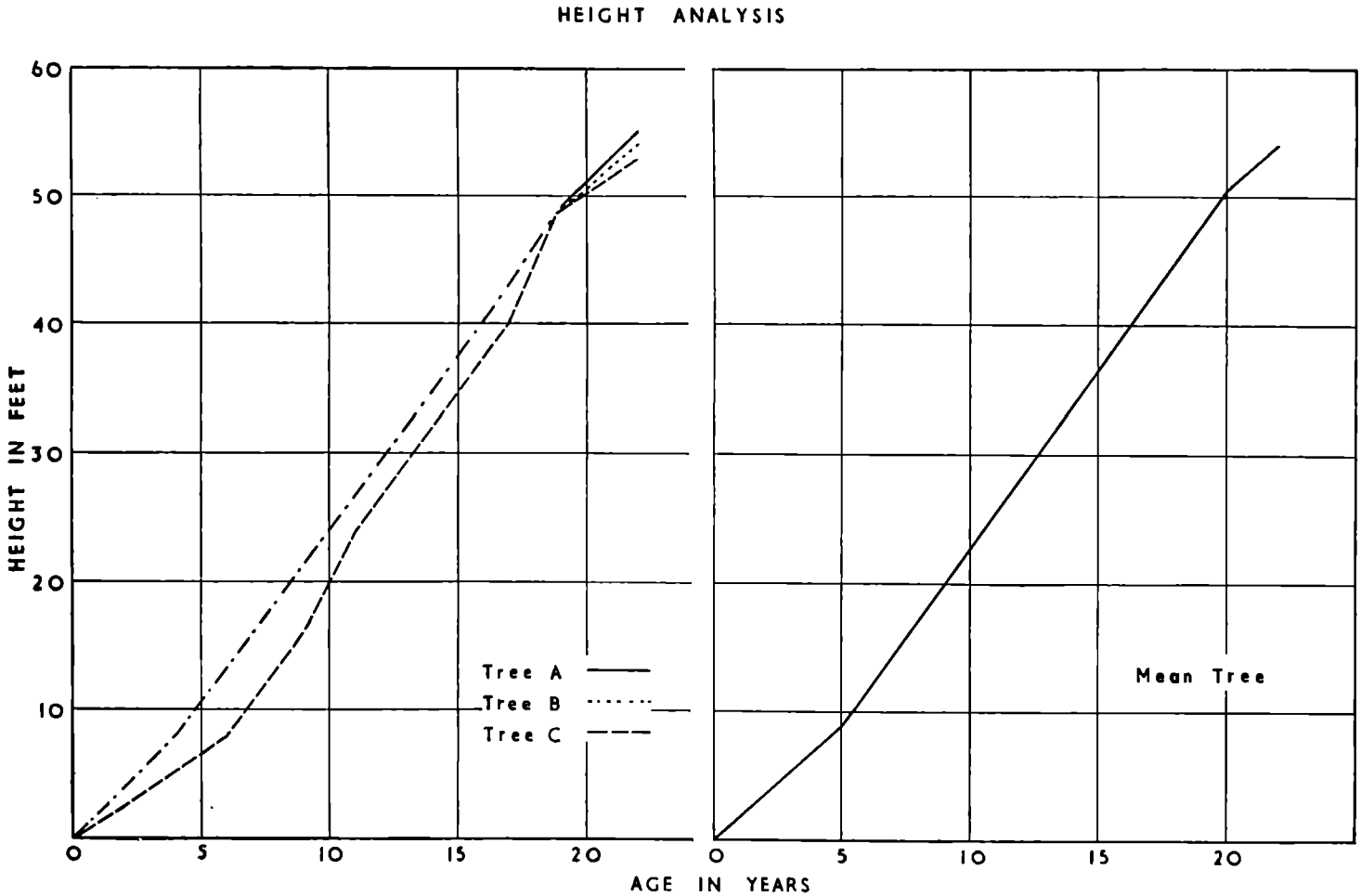


FIGURE 10. Worked Example A : Thirtieth page. (See para. 95, page 18.)
Note. Trees A and B have identical curves up to 48 feet, and then diverge.

R.L.
S.A.D.

WORKED EXAMPLE A : THIRTY-FIRST PAGE

(See para. 47, page 11 ; paras. 78–83, page 16)

F.C. Sample Plot Form No. 3a.

GIRTHING SHEET

Sheet I

Plot No. : *W.38* Area : *0·320 acres* Location : *Cpt. 75 Gwydyr*
Species : *Abies grandis* Date : *January, 1957*
Initials : *E.H.* Checked by : *D.K.*

Girth Class (inches)	Number of Trees	Total		Basal Area (square feet q.g.)		Main Crop Heights (feet)
		Main Crop	Thinnings	Main Crop	Thinnings	
Trees under 4 inches				—	—	
14½	*(162)*		*1*		*·091*	
15 ½	*(85)*		*1*		*·104*	
16 ½						
17 ½						
18 ½	*18*	*1*		*·149*		
19 ½	*(29), 142, (160)* *(110)*	*1*	*2* *1*	*·157*	*·313* *·165*	
20 ½	*10, (151)* *(81), 113*	*1* *1*	*1* *1*	*·174* *·182*	*·174* *·182*	
21 ½	*72*	*1*		*·191*		
22 ½	*122, (165)*	*1*	*1*	*·210*	*·210*	
23 ½	*116* *(133)*	*1*	 *1*	*·230*	 *·240*	
24 ½	*(83), 111, 126* *(26), 31 (86)*	*2* *1*	*1* *2*	*·500* *·261*	*·250* *·521*	
25 ½	*(9), (150)*		*2*		*·543*	
26 ½	*53, 95* *21*	*2* *1*		*·587* *·305*		
27 ½	*37, 74, 94, 153* *3, 8, 128*	*4* *3*		*1·266* *·985*		
28 ½	*6, 49* *170*	*2* *1*		*·681* *·353*		
29 ½	*(14), 46, 99, (108), 176* *156*	*3* *1*	*2*	*1·095* *·378*	*·730*	
	Totals : *carried forward*	*27*	*16*	*7·704*	*3·523*	
	Average Basal Area :			—	—	
	Average Girth :			—	—	

F.C. Sample Plot Form No. 3a.

GIRTHING SHEET

Sheet II

Plot No. : *W.38* Area : *0·320 acres* Location : *Cpt. 75 Gwydyr*
Species : *Abies grandis* Date : *January, 1957*
Initials : *E.H.* Checked by : *D.K.*

Girth Class (inches)	Number of Trees	Total		Basal Area (square feet q.g.)		Main Crop Heights (feet)
		Main Crop	Thinnings	Main Crop	Thinnings	
Trees under 4 inches	*Brought forward :—*	*27*	*16*	*7·704*	*3·523*	
30	*32, (65), 152*	*2*	*1*	*·781*	*·391*	
½	*(67), 101*	*1*	*1*	*·404*	*·404*	
31	*7, (76), 79, (123)*	*2*	*2*	*·834*	*·834*	
½	*27, 58, 60, 69*	*4*		*1·723*		
32	*(63), 118*	*1*	*1*	*·444*	*·444*	
½	*15, 35, 68*	*3*		*1·375*		
33	*34, 38*	*2*		*·945*		
½	*1, 48, 89, 140, [178*	*4*		*1·948*		
		1		*·487*		
34	*43, 59, 87*	*3*		*1·505*		
½	*70, 88*	*2*		*1·033*		
35	*93, 138*	*2*		*1·063*		
½						
36	*47, 102, 114, 127, 172*	*5*		*2·813*		
½	*132, 159*	*2*		*1·156*		
37	*135, 137*	*2*		*1·188*		
½	*97*	*1*		*·610*		
38	*166*	*1*		*·627*		
½	*16, 82, 147, 171*	*4*		*2·573*		
39	*104, 155*	*2*		*1·320*		
½	*106*	*1*		*·677*		
40						
½	*12, 57*	*2*		*1·424*		
41	*146*	*1*		*·730*		
42	*157*	*1*		*·766*		
43½	*168*	*1*		*·821*		
44	*107*	*1*		*·840*		
	Totals :	*78*	*21*	*35·791*	*5·596*	
100 largest girthed trees per acre :						
Total basal area = 19·633 square feet q.g.	Average Basal Area :			*·459*	*·266*	
Average basal area = ·614 square feet q.g.						
Average girth = 37½ inches.	Average Girth :			*32½*	*25*	

WORKED EXAMPLE A : THIRTY-THIRD PAGE

(See paras. 50, 51, page 12 ; para. 84, page 16)

F.C. Sample Plot Form No. 3b.

Plot No. *W.38* Location : *Cpt. 75 Gwydyr* Species : *Abies grandis*
Date : *January, 1957* Initials : *V.W.* Checked by : *D.K.*

TREE CLASSIFICATION

Stem and Crown	Canopy 1	Per cent	2	Per cent	3	Per cent	4	Per cent	Dead Trees Canopy and Stem	5	Per cent
1^1									1^1		
1^2									1^2		
1^3									1^3		
2^1									2^1		
2^2									2^2		
2^3									2^3		
3^1									3^1		
3^2									3^2		
3^3									3^3		
—									4^1		
—									4^2		
—									4^3		

Before Thinning *99*

Stem and Crown	Canopy 1	Per cent	2	Per cent	3	Per cent	4	Per cent	Dead Trees Canopy and Stem	5	Per cent
1^1									1^1		
1^2	*5*	*24*	*2*	*9*	*1*	*5*			1^2		
1^3			*1*	*5*	*3*	*14*	*2*	*9*	1^3		
2^1									2^1		
2^2	*1*	*5*	*1*	*5*	*3*	*14*			2^2		
2^3					*1*	*5*	*1*	*5*	2^3		
3^1									3^1		
3^2									3^2		
3^3									3^3		
—									4^1		
—									4^2		
—									4^3		
	6	*29*	*4*	*19*	*8*	*38*	*3*	*14*			

Thinning *21*

F.C. Sample Plot Form 3b—*continued*

	Canopy							
Stem and Crown	1	Per cent	2	Per cent	3	Per cent	4	Per cent
1^1								
1^2								
1^3								
2^1								
2^2								
2^3								
3^1								
3^2								
3^3								

Main Crop
78

Note. All parts of Form 3b normally fall on one page.

WORKED EXAMPLE A : THIRTY-FIFTH PAGE

(See paras. 53, 56–58, pages 12 & 13 ; paras. 85–87, 90 (*a*), page 17)

Sample Plot Form No. 4a.

MEASUREMENTS OF THINNINGS

Sheet I

Sample Plot No. : *W.38* Species : *Abies grandis* Initials : *D.K.*

Date : *January, 1957* Checked by : *E.H.*

Tree No.	Girth at 4ft. 3ins. inches	Total Height feet	Timber Height feet	½ Ti.H. Girth O.B. inches	½ Ti.H. Girth U.B. inches	Volume O.B. hoppus feet	Volume U.B. hoppus feet	Remarks
9	*25*	*69*	*55 10*	*24½*		*2·61*		
			10	*22*		*2·10*		
			10	*20*		*1·74*		
			10	*17½*		*1·33*		
			15	*12½*		*1·02* *8·80*		
14	*29*	*71*	*57 10*	*28½*		*3·53*		
			10	*26*		*2·93*		
			10	*24*		*2·50*		
			10	*20½*		*1·82*		
			17	*14½*		*1·55* *12·33*		
29	*19*	*58*	*39 10*	*18½*		*1·49*		
			10	*17*		*1·25*		
			19	*12½*		*1·29* *4·03*		
26	*24½*	*65*	*51 10*	*24*		*2·50*		
			10	*21*		*1·91*		
			10	*19*		*1·57*		
			10	*16½*		*1·18*		
			11	*12½*		*·75* *7·91*		
63	*32*	*74*	*63 10*	*31½*		*4·31*		
			10	*29½*		*3·78*		
			10	*27*		*3·16*		
			10	*24*		*2·50*		
			10	*19½*		*1·65*		
			13	*12½*		*·88* *16·28*		
65	*30*	*69*	*55 10*	*29½*		*3·78*		
			10	*27*		*3·16*		
			10	*24*		*2·50*		
			10	*20½*		*1·82*		
			15	*13½*		*1·19* *12·45*		

WORKED EXAMPLE A : THIRTY-SIXTH PAGE

(Reverse of Form 4a, Sheet I)

Tree No.	Girth at 4ft. 3ins. inches	Total Height feet	Timber Height feet	½ Ti.H. Girth O.B. inches	½ Ti.H. Girth U.B. inches	Volume O.B. hoppus feet	Volume U.B. hoppus feet	Remarks
67	30½	75	60 10	30		3·91		
			10	28		3·40		
			10	26		2·93		
			10	22½		2·20		
			10	18½		1·49		
			10	12		·63 14·56		
76	31	74	60 10	31		4·17		
			10	28½		3·53		
			10	25½		2·82		
			10	23		2·30		
			10	18½		1·49		
			10	11½		·57 14·88		
81	20½	68	48 10	20		1·74		
			10	18		1·41		
			10	16		1·11		
			18	13		1·32 5·58		
83	24	69	54 10	23½		2·40		
			10	21		1·91		
			10	19½		1·65		
			10	17		1·25		
			14	12		·88 8·09		
85	15½	55	40 10	15		·98		
			10	13½		·79		
			10	12		·63		
			10	10		·43 2·83		
86	24½	66	51 10	24		2·50		
			10	21		1·91		
			10	19½		1·65		
			10	17		1·25		
			11	12½		·75 8·06		

Sample Plot Form No. 4a.

MEASUREMENT OF THINNINGS

Sheet II

Sample Plot No. : *W.38* Species : *Abies grandis* Initials : *D.K.*
Date : *January, 1957* Checked by : *E.H.*

Tree No.	Girth at 4ft. 3ins. inches	Total Height feet	Timber Height feet	½ Ti.H. Girth O.B. inches	½ Ti.H. Girth U.B. inches	Volume O.B. hoppus feet	Volume U.B. hoppus feet	Remarks
108	*29*	*72*	*58 10*	*29*		*3·65*		
			10	*26*		*2·93*		
			10	*23*		*2·30*		
			10	*20½*		*1·82*		
			18	*15½*		*1·88* *12·58*		
110	*19½*	*58*	*45 10*	*19*		*1·57*		
			10	*17½*		*1·33*		
			10	*16*		*1·11*		
			15	*13½*		*1·19* *5·20*		
123	*31*	*70*	*57 10*	*30½*		*4·04*		
			10	*27*		*3·16*		
			10	*24*		*2·50*		
			10	*21*		*1·91*		
			17	*14½*		*1·55* *13·16*		
133	*23½*	*66*	*51 10*	*23*		*2·30*		
			10	*21½*		*2·01*		
			10	*19*		*1·91*		
			10	*16*		*1·11*		
			11	*12*		*·69* *8·02*		
150	*25*	*71*	*57 10*	*25*		*2·71*		
			10	*23*		*2·30*		
			10	*21*		*1·91*		
			10	*18½*		*1·49*		
			17	*12½*		*1·15* *9·56*		
151	*20*	*59*	*48 10*	*19½*		*1·65*		
			10	*18*		*1·41*		
			10	*16*		*1·11*		
			18	*12½*		*1·22* *5·39*		

WORKED EXAMPLE A : THIRTY-EIGHTH PAGE

(Reverse of Form 4a, Sheet II)

Tree No.	Girth at 4ft. 3ins. inches	Total Height feet	Timber Height feet	½ Ti.H. Girth O.B. inches	½ Ti.H. Girth U.B. inches	Volume O.B. hoppus feet	Volume U.B. hoppus feet	Remarks
160	*19*	*57*	*42 10*	*18½*		*1·49*		
			10	*16*		*1·11*		
			10	*14*		*·85*		
			12	*11½*		*·69* *4·14*		
162	*14½*	*42*	*29 10*	*14*		*·85*		
			19	*12*		*1·19* *2·04*		
165	*22*	*64*	*49 10*	*21½*		*2·01*		
			10	*19*		*1·57*		
			10	*17½*		*1·33*		
			19	*13½*		*1·50* *6·41*		

Total number of thinnings = *21*
Total volume over bark = *182·30 hoppus feet.*
Total basal area = *5·596 square feet q.g.*
Average basal area = *·266 square feet q.g.*
Average girth = *25 inches.*

WORKED EXAMPLE A : THIRTY-NINTH PAGE (See paras. 111, 113, 114, page 21)

F.C. Sample Plot Form No. 7.

RECORD OF PERIODICAL MEASUREMENTS PER ACRE

Sample Plot No. : *W.38* Thinning Grade : *C/D* Acreage : *0·320*

Species : *Abies grandis* Quality Class : *I/II*

Q.G.

Year of measurement	Age of crop	Main Crop (after thinning)										Yield from Thinnings				Total Crop		Periodic Annual Increment		Mean Annual Increment	Entered and checked by
		Number of trees per acre	Height		True Girth at 4 ft. 3 ins.		Basal area per acre	Form Factor	Volume per acre (over bark)	Crown per cent	Bark per cent	Number of trees	True Girth at 4ft.3ins.	Basal area per acre	Volume per acre (over bark)	Basal area	Volume (over bark)	Basal area	Volume	Volume	
			Average of 100 largest trees	Average of crop	Average of 100 largest trees	Average of crop															
	years		ft.	ft.	ins.	ins.	sq. ft. q.g.		hoppus ft.				ins.	sq. ft. q.g.	hoppus ft.	sq. ft. q.g.	hoppus ft.	sq. ft. q.g.	hoppus ft.	hoppus ft.	
1947					*Previous thinnings*							*310*	—	*(23·7)*	*350*						
8/1948	*22*	*522*	*54*	*50*	*29*	*21½*	*106·6*	*·433*	*2,308*	*65*	*10*	*256*	*17*	*32·5*	*648*	*162·8*	*3,306*	—	—	*150*	*P.M. J.N.R.J.*
7/1951	*25*	*362*	*60½*	*57*	*31½*	*25½*	*102·0*		*(2,520)*			*160*	*20*	*27·2*	*641*	*185·4*	*(4,159)*	*7·5*	*(284)*	*(166)*	*D.H. D.E.E.*
10/1954	*28*	*312*	*71*	*67½*	*36*	*29½*	*118·5*	*·448*	*3,586*	*56*	*10½*	*50*	*26½*	*15·5*	*473*	*217·4*	*5,698*	*10·7*	*(6years) 399*	*204*	*V.W. E.H.*
12/1954						*Blown trees*						*3*	*44½*	*2·7*	*83*						*J.B. J.W.*
1/1957	*30*	*244*		*(73)*	*37½*	*32½*	*111·8*		*(3,660)*			*65*	*25*	*17·5*	*570*	*230·9*	*(6,425)*	*6·8*	*(363)*	*(214)*	*D.K. E.H.*

Note : Figures n brackets are estimated.

Sample Plot Form No. 4a.

MEASUREMENTS OF THINNINGS

Sample Plot No. : *E.91* Species : *Oak* Initials : *A.B.*
Date : *January, 1949* Checked by : *D.C.*

Tree No.	Girth at 4ft. 3ins. inches	Total Height feet	Timber Height feet	½ Ti.H. Girth O.B. inches	½ Ti.H. Girth U.B. inches	Volume O.B. hoppus feet	Volume U.B. hoppus feet	*Branchwood** [Remarks] *Length feet*	*Girth O.B. inches*	*Volume O.B. hoppus feet*
49	*29*	*69*	*58 19*	*26*	*23½*	*5·58*	*4·55*	*18*	*12*	*1·12*
			16	*22*	*19½*	*3·36*	*2·64*			
			23 10	*16*	*14½*	*1·11*	*·91*			
			23 13	*11*	*9½*	*·68 1·79*	*·51 1·42*			
						10·73	*8·61*			
143	*40*	*74*	*65* 10	*39*	*37*	*6·60*	*5·94*	*25*	*13½*	*1·98*
			31 10	*36*	*34*	*5·63*	*5·02*			
			31 11	*34*	*32½*	*5·52 17·75*	*5·04 16·00*	*29*	*16*	*3·22*
			19	*25*	*22½*	*5·15*	*4·18*			
			15	*14*	*13½*	*1·28*	*1·19*	*14*	*13*	*1·03*
						24·18	*21·37*	*8*	*11*	*·42*
								6	*10*	*·26*
										6·91
145 etc.										

* *Note.* As explained in paras. 58, 59 and 86, pages 13 and 17, the measurements and volumes of broadleaved thinnings will be recorded separately from the measurements and volumes of branchwood. In the above example, these have been recorded in the Remarks column of Form 4a, but they may, if more convenient, be recorded on a separate sheet. The measurements of stemwood and branchwood of these two trees are shown diagramatically in figure 11 following.

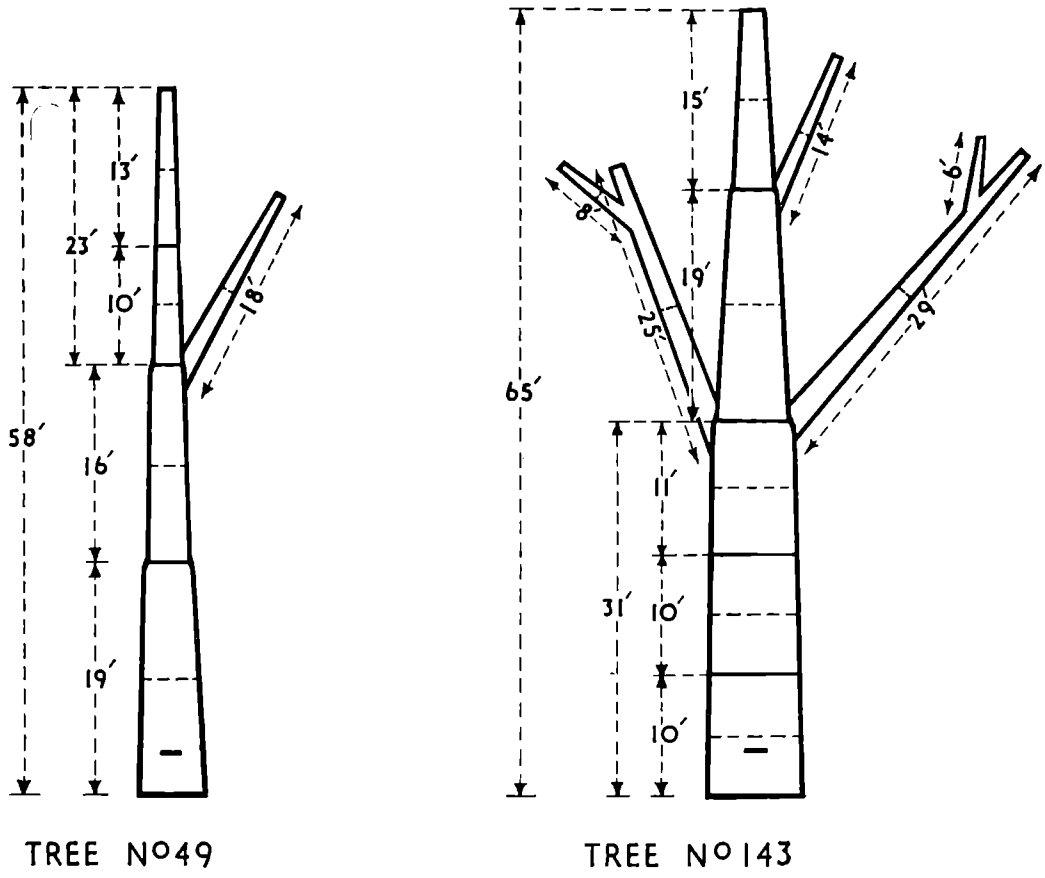


FIGURE 11. Diagrammatic representation of the two oak trees whose measurements are recorded on Form 4a, Worked Example B, page 89.

Appendix IX—*continued*

REPORT ON WINDBLOWN AREA

Date of blow	Approx. extent of blow in acres	Damage : Total blow Partial (Give per cent.)	Direction of wind causing blow	Name of forest :— and one-inch Map ref. Block :— Compt. Nos. :—
Trees blown down by Uprooting/Stems broken off		If uprooted, major roots Broken off/Torn up		If major roots broken, roots Alive/Dead/Diseased
Description of root diseases or stem rot :—				
Species : (If mixed, state proportions and how mixed)				
Age of crop years		Average height ft.		Average B.H. Q. girth ins. (dominants only)
Past thinning Heavy/Moderate/Light		Last thinning Date Age		Dates of previous thinnings, especially first thinning if traceable.
Elevation (top and bottom) ft. to ft.		Relative elevation (height of nearby hilltops and valley bottoms)		Aspect N NE E SE Flat S SW W NW
Exposure :Severe (exposed to all winds or to any strong and prevailing wind). Moderate (intermediate). Sheltered (not exposed to prevailing or other strong winds). Details :				
Slope : Level (0°–5°) Gentle (6°–10°)		Moderate (11°–15°) Steep (16°–25°)		Very steep (26°–45°) Precipitous (46° & over)
Topography of the blown area : even slope/concave slope/convex slope/level Describe with details of knolls, gullies, shelves, etc.				
Geology (name of formation and type of drift, if any)				
Soil : surface : peat (over 6 ins. deep)/heath (peat less than 6 ins.) mineral below : clay/clayey loam/loam/sandy loam/sand. Pan : present/absent/depth/				
Drainage : free/impeded	Depth of water table ins.	Depth of free rooting ins.		
Artificially drained/Not artificially drained	Describe kind and intensity of drainage and state of drains.			
Any special factors which may have influenced the windblow :				Crowns : Large Average Small Spacing : (give Min. Max. and Average).
A map of the blow and its surroundings showing contours, etc. (say 6 inches = 1 mile) should be sketched on the back of this sheet.				

Date : Signed :

Address : Designation :

Appendix X

FORMULAE AND TABLES

In this Appendix are assembled all the formulae given elsewhere in this bulletin and in addition some other formulae and tables of use in sample plot work.

Calculation of Areas

The following three tables Nos. 12, 13, and 14 give the approximate dimensions for square, circular and triangular plots of given areas.

LENGTH OF SIDE FOR SQUARE PLOTS

TABLE 12

Size of Plot (Acres)	Length of Side	
	Links (of 66 foot chain)	Feet
0·1	100	66
0·2	141	93½
0·25	158	104½
0·3	173	114
0·4	200	132
0·5	224	147½
0·6	245	161½
0·7	265	174½
0·75	274	180½
0·8	283	186½
0·9	300	198
1·0	316	209

LENGTH OF RADIUS FOR CIRCULAR PLOTS

TABLE 13

Size of Plot (Acres)	Length of Radius		
	Links (of 66-foot chain)	Feet	Inches
0·05	40	26	4
0·1	56½	37	3
0·2	80	52	9
0·25	89	58	10
0·3	97½	64	4
0·4	113	74	6
0·5	126	83	3

LENGTH OF SIDE FOR EQUILATERAL TRIANGLES

TABLE 14

Size of Plot (Acres)	Length of Side		
	Links (of 66-foot chain)	Feet	Inches
0·05	107½	71	0
0·1	152	100	3
0·2	214	141	6
0·25	240	158	6
0·3	263	173	9
0·4	304	200	6
0·5	340	224	4

The area of an equilateral triangle is found by the formula :

$$\text{Area} = \frac{\sqrt{3}}{4} \times l^2$$

Where l = length of side

$\sqrt{3} = 1{\cdot}732$

Distances on Slopes

The horizontal equivalent of a distance measured along a slope is calculated by multiplying the length along the slope, by the cosine of the angle of slope. Table 15 gives the cosines of angles from 5 degrees to 30 degrees.

COSINES OF ANGLES

TABLE 15

Angle Degrees	Cosine	Angle Degrees	Cosine
5	·99619	18	·95105
6	·99452	19	·94551
7	·99254	20	·93969
8	·99026	21	·93358
9	·98768	22	·92718
10	·98480	23	·92050
11	·98162	24	·91354
12	·97814	25	·90630
13	·97437	26	·89879
14	·97029	27	·89100
15	·96592	28	·88294
16	·96126	29	·87462
17	·95630	30	·86602

Non-rectangular Plots

When a plot has four straight sides, but the angles between sides are not right angles (Figure 12), the plot will be divided into two triangles DAB and DCB, and the area of each triangle calculated. As a check this procedure should be repeated by dividing the plot into the triangles ABC and ADC. The mean of these areas is accepted as the area of the plot, e.g.

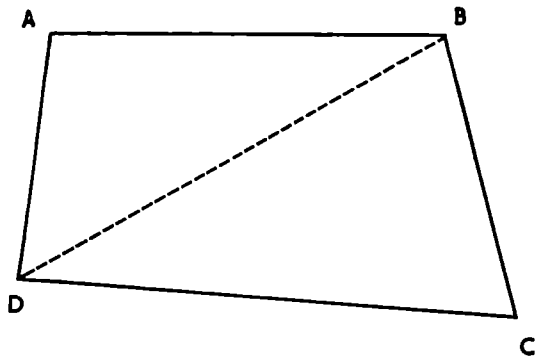


FIGURE 12.
Treatment of a four-sided plot where the angles are not right angles.

$$\text{Area ABCD} = \tfrac{1}{2}(\text{AD} \times \text{AB} \times \sin.\ \text{A}) + \tfrac{1}{2}(\text{BC} \times \text{CD} \times \sin.\ \text{C})$$
$$\text{or} \quad = \tfrac{1}{2}(\text{AB} \times \text{BC} \times \sin.\ \text{B}) + \tfrac{1}{2}(\text{DC} \times \text{AD} \times \sin.\ \text{D})$$

When a plot is five sided (Figure 13), the lengths of sides will be measured, and in addition at least one diagonal measurement should be taken so that the plot can be divided into three triangles, and the area calculated by the method demonstrated above.

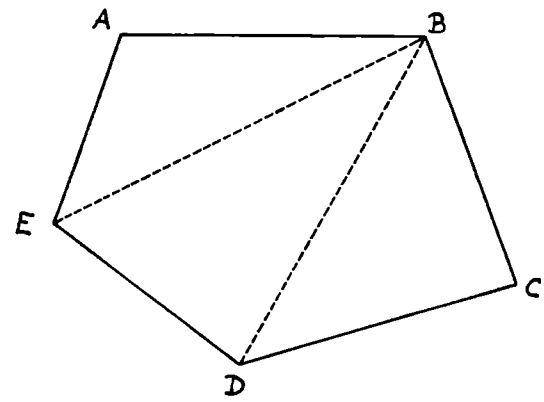


FIGURE 13.
Treatment of five-sided plot.

If the length of a diagonal cannot be measured, its length can be calculated using the perimeter measurements and the angles between the sides. Suppose that, in the plan above, the area of the triangle EDB has to be calculated.

Then : The length of side DB is found by :

$$\text{DB}^2 = \text{DC}^2 + \text{CB}^2 - 2\ \text{DC.\ CB cos.\ C};$$

The length of side EB is found by :

$$\text{EB}^2 = \text{EA}^2 + \text{AB}^2 - 2\ \text{EA.\ AB cos.\ A}.$$

The area is then :

$$\text{Area EDB} = \sqrt{s\ (s - \text{ED})\ (s - \text{DB})\ (s - \text{EB})}$$

$$\text{where } s = \frac{\text{ED} + \text{DB} + \text{EB}}{2}$$

This formula for calculating the area can also be used to find the area of four or five sided plots in which the sides and diagonals have been measured, but not the angles.

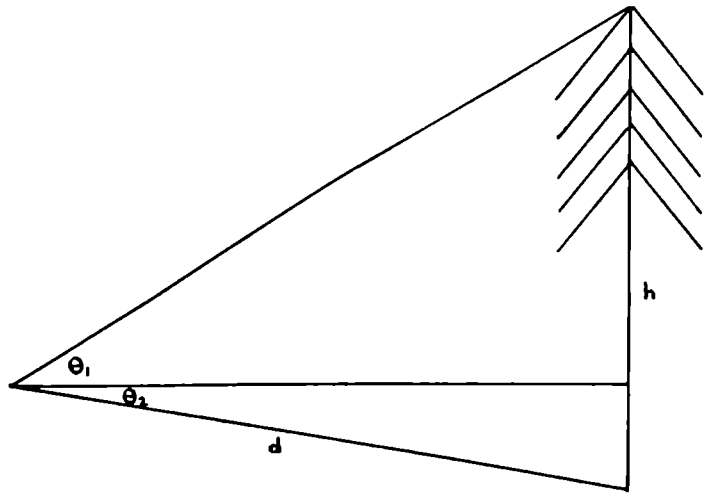


FIGURE 14. Calculation of tree height using the sines of angles.

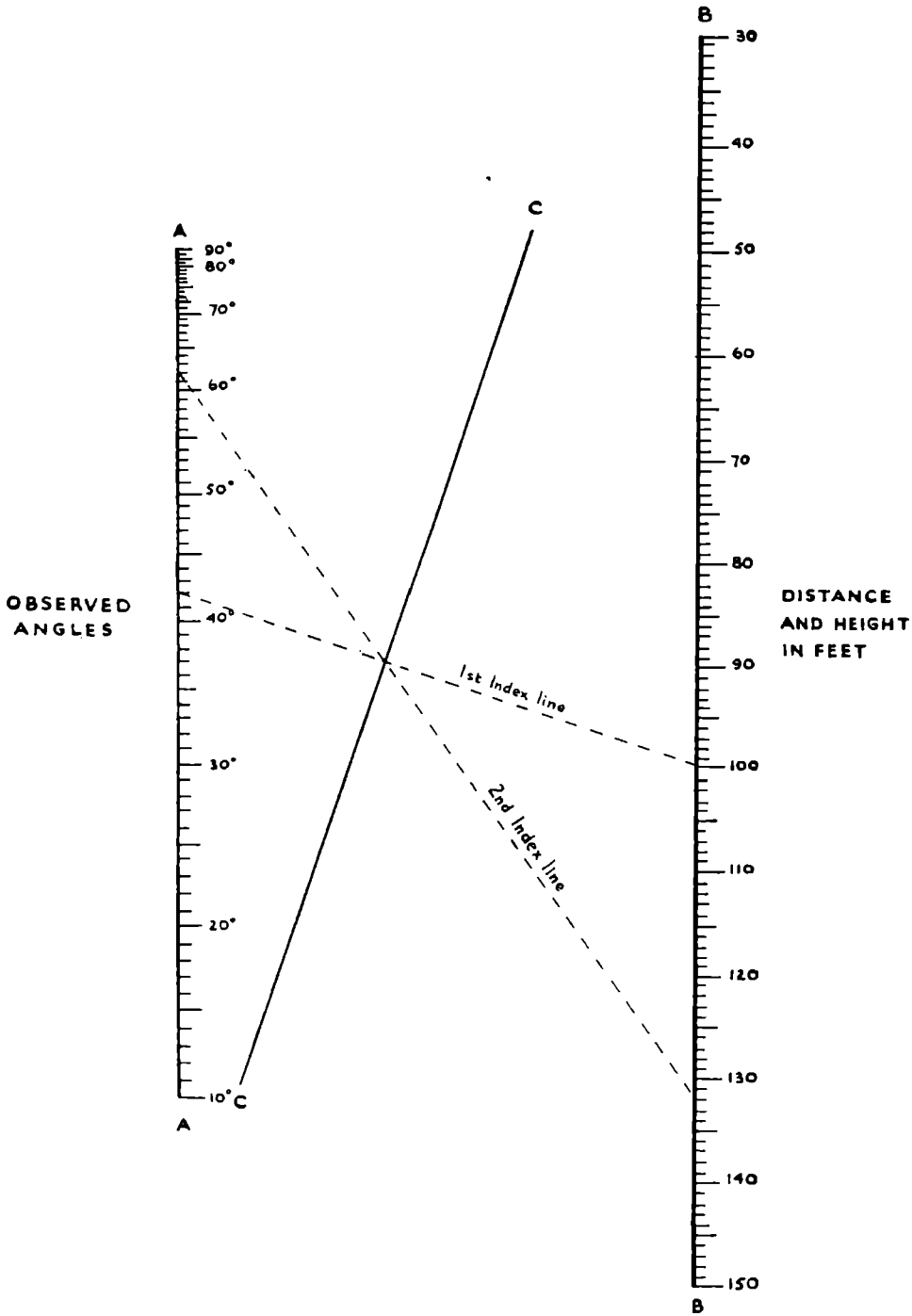


FIGURE 15. Alignment chart for use with an Abney level

Height Measurement

When the height of a tree is measured by hypsometer, other than one working with a fixed based line, the chart devised by Roy may be used. (*Indian Forester* Vol. LXV, pp. 72–3, 1939 : A ready reference chart for Abney's heights.) (See Figure 15.) This chart is reproduced by kind permission of the author and the editor.

The chart is designed to enable heights to be quickly determined from the angular measurements made with an Abney level or similar instrument, without mathematical calculations.

In measuring tree heights, three observations are necessary :

θ_1 = angle observed to the top of the tree.
θ_2 = angle observed to the base of the tree.
d = distance of the eye-piece of the instrument from the base of the tree.

(See Figure 14.)

To read the heights from the chart, given these measurements, place the straight edge of a rule on $(90° - \theta_1)°$ on the axis AA and d on the axis BB (1st index line). The point of intersection of this line with the constant transversal line CC is marked with a soft pencil. The edge of the rule is then placed on this point of intersection and the point corresponding to the sum of the observed angles $\theta_1 + \theta_2$ on the axis AA (2nd index line). The point of intersection of the edge of the rule with the axis BB gives the height required.

If both the angles are observed from a point below the base of the tree, θ_2 should be taken as negative and the differences of the observed angle should be taken. If d is horizontal, $\theta_2 = 0$ and the sum of the observed angles $= \theta_1$. If θ_2 is observed to a band at breast height on the tree, then that height should be added to the height read from the chart.

Alternatively the height of the tree may be calculated by the following formula, as illustrated in Figure 14, page 93.

$$\text{height} = d \frac{\sin.(\theta_1 + \theta_2)}{\sin.(90° - \theta_1)}$$

Volume of Single Tree

The volume of single trees is calculated by sections and is determined either by Huber's formula, or, in the case of trees measured with the Dendrometer, by Smalian's formula.

Huber's Formula

$$v = g_m \times l$$

Where v = volume of section
g_m = mid sectional area
l = length of section

The sum of the volumes of the individual sections gives the volume of the tree.

Smalian's Formula

$$v = \frac{g_1 + g_2}{2} \times l$$

Where v = volume of section
g_1 = sectional area at the base of the section
g_2 = sectional area at the top of the section
l = length of section

The sum of the volumes of the individual sections gives the volume of the tree.

Total Volume of Thinnings

The total volume of thinnings, when only a sample is measured, is found by a proportional basal area adjustment as follows :

$$V = \frac{v \times G}{g}$$

Where V = total volume of thinnings
v = volume of sample thinnings
G = total basal area of thinnings of 8½ inches girth and over.
g = basal area of sample thinnings

Volume of Standing Crop

The volume of the standing crop is found as follows :

$$V = N \times v_g$$

Where V = total volume of the standing crop
N = total number of trees in the plot of 8½ inches girth and above
v_g = volume corresponding to the mean basal area of trees of 8½ inches girth and over

Total Basal Area

The total basal area of the plot is found by adding the sum of basal areas in each girth class.

$$G = n_1g_1 + n_2g_2 + n_3g_3 \ldots\ldots\ldots$$

Where G = total basal area
g_1, g_2 = basal area of a girth class
n_1, n_2 = number of trees in a girth class

Mean Basal Area

$$g = \frac{G}{N}$$

Where G = total basal area in plot
N = total number of trees in plot
g = average basal area of plot

Mean girth, is the girth corresponding to the average basal area of the plot.

The mean girth of the 100 largest girthed trees, is the girth corresponding to the average basal area of the 100 *largest* girthed trees per acre.

Mean height, is the height corresponding to the mean basal area of the plot, and is determined from a height-basal area graph.

Top height, is the height corresponding to the mean basal area of the 100 largest-girthed trees per acre (not necessarily the 100 tallest trees per acre) as obtained from a height/basal area graph.

Bark Per Cent

$$b = \frac{v - v_u}{v} \times 100$$

Where b = bark per cent
v = over bark volume of tree
v_u = under bark volume of tree

Average Bark Per Cent

$$\bar{b} = \frac{\Sigma v - \Sigma v_u}{\Sigma v} \times 100$$

Where $\bar{b}$ = average bark per cent
Σv = sum of the over-bark volumes of trees
Σv_u = sum of the under-bark volumes of trees

Crown Per cent

$$c = \frac{h - \frac{1}{2}(LC - UC)}{h} \times 100$$

Where c = crown percentage
h = total height of tree
LC = height of lower crown from ground level
UC = height of upper crown from ground level

Average Crown Per Cent

$$\bar{c} = \frac{c_1 + c_2 + c_3 + \ldots\ldots\ldots}{N}$$

Where $\bar{c}$ = average crown per cent
c_1, c_2 = crown per cent of individual trees
N = number of trees

Tree Form Factor

$$f = \frac{v}{g \times h}$$

Where f = tree form factor
v = volume of tree to 3 inches diameter over bark
g = basal area
h = height of tree (to tip)

Crop Form Factor

$$F = \frac{V}{G \times h_g}$$

Where F = crop form factor
V = total volume of plot
G = total basal area of plot
h_g = mean height of plot

Conversion Factors

1 acre	= 10 square chains (100,000 square links)
1 acre	= 4,840 square yards
1 acre	= 43,560 square feet
1 square mile	= 640 acres
100 links	= 1 chain = 66 feet
80 chains	= 1 mile
1 mile	= 1,760 yards
1 mile	= 5,280 feet

In Table 16 below :

Column A × column C = column B
Column B × column D = column A
e.g. Feet × 0·3048 = metres
Metres × 3·281 = feet

TABLE 16

A	B	C	D
Inches	Centimetres	2·540	0·3937
Feet	Metres	0·3048	3·2808
Miles	Kilometres	1·6093	0·6214
Square feet	Square metres	0·0929	10·7639
Square miles	Square Kilometres	2·590	0·3861
Acres	Hectares	0·4047	2·471
True cubic feet	Cubic metres	0·02832	35·31
Hoppus square feet	Square metres	0·1183	8·454
Hoppus cubic feet	Cubic metres	0·03605	27·736
True measure (areas or volumes)	Quarter girth or Hoppus measure	0·7854	1·273
Inches quarter girth	Centimetres diameter	3·234	0·3092
Number of stems per acre	Number stems per hectare	2·471	0·4047
Hoppus square feet per acre	Square metres per hectare	0·2922	3·421
Hoppus cubic feet per acre	Cubic metres per hectare	0·0891	11·22
Feet	Links of a 66-foot chain	1·515	0·660

Number of Trees per acre at Various Square Spacings

TABLE 17

Distance Apart (feet)	Number of trees per acre	Distance Apart (feet)	Number of trees per acre	Distance Apart (feet)	Number of trees per acre
3	4,840	9½	482	16	170
3½	3,546	10	435	16½	164
4	2,722	10½	395	17	150
4½	2,151	11	360	17½	142
5	1,742	11½	339	18	134
5½	1,440	12	302	19	120
6	1,210	12½	270	20	109
6½	1,031	13	257	22	90
7	889	13½	239	24	75
7½	774	14	222	26	64
8	680	14½	207	28	55
8½	603	15	193	30	48
9	537	15½	181		

Map Scales

The following map scales are commonly used, and the table gives, for these scales, the number of miles, chains, yards, feet and links per unit.

TABLE 18

Popular Name	Map Scale	No. of units on the map represented by one inch					
		Miles	Yards	Feet	Chains	Links of 66-foot chain	Kilo-metre
1 to 2 Million	1/2,000,000	31·56	—	—	—	—	50·82
1 to 1¼ Million	1/1,250,000	—	—	—	—	—	—
1 to 1 Million	1/1,000,000	15·782	—	—	—	—	25·41
Ten Mile	1/625,000	9·78	—	—	782·4	—	15·73
Quarter inch	1/253,440	4	7,040	21,120	320	32,000	6·44
Half inch	1/126,720	2	3,520	10,560	160	16,000	3·22
One inch	1/63,360	1	1,760	5,280	80	8,000	1·61
Two-and-a-half inch	1/25,000	0·395	694	2,083	31·6	3,156	0·635
Six inch	1/10,560	0·166	293	880	13·3	1,333	0·267
25 inch	1/2,500	0·0395	69·4	208·33	3·16	316	0·064

Sectional Area Tables, and Tables of Diameters With the Corresponding Circumferences

The sectional area tables which follow are in hoppus measure ; they give sectional areas in terms of circumference calculated from the formula

$$\frac{(C/4)^2}{144},$$

where C = circumference (girth) in inches

and also sectional areas in terms of diameter calculated from the formula :

$$\frac{(\pi d/4)^2}{144}$$

where d = diameter in inches

The diameter tables are for use with the Dendrometer.

ABBREVIATED DECIMAL HOPPUS TABLES SHOWING QUARTER GIRTH (HOPPUS) BASAL AREA IN TERMS OF TRUE GIRTH

TABLE 19

True Girth Inches	Basal Area Square feet quarter girth	True Girth Inches	Basal Area Square feet quarter girth	True Girth Inches	Basal Area Square feet quarter girth	True Girth Inches	Basal Area Square feet quarter girth
1	·00043	21	·191	41	·730	61	1·615
1½	·00098	21½	·201	41½	·748	61½	1·642
2	·00174	22	·210	42	·766	62	1·668
2½	·00271	22½	·220	42½	·784	62½	1·695
3	·00391	23	·230	43	·803	63	1·723
3½	·00532	23½	·240	43½	·821	63½	1·750
4	·00694	24	·250	44	·840	64	1·778
4½	·00879	24½	·261	44½	·859	64½	1·806
5	·01085	25	·271	45	·879	65	1·834
5½	·01313	25½	·282	45½	·899	65½	1·862
6	·01563	26	·293	46	·918	66	1·891
6½	·01834	26½	·305	46½	·938	66½	1·919
7	·021	27	·316	47	·959	67	1·948
7½	·024	27½	·328	47½	·979	67½	1·978
8	·028	28	·340	48	1·000	68	2·007
8½	·031	28½	·353	48½	1·021	68½	2·037
9	·035	29	·365	49	1·042	69	2·066
9½	·039	29½	·378	49½	1·063	69½	2·096
10	·043	30	·391	50	1·085	70	2·127
10½	·048	30½	·404	50½	1·107	70½	2·157
11	·053	31	·417	51	1·129	71	2·188
11½	·057	31½	·431	51½	1·151	71½	2·219
12	·063	32	·444	52	1·174	72	2·250
12½	·068	32½	·458	52½	1·196	72½	2·281
13	·073	33	·473	53	1·219	73	2·313
13½	·079	33½	·487	53½	1·242	73½	2·345
14	·085	34	·502	54	1·266	74	2·377
14½	·091	34½	·517	54½	1·289	74½	2·409
15	·098	35	·532	55	1·313	75	2·441
15½	·104	35½	·547	55½	1·337	75½	2·474
16	·111	36	·563	56	1·361	76	2·507
16½	·118	36½	·578	56½	1·386	76½	2·540
17	·125	37	·594	57	1·410	77	2·573
17½	·133	37½	·610	57½	1·435	77½	2·607
18	·141	38	·627	58	1·460	78	2·641
18½	·149	38½	·643	58½	1·485	78½	2·675
19	·157	39	·660	59	1·511	79	2·709
19½	·165	39½	·677	59½	1·537	79½	2·743
20	·174	40	·694	60	1·563	80	2·778
20½	·182	40½	·712	60½	1·589	80½	2·813

ABBREVIATED DECIMAL HOPPUS TABLES SHOWING QUARTER GIRTH (HOPPUS) BASAL AREA IN TERMS OF TRUE GIRTH

TABLE 19—*continued*

True Girth Inches	Basal Area Square feet quarter girth	True Girth Inches	Basal Area Square feet quarter girth	True Girth Inches	Basal Area Square feet quarter girth	True Girth Inches	Basal Area Square feet quarter girth
81	2·848	101	4·428	121	6·355	141	8·629
81½	2·883	101½	4·471	121½	6·407	141½	8·690
82	2·918	102	4·516	122	6·460	142	8·752
82½	2·954	102½	4·560	122½	6·513	142½	8·813
83	2·990	103	4·605	123	6·566	143	8·875
83½	3·026	103½	4·649	123½	6·620	143½	8·938
84	3·063	104	4·694	124	6·674	144	9·000
84½	3·099	104½	4·740	124½	6·728	144½	9·063
85	3·136	105	4·785	125	6·782	145	9·125
85½	3·173	105½	4·831	125½	6·836	145½	9·188
86	3·210	106	4·877	126	6·891	146	9·252
86½	3·248	106½	4·923	126½	6·945	146½	9·315
87	3·285	107	4·969	127	7·000	147	9·379
87½	3·323	107½	5·016	127½	7·056	147½	9·443
88	3·361	108	5·063	128	7·111	148	9·507
88½	3·399	108½	5·109	128½	7·167	148½	9·571
89	3·438	109	5·157	129	7·223	149	9·636
89½	3·477	109½	5·204	129½	7·279	149½	9·701
90	3·516	110	5·252	130	7·335	150	9·766
90½	3·555	110½	5·300	130½	7·392		
91	3·594	111	5·348	131	7·448		
91½	3·634	111½	5·396	131½	7·505		
92	3·674	112	5·444	132	7·563		
92½	3·714	112½	5·493	132½	7·620		
93	3·754	113	5·542	133	7·678		
93½	3·794	113½	5·591	133½	7·735		
94	3·835	114	5·641	134	7·793		
94½	3·876	114½	5·690	134½	7·852		
95	3·917	115	5·740	135	7·910		
95½	3·958	115½	5·790	135½	7·969		
96	4·000	116	5·840	136	8·028		
96½	4·042	116½	5·891	136½	8·087		
97	4·084	117	5·941	137	8·146		
97½	4·126	117½	5·992	137½	8·206		
98	4·168	118	6·043	138	8·266		
98½	4·211	118½	6·095	138½	8·326		
99	4·254	119	6·146	139	8·386		
99½	4·297	119½	6·198	139½	8·446		
100	4·340	120	6·250	140	8·507		
100½	4·384	120½	6·302	140½	8·568		

QUARTER GIRTH (HOPPUS) BASAL AREA, IN TERMS OF DIAMETER IN INCHES

TABLE 20

Diameter in inches	Area of Circle in square feet quarter girth	Diameter in inches	Area of Circle in square feet quarter girth	Diameter in inches	Area of Circle in square feet quarter girth	Diameter in inches	Area of Circle in square feet quarter girth	Diameter in inches	Area of Circle in square feet quarter girth	Diameter in inches	Area of Circle in square feet quarter girth	Diameter in inches	Area of Circle in square feet quarter girth	Diameter in inches	Area of Circle in square feet quarter girth
1·0	·0043	5·0	·107	9·0	·347	13·0	·724	17·0	1·238	21·0	1·889	25·0	2·677	29·0	3·603
·1	·0053	·1	·111	·1	·355	·1	·735	·1	1·253	·1	1·907	·1	2·699	·1	3·627
·2	·0062	·2	·116	·2	·363	·2	·746	·2	1·267	·2	1·925	·2	2·720	·2	3·652
·3	·0072	·3	·120	·3	·371	·3	·758	·3	1·282	·3	1·943	·3	2·742	·3	3·677
·4	·0084	·4	·125	·4	·379	·4	·769	·4	1·297	·4	1·962	·4	2·764	·4	3·703
·5	·0097	·5	·130	·5	·387	·5	·781	·5	1·312	·5	1·980	·5	2·785	·5	3·728
·6	·0110	·6	·134	·6	·395	·6	·792	·6	1·327	·6	1·999	·6	2·807	·6	3·753
·7	·0124	·7	·139	·7	·403	·7	·804	·7	1·342	·7	2·017	·7	2·829	·7	3·779
·8	·0139	·8	·144	·8	·411	·8	·816	·8	1·357	·8	2·036	·8	2·851	·8	3·804
·9	·0155	·9	·149	·9	·420	·9	·828	·9	1·372	·9	2·055	·9	2·874	·9	3·830
2·0	·0171	6·0	·154	10·0	·428	14·0	·840	18·0	1·388	22·0	2·073	26·0	2·896	30·0	3·855
·1	·0188	·1	·159	·1	·437	·1	·852	·1	1·403	·1	2·092	·1	2·918	31·0	4·117
·2	·0207	·2	·165	·2	·446	·2	·864	·2	1·419	·2	2·111	·2	2·940	32·0	4·387
·3	·0227	·3	·170	·3	·455	·3	·876	·3	1·435	·3	2·130	·3	2·963	33·0	4·665
·4	·0247	·4	·175	·4	·463	·4	·888	·4	1·450	·4	2·149	·4	2·986	34·0	4·952
·5	·0268	·5	·181	·5	·472	·5	·901	·5	1·466	·5	2·169	·5	3·008	35·0	5·247
·6	·0290	·6	·187	·6	·481	·6	·913	·6	1·482	·6	2·188	·6	3·031	36·0	5·552
·7	·0313	·7	·192	·7	·490	·7	·926	·7	1·498	·7	2·207	·7	3·054	37·0	5·864
·8	·0336	·8	·198	·8	·500	·8	·938	·8	1·514	·8	2·227	·8	3·077	38·0	6·186
·9	·0360	·9	·204	·9	·509	·9	·951	·9	1·530	·9	2·246	·9	3·100	39·0	6·516
3·0	·0386	7·0	·210	11·0	·518	15·0	·964	19·0	1·546	23·0	2·266	27·0	3·123	40·0	6·854
·1	·0412	·1	·216	·1	·528	·1	·977	·1	1·563	·1	2·286	·1	3·146	41·0	7·201
·2	·0439	·2	·222	·2	·537	·2	·990	·2	1·579	·2	2·306	·2	3·169	42·0	7·556
·3	·0467	·3	·228	·3	·547	·3	1·003	·3	1·596	·3	2·326	·3	3·193	43·0	7·921
·4	·0496	·4	·235	·4	·557	·4	1·016	·4	1·612	·4	2·346	·4	3·216	44·0	8·293
·5	·0525	·5	·241	·5	·567	·5	1·029	·5	1·629	·5	2·366	·5	3·240	45·0	8·675
·6	·0555	·6	·247	·6	·576	·6	1·043	·6	1·646	·6	2·386	·6	3·263	46·0	9·064
·7	·0587	·7	·254	·7	·586	·7	1·056	·7	1·662	·7	2·406	·7	3·287	47·0	9·463
·8	·0619	·8	·261	·8	·597	·8	1·069	·8	1·679	·8	2·426	·8	3·311	48·0	9·870
·9	·0652	·9	·267	·9	·607	·9	1·083	·9	1·696	·9	2·447	·9	3·334	49·0	10·285
4·0	·0686	8·0	·274	12·0	·617	16·0	1·097	20·0	1·714	24·0	2·467	28·0	3·358	50·0	10·709
·1	·0720	·1	·281	·1	·627	·1	1·110	·1	1·731	·1	2·488	·1	3·382	51·0	11·142
·2	·0756	·2	·288	·2	·638	·2	1·124	·2	1·748	·2	2·509	·2	3·407	52·0	11·583
·3	·0792	·3	·295	·3	·648	·3	1·138	·3	1·765	·3	2·530	·3	3·431	53·0	12·033
·4	·0829	·4	·302	·4	·659	·4	1·152	·4	1·783	·4	2·550	·4	3·455	54·0	12·491
·5	·0868	·5	·310	·5	·669	·5	1·166	·5	1·800	·5	2·572	·5	3·479	55·0	12·958
·6	·0906	·6	·317	·6	·680	·6	1·180	·6	1·818	·6	2·592	·6	3·504	56·0	13·434
·7	·0946	·7	·324	·7	·691	·7	1·195	·7	1·836	·7	2·613	·7	3·528	57·0	13·918
·8	·0987	·8	·332	·8	·702	·8	1·209	·8	1·853	·8	2·635	·8	3·553	58·0	14·410
·9	·1029	·9	·339	·9	·713	·9	1·223	·9	1·871	·9	2·656	·9	3·578	59·0	14·912
														60·0	15·421

Circumference Corresponding to a Given Diameter

TABLE 21

Diameter	Corresponding circumference	Diameter	Corresponding circumference	Diameter	Corresponding circumference	Diameter	Corresponding circumference	Diameter	Corresponding circumference
Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches
1	3·14	11	34·56	21	66·97	31	97·39	41	128·81
2	6·28	12	37·70	22	69·11	32	100·53	42	131·95
3	9·42	13	40·84	23	72·26	33	103·67	43	135·09
4	12·57	14	43·98	24	75·40	34	106·81	44	138·23
5	15·71	15	47·12	25	78·54	35	109·96	45	141·57
6	18·85	16	50·27	26	81·26	36	113·10	46	144·51
7	21·99	17	53·41	27	84·82	37	116·24	47	147·66
8	25·13	18	56·55	28	87·96	38	119·38	48	150·80
9	28·27	19	59·69	29	91·11	39	122·52	49	153·94
10	31·42	20	62·83	30	94·25	40	125·66	50	157·00

Diameter Corresponding to a Given Circumference

TABLE 22

Circumference	Corresponding diameter	Circumference	Corresponding diameter	Circumference	Corresponding diameter	Circumference	Corresponding diameter	Circumference	Corresponding diameter	Circumference	Corresponding diameter
Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches
1	·32	21	6·68	41	13·05	61	19·42	81	25·78	101	32·15
2	·64	22	7·00	42	13·37	62	19·74	82	26·10	102	32·47
3	·95	23	7·32	43	13·69	63	20·05	83	26·42	103	32·79
4	1·27	24	7·64	44	14·01	64	20·37	84	26·74	104	33·10
5	1·59	25	7·96	45	14·32	65	20·69	85	27·06	105	33·42
6	1·91	26	8·28	46	14·64	66	21·00	86	27·37	106	33·74
7	2·23	27	8·59	47	14·96	67	21·33	87	27·69	107	34·06
8	2·55	28	8·91	48	15·28	68	21·65	88	28·01	108	34·38
9	2·86	29	9·23	49	15·60	69	21·96	89	28·33	109	34·70
10	3·18	30	9·55	50	15·92	70	22·28	90	28·65	110	35·01
11	3·50	31	9·87	51	16·23	71	22·60	91	28·97	111	35·33
12	3·82	32	10·19	52	16·55	72	22·92	92	29·28	112	35·65
13	4·14	33	10·50	53	16·87	73	23·24	93	29·60	113	35·97
14	4·46	34	10·82	54	17·19	74	23·55	94	29·92	114	36·29
15	4·77	35	11·14	55	17·51	75	23·87	95	30·24	115	36·60
16	5·09	36	11·46	56	17·83	76	24·19	96	30·56	116	36·92
17	5·41	37	11·78	57	18·15	77	24·51	97	30·88	117	37·24
18	5·73	38	12·10	58	18·46	78	24·83	98	31·19	118	37·56
19	6·05	39	12·41	59	18·78	79	25·15	99	31·51	119	37·88
20	6·37	40	12·73	60	19·10	80	25·46	100	31·83	120	38·10

Appendix XI

GENERAL NOTES ON COMPUTATION

General Principles

In all computations, three general principles should be observed.

(1) The calculations should be so arranged that they can be checked in logical stages. Wherever it is necessary to write down for later use the result of an intermediate stage in the computation, this should be done in the logical place on the working sheet or form, and not on rough paper which will be thrown away.

(2) All calculations should be presented so that they can be understood by those who may wish to use the data at a later date, perhaps many years later. Unless the computations follow a pattern defined by a written code, the formulae that have been used at each stage should be given. If approximations are used at any stage of the calculations, the fact should be clearly stated.

(3) No unnecessary arithmetic should be done. In complex problems, it is often possible to reduce the amount of actual arithmetic by representing the sequence of calculations algebraically. Common terms can then be cancelled from such expressions, to leave the minimum of computation.

Working Methods

(1) *On printed forms :* Neatness and clear figuring are essential. The columns of the forms should be used for the entries of units indicated by the headings ; if changes are necessary in particular cases, the headings of the column should be altered accordingly. If extra calculations, for which there is no room on the form, have to be done, they should be written neatly on the back of the form or on a separate sheet attached to the form.

Copying from one form to another should be avoided wherever possible.

(2) *Without printed forms :* Wherever possible, a form should be prepared for the calculations, giving in the column headings, the units and nature of the measurements. Where the calculation is unlikely to be repeated, and there is therefore little point in preparing a form, the working sheet should be divided into two halves, by a vertical line. On the left of this line should be shown the stages in the calculations and the intermediate and final answers. On the right of the line, all the arithmetic involved in reaching the answers should be written neatly so that the computations can be checked.

Checking

There is no " fool-proof " method of checking calculations. The most reliable method is to do the calculations in two different ways, but this is not always possible. If self-checking computations cannot be devised, it is preferable that the work should be checked by a second person. Checking by the person who did the original calculations is always dangerous, but, if it cannot be avoided, the checking should be done several days after the original calculations.

The most frequent sources of mistakes in calculations are miscopying and inaccurate mental arithmetic. Careful attention should therefore be paid to stages which include either of these operations.

Commonsense appreciation of the results of a computation frequently indicates an " impossible " answer, and is the best safeguard against gross errors.

Numbers of significant figures

It is important to distinguish between the numbers of significant figures and the numbers of decimal places.

(1) *Decimal places.* The numbers of decimal places to which a value is expressed is the number of digits *written after the decimal point.* Thus :

23·267
1·382
·026
·002

are all expressed to three decimal places.

It is important that, in any one series of calculations, the number of decimal places is kept constant, as the position of the decimal point signifies the degree of accuracy of the measurement e.g. 16·05 claims that the real value lies between 16·0450 and 16·0549.

(2) *Significant figures.* Significant figures are those whose value is definitely known, but excluding zeros at the left hand end of the number. Thus 23·3, 1·38, 0·0267, 0·00267 are all expressed to three significant figures.

It is generally wasteful to start a calculation with more than three significant figures, although all data should be expressed to the same number of decimal places. Throughout the calculation, two or three more significant figures should be carried than will be required in the final result.

Rounding up and down

In expressing the result of a calculation to a given number of decimal places, or alternatively to a given number of significant figures, the last digit of the figure is retained unchanged if the digit which follows is 4 or less. The last digit is increased by one if the digit which follows is 5 or more. For example, 5·762 is expressed, correct to two decimal places, as 5·76, but 5·768 is expressed as 5·77.

Care must be taken to avoid rounding up twice. For example, 5·7649 written correct to three decimal places is 5·765, and in rounding up again correct to two decimal places, the value 5·77 would be obtained. In fact, the figure, correct to two decimal places, should be 5·76.

Appendix XII

MAIN DIFFERENCES BETWEEN THE REVISED CODE OF 1958 AND THE PROCEDURE OF 1931

Revised Code, 1958	1931 Procedure
Description of Sample Plot	
A Pre-establishment Form (Sample Plot Form No. 2) and a separate soil description sheet have been introduced, in addition to the general Description Sheet (Sample Plot Form No. 2a).	General Description Sheet only used.
Numbering of the Main Crop	
In some young crops trees are not numbered ; this depends on the height and girth and percentage of trees of $8\frac{1}{2}$ inches girth and over.	All trees numbered in all sample plots.
Measurements, General	
Full measurement procedure used at every second or third thinning of plot ; at the other thinnings an abbreviated procedure is used.	Full measurement procedure at each thinning.
Volumes are measured in hoppus measure over bark.	Volumes are measured in true measure under bark.
Lengths are measured to the nearest foot.	Lengths are measured to the nearest half foot.
Measurement of Thinnings	
If there are more than 40 thinnings in a plot, only a sample of about 30 thinnings need be measured.	All the thinnings felled are measured.
Selection of Trees for Height Measurement	
Trees for height measurement selected objectively from a systematic sample of every *nth* tree.	Trees for height measurement selected subjectively over a range of girth by reference to a height-girth graph.
Height Analysis	
The height growth of three trees are analysed at the establishment of a plot or at the first subsequent measurement where suitable trees are available. Height analysis is not usually done a second time in the same plot. The trees for analysis are chosen subjectively from thinnings which are unforked and have been dominants or co-dominants with heights similar to the top height of the plot.	When all the sample trees are felled, five of them are selected for height analysis, and are cut into lengths of not more than 10 feet. Trees selected for analysis do not include any with girths smaller than the mean girth of the plot, and the largest trees are also excluded when the number of trees permits.
Measurement of Sample Trees	
Sample trees selected objectively from the main crop only.	Sample trees selected subjectively from main crop and thinnings.
Form quotient method of measuring has been replaced by :	
(i) Use of Dendrometer.	
(ii) The method of partially climbing sample trees described in Appendix IV.	

Revised Code, 1958	1931 Procedure
The crown diameter of each sample tree is measured ; volumes of sample trees only measured under bark on certain species.	No measurements of crown diameter made ; volumes measured both over and under bark on all sample trees.
Calculations :	
General	
Grouping has been abolished except for differentiating the group containing the 100 largest girthed trees per acre.	A modified form of Block's method of grouping is used.
Heights	
Top height is the height corresponding to the mean basal area of the 100 largest trees per acre ; in un-numbered plots it is estimated from the mean height.	Top height is the height corresponding to the mean basal area of the group, according to Block's system, containing the largest girthed trees.
Mean height of the main crop is the height corresponding to the mean basal area of the plot ; in un-numbered plots it is the arithmetic mean height of the trees measured.	Mean height of the main crop is calculated by Lorey's formula.
Mean height of the thinnings is no longer calculated.	Mean height of the thinnings is obtained by grouping the thinnings into one or two inch girth classes. The means of each group are plotted onto a height-girth graph, and the mean height is the height corresponding to the mean girth of the thinnings.
Volume calculation	
From volume-basal area line without grouping.	(i) By groups from volume-girth line. (ii) By groups, using the form factor method of calculation. Form factors are obtained from form factor-girth graphs.
Form Factor	
The average form factor is obtained by dividing the volume of the plot by the product of the mean height and total basal area of the plot.	
Forms	
These have been revised in some cases from those discussed in 1931. Three new forms have been introduced and the use of one form discontinued. The new forms are : (1) Form No. 2—for recording pre-establishment data. (2) Form 2c—for recording the soil descriptions. (3) Form 3a—for recording the half inch classes and heights of standing trees, the basal area of the thinnings, and the basal area of the main crop at *intermediate measurements*. The use of this form makes the use of the form for recording heights of standing trees redundant.	

Revised Code, 1958	1931 Procedure
Three forms have been completely revised. These are :	
Form 2a—Description on establishment ; this has been redesigned, but the headings on the form are substantially the same.	
Form 2b—Description on remeasurement form ; this has been revised so as to serve for several measurements.	
Form 7—Final record form—the column for recording the mean height of the thinnings is omitted ; and columns have been added for recording the mean girth of the 100 largest trees, and the mean annual increment (M.A.I.) ; the sequence of the columns has been rearranged.	
Graphs	
Heights of trees plotted against basal area.	Heights of trees plotted against girth.
Volumes of sample trees plotted against basal area.	Volumes of sample trees plotted against girth.
The form factor/girth graph and the height/girth graph of thinnings have been abolished.	
Thinning grades	
Numerical definitions of thinning grades have been added to the qualitative definitions.	

Appendix XIII

SUMMARY OF DUTIES OF THE SAMPLE PLOT FORESTER

The forester in charge of the sample plots in a region will be responsible for all field work and records connected with them. His duties and responsibilities are outlined in this Appendix and will include :

(1) *Responsibility for seeing that thinnings and all other operations are done correctly and at the right time.*

In matters which are not specifically prescribed (e.g. drainage), generally accepted silvicultural practice will be followed. Any delegation of work to local staff does not relieve the sample plot forester of his responsibility for seeing that the work is done properly.

(2) *Responsibility for all measurements.*

(3) *Responsibility for the sample plot records.*

A number of points require attention.

(i) All entries in the sample plot file must be accurate. They will be signed by the person making the entry, and in addition all computations will be checked and initialled by the person checking them.

(ii) All records must be neat and legible. This may sometimes necessitate the copying of entries made in the field on to new forms ; but copying should be avoided as far as possible because both the copying and the checking of it take up time. Where copying is unavoidable, the original " field sheets " will be retained.

(iii) Plot and soil descriptions should normally be done by the sample plot forester himself, and should be completed before leaving the site.

(iv) If, for any reason, the entries on forms do not correspond with headings, the headings will be altered.

(v) Abbreviations not in general use should be avoided as far as possible ; where they are used, their meaning will be explained on the sheet on which they occur.

(vi) " Field sheets " not forming part of the permanent record will show the plot number and date, and will be initialled by the person making the entry. These field sheets will be placed at the back of the appropriate file.

(vii) Files should be completed as soon as possible, and in any case not more than two months after completion of the field work.

(viii) As an aid to ensure that no item of work is missed out, an " action sheet " may be used, in which all the items of work are mentioned can be crossed out as they are done. A specimen form is given at the end of this Appendix. The use of this form is optional and it may be destroyed after use.

(4) *Appropriate action when deviations from prescribed treatment or measuring procedure become necessary.*

Normally the circumstances as well as recommendations for suitable action will be reported to the officer responsible ; if this is not practicable, the necessary action will be taken first and the matter reported afterwards.

All deviations will be recorded in the file.

(5) *Appropriate action when plot is damaged by wind, disease or other causes.*

When reports of serious damage are received from the Conservancy or other sources, the forester will inspect the plot and submit a report on the form provided describing the damage (see para. 60) and recommending what action should be taken ; particularly whether the plot should be written off or not.

(6) *Care and maintenance of the tools, measuring instruments and other equipment.*

It is particularly important that the accuracy of measuring instruments i.e., tapes, hypsometers and prismatic compasses, is tested frequently, and that all tools are properly maintained.

(7) *Liaison with local staff.*

While it is the responsibility of the sample plot officer to inform the Conservancy or, on a private estate, the owner, or his representative,

before the plot is measured, the forester in charge of the plot will not commence work until he has called on the local forester with whom he will make the necessary arrangements concerning labour for felling etc.

He will also call on and notify the local forester when the work has been completed.

(8) *Preparation of progress reports.*

At the end of every month the forester will submit a monthly progress report on form M.R.5 (specimen attached) to indicate the progress of work during the month. NIL returns are necessary except where no sample plot work is done for several months at a time.

(9) *Preparation of programme of work.*

Every year, on the 1st of September, the sample plot forester will submit for approval a list showing which of the plots are due for measurement in the following forest year starting on the 1st of October.

PERMANENT SAMPLE PLOTS—ACTION SHEET

Plot No..... Location ..... Species.....

Thinning Grade..... Date.....

Initials	Field Work	Initials: Done by	Initials: Checked by	File Work
	Plot surveyed. Area determined and checked. Surrounds demarcated. Thinnings marked. Trees banded. M/C numbered. Thinnings girthed and classified. Maincrop girthed and classified. Trees entered in ½ inch classes on Form 3a. Thinnings felled. Thinnings measured All/Sample. Trees for height measurement selected. Heights measured, Rods/Abney/Haga/Blume-Leiss. Heights calculated and checked (also checked against Height Sheet previous measurement). Sample trees selected. Sample trees measured. Height analyses. Selected trees marked for pruning. Trees pruned. Soil pit dug. Soil description. General description (Forms 2a or 2b). Plot checked against General Register. Tools checked.			Form 3. General Register checked against ½ inch class and thinning sheet. Form 3a. Girthing sheet completed. Form 4, or 4b. Sample tree sheet completed. Form 4a. Thinning sheet completed. Form 6. Volume calculation completed. Form 5. Height analyses. Form 3b. Stem classification. *Graphs.* Height/Basal Area. Volume/Basal Area. Height analyses. Form 2a or 2b. General description sheet completed. Soil sheet completed. Form 1. Plot plan. Plot location (tracing from 1 inch O.S. map). Form 7. Final summaries. File checked by Forester i/c party.

MONTHLY PROGRESS REPORT

M.R.5

.....Sample Plot Party .....19.....

ESTABLISHMENTS

Plot No.	Species	Grade	Location	P. Yr.	Age	Top Ht.	Remarks	Office Use				
								Cards		P.A. V.Ts.	Charts	Map
								Num.	Sp.			

REMEASUREMENTS

Plot No.	Species	Grade	Intermediate or complete	Location					

OTHER WORK

Plots visited (remarks (and measurements if any) to be entered in file at H.Q.)

If necessary continue overleaf. Signed .....Date .....

Appendix XIV

DEFINITIONS

A number of terms have been used in the code of sample plot procedure, which for ease of presentation have not been fully defined in the text. These, and also a number of others which have been defined, are given in this Appendix. Most of the definitions given are those used in general practice and have been obtained from either the *Concise Oxford Dictionary* or the *British Commonwealth Forest Terminology, 1953, Part 1.* A few, however, are used only in research work and are not elsewhere defined.

Note : The sources of definitions, other than our own, are shown thus :

COD = *Concise Oxford Dictionary.*

BCFT 16 = *British Commonwealth Forest Terminology, 1953. Part 1, page 16.*

	References
Age. The number of growing seasons since planting or sowing. The age of a crop is calculated to a whole year and 1st July is taken as the operative date for increase in age ; e.g. a crop planted after the end of growing season 1930 (i.e. P.31), is 24 years old if measured on or before 30th June, 1955, but 25 years old if measured on or after 1st July, 1955. Nursery years are not included in the age of a crop except if this is unavoidable, as may occur if there are no reliable records of the date of planting and the age has to be determined from ring counts. In naturally regenerated crops, the age is reckoned by ring counts as the arithmetic mean age of dominant trees.	
Basal area. The area of the cross-section of a stem at breast height. When applied to a crop (crop basal area) it is the sum of the basal areas of the stems, or the total basal area per unit of land area. (Abbreviation B.A.)	BCFT 16
Basal area, mean. The crop basal area divided by the number of stems.	
Branch angle. The upper angle between the stem and the basal three inches of a branch (usually the dominant branch of a sample whorl).	
Buttress. An outgrowth from the butt connecting with the roots, an exaggerated form of root swelling.	BCFT 24
Canker. A definite, relatively localized, necrotic lesion primarily of the bark and cambium.	BCFT 24
Canopy. The cover of branches and foliage formed by the crowns of a crop of trees.	cf. BCFT 24
Crooked stem. Stem which has one or more bends or curves which do not originate at the base of the tree.	
Crown Class. Any class into which the trees forming a stand or crop are divided on the basis of the type of crown and its position with reference to the general canopy and to the crowns of neighbouring trees ; also the trees falling into such a class.	BCFT 34
Crown diameter. The mean of the vertical projection of the greatest and smallest crown diameters. Measured at ground level to the nearest foot.	
Crown length. The vertical measurement of the crown of a tree measured along the main axis of the stem, or its continuation, from a point halfway between lower crown and upper crown and the tip of the tree.	cf. BCFT 34
Crown height, lower. The height above ground of the lowest live branch on the main stem (excluding epicormic shoots). Measured and recorded to the nearest foot.	
Crown height, upper. The height above ground on the main stem at which live branches are found on all sides ; measured and recorded to the nearest foot.	

References

Crown per cent. The ratio of the crown length to total height of tree

$$= \frac{\text{height of tree} - \frac{1}{2}\,(\text{upper crown height} + \text{lower crown height}) \times 100}{\text{height of tree}}$$

Dead plants or trees. Plants or trees without living needles, leaves or buds.

Dying trees. Trees which, owing to disease, insect attack, or suppression, are unlikely to survive for more than three to five years.

Epicormic branch. A branch originating from a dormant or adventitious bud arising on the trunk or an older branch. Syn. Epicormic shoot. BCFT 44

Forest Year. This is a twelve month period which commences at the end of each growing season. The 1st October is taken as the starting date of the Forest Year but the actual year quoted is that of the following calendar year, e.g. Forest year 1957 commences on the 1st October, 1956. (Abbreviation F.Y.)

Forked Tree. A tree which has one or more stems arising from, and competing with, the main trunk, at or above breast height. If the forking occurs below breast height, each stem is treated as a separate tree.

Form Factor. The ratio of the volume of a tree or its part to the product of its basal area and height

$$= \frac{\text{Volume over bark to timber height}}{\text{Height} \times \text{basal area}}$$

(Abbreviation F.F.)

Girth. The circumference of a stem ; measured by tape in $\frac{1}{2}$ inch true girth classes, girths falling exactly on a quarter inch being rounded up or down to the nearest whole inch, e.g. $12\frac{3}{4}$ will be recorded as 13 inches, $13\frac{1}{4}$ inches as 13, $13\frac{3}{4}$ as 14 inches, etc. In special cases, which will be specified, girth may be measured in one-inch true girth classes.

Girth, mean. The girth corresponding to the mean basal area of a group of trees or a stand. BCFT 69

Ground level. The highest point of the ground touching the tree stem.

Height. The vertical distance between ground level and the extreme tip of a tree.

Height, arithmetic mean. The sum of the heights of the trees divided by the number of trees measured.

Height, breast. This is the standard height for measuring girth and basal area of individual trees. It is taken as 4 feet 3 inches above ground level. On sloping ground it is measured on the upper side of the tree. On leaning trees, it is measured parallel to the axis of the stem on the side where the tree forms the smallest angle with the ground.

Height, mean. The height corresponding to the mean basal area of a group of trees or a stand, as obtained from a height/basal area graph.

Height, pruned. The vertical height from ground level to a point on the stem three inches below the underside of the lowest branch remaining after pruning.

Height, timber. The height of a tree to a point where its girth is $9\frac{1}{2}$ inches over bark, or to the point above which no main stem can be distinguished, whichever comes first.

Height, top. The height corresponding to the mean basal area of the 100 largest-girthed trees per acre (not necessarily the 100 tallest trees per acre as obtained from a height/basal area graph).

Height, arithmetic mean top. The arithmetic mean height of the 100 largest-girthed trees per acre.

Hoppus foot. The unit of measurement for tree or log volumes under the hoppus system followed by foresters and timber merchants throughout the British Isles. In this system the volume is computed by multiplying the quarter girth sectional area at the mid-point of the log or tree by the length in feet.

References

Hoppus foot—contd.

Hence the relationship between one hoppus foot and one cubic foot is the same as that between one square foot quarter girth and one square foot true measure, i.e.:—

1 hoppus foot = 1·273 cubic feet.

1 cubic foot = 0·7854 hoppus feet.

See also *Quarter Girth Measure*.

Leader. The terminal shoot of a tree or plant. Syn. Leading shoot. — BCFT 83

Leader, multiple. The development of more than one leader resulting in forked growth ; usually due to injury. — BCFT 83

Lean. The inclination or slope of the stem from the perpendicular. — cf. COD

Mixture. Where two or more species are present after thinning, and the subsidiary species together occupy either more than ten per cent of the total number of trees, or more than ten per cent of the total basal area.

Plot, sample. A plot for the determination of yield, etc., enclosed within a surround. A uniform silvicultural treatment is applied to both plot and surround.

Quality Class. A measure of the relative productive capacity of a site for a particular species. The top height at a given age is used as the basis for classification. — cf. BCFT 119

Quarter Girth. The girth or circumference of a tree or log (normally measured in inches) divided by 4. cf. B.C.F.T. 69.

Quarter Girth Measure

(*a*) *As used in this Bulletin for basal areas*, quarter girth measure implies the calculation of the cross-sectional area of a tree or log by the formula:—

$$\text{Area in sq. ft. quarter girth measure} = \left(\frac{\text{(girth in inches)}}{4}\right)^2 \times \frac{1}{144}$$

The relationship between square feet quarter girth and square feet true measure is: 1 square foot quarter girth measure (sq. ft. q.g.) $\frac{4}{\pi}$ square feet true measure (and since $\frac{4}{\pi} = 1 \cdot 273$) $= 1 \cdot 273$ square feet true measure.

Conversely, 1 square foot true measure = 0·7854 square feet quarter girth measure.

(*b*) *As used colloquially for tree or log volumes*, quarter girth measure implies the calculation of volumes by hoppus measure (see *hoppus foot*).

Sample, objective. A sample selected by a method which is unbiased and leaves no room for personal choice ; it may be either systematic or random.

Sample, random. A sample selected in such a manner that all possible samples of the same size have equal chances of being chosen. — BCFT 114

Sample, systematic. A sample selected in conformity with some pre-determined regular pattern. — cf. BCFT 114

Series, thinning. Two or more adjacent plots of the same species, thinned to different grades of thinning for purposes of comparison.

Stem class. A class into which trees of a stand or crop are placed on the basis of some quality of the stem ; also the trees falling into such a class. cf. Crown class. — BCFT 129

Stop. A point in the stem where there is a sudden marked change in girth.

References

Subsidiary species. Where two or more species are present after thinning and the species, other than the main species, together occupy 10 per cent or less of the total number of trees and total basal area of the crop, these species are classed as subsidiary species (cf. mixture).

Surround. The surround is the strip of forest which surrounds a sample plot. It is of the same age and species as the plot and receives the same treatment in order to insulate the plot against outside influences (Syn. Strip Isolation). cf. BCFT 131

Taper. The decrease in thickness of a tree stem from the base upwards. BCFT 134

Thinning. A felling made in an immature stand for the purpose of improving the growth and form of the trees that remain, without permanently breaking the canopy. cf. BCFT 136

Thinning, crown. A type of thinning based on the release of the crowns of selected dominant trees primarily by the removal of other trees in the upper canopy classes.

Thinning, free. A type of thinning based on the selection of the best trees (defined according to the particular objects of management) and the removal of others irrespective of their canopy class.

Thinning, low. A type of thinning based on the removal of trees in ascending order of canopy class.

Thinning, mechanical. A type of thinning in which the trees to be cut are selected by some rule-of-thumb, e.g. alternate trees in alternate rows, or every second, third, fourth, etc. line, or a minimum spacing gauged by a standard stick (" Stick thinning ").

Thinning, selection. A type of thinning based on the removal of the largest stems of the crop.

Thinning grade. A classification of severity of thinnings within any particular thinning type. (See appendix III.)

Thinning intensity. A classification or scale of thinning combining grade and periodicity, i.e. heavy grade + short periodicity = high intensity.

Thinning method. See " Thinning type ".

Thinning periodicity. The interval between successive thinnings.

Thinning type. A classification of kinds of thinnings based either on the trees removed or on the trees left in thinning. Syn. " Thinning method ".

Volume. All volumes unless otherwise stated refer to hoppus measure over bark.

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