STUDIES ON DECAY OF BALSAM FIR AND RED SPRUCE IN THE EASTERN TOWNSHIPS OF QUEBEC

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INTRODUCTION

For a long time it has been well established that losses from decay in living trees vary in intensity with tree species, age, site, stand history, and other less important factors. Several authors, both in the United States and in Canada, have collected information of this kind, especially since Meinecke (16) set forth the "pathological rotation" principle. Publications on this question have been reviewed by Spaulding and Hansbrough (20) in 1944 and more recently by Basham et al (1) and Foster & Foster (9). In most of these studies, causes and means of entrance of decay have been determined for a number of commercial tree species in various parts of Canada and the United States. However, the object of such investigations was mainly to find what relationships might exist between losses caused by decay and any variable in the stand in view of establishing the basis for control measures.

Knowing the importance of decay in the forest, especially in easily accessible and valuable stands under management, measures to reduce losses should be applied when economically feasible. These measures, however, have to be based on established principles derived from knowledge of the yield of a given commercial species growing under the most common sets of conditions. An important point to determine tree decay control is certainly the age of maturity of a species on a given site. This stage in the development of a tree, or the "pathological cutting age" is "the maximum at which the stand can be cut if a loss of economic importance is to be avoided" (Meinecke). It is therefore necessary to draw, with reasonable statistical precision, the growth curve of a species and to determine the cull factor for each age class. Data for such studies can be obtained only by accurate measurements in the forest. At the same time, such investigation will provide useful information for the estimation of net volume in inventories and secure precise data on the kind of decay infections, their means of entrance, their incidence and intensity. It is now generally accepted that information about the main commercial species should be obtained from the most common sites in every forest district of this country. Investigations of this kind are currently in progress in all provinces of Canada, particularly in British Columbia and in Ontario, where they are carried out on an extensive scale.

As in any other part of this continent, losses from decay in living conifers are sometimes heavy in Quebec, especially in spruce-fir stands. This research project was conducted with about the same general conception and similar method of investigation already in use elsewhere in Canada. However, the influence of site as differentiated by the forest type method or the lesser vegetation, was emphasized.

The investigation summarized in the present report is part of a general project on conifer decay, initiated in 1938 and aimed to be carried out in most of the forest regions of this Province. Conifer decay studies were first undertaken in 1922 by W.E. Hiley (12) and the same year by A.W. McCallum (15) in the Saguenay and the Lower St.Lawrence districts. Data on more than 10,000 trees gathered between 1938 and 1945 by the Provincial Division of Forest Pathology in spruce-fir stands of the Quebec area, the Laurentide Park, and the North Shore District (Pomerleau) (17). After an interval of ten years, this programme of work was resumed in 1954, under the aegis of this laboratory, in the southeastern part of the Province of Quebec, usually known as the Eastern Townships. During the field seasons of 1954 and 1955 such studies were carried out on the private properties of the East Angus Division of the St. Lawrence Corporation Limited. The field work was conducted in close co-operation of this pulpwood industry. The present report is based on the analysis of data collected from 2464 trees.

METHOD OF STUDY

Location of Sample Areas

As indicated in the introduction, similar investigations have already been conducted in several areas of Quebec and will be carried on in the main forest districts of this Province. The southeastern region of Quebec (Fig. 1) is not as important for wood production as the northern districts, because this part of the Province is heavily settled. Nevertheless, a large quantity of wood is drawn each year from private properties and the public lands. The milder climate and richer soil result in a forest which is more productive than anywhere else in Quebec. Located in the tolerant hardwood forest of the Great Lakes-St.Lawrence Forest Region, the soil geological formations and the climate of this district differ widely from the Boreal Forest Region. Still, large tracts of spruce-fir stands are found among hardwood stands and cultivated lands. Another important difference between the Eastern Townships and other districts is the easy accessibility of the forest and, consequently, the increased value of the wood. One of the greatest difficulties encountered during this investigation was, however, the almost complete absence of undisturbed stands. Practically all the forest has been heavily cut over in the last century. Consequently, the number of trees older than 60 or 70 is declining rapidly in this area.

Field Procedure

The working procedure for collecting data was improved during the period 1938 to 1944 in this Province and is essentially the same as that in use in Canada and the United States for similar studies. The selection of sample areas was governed largely by stands available in which no recent disturbance was found, and also the age range of the two species under investigation on a given site. In sample plots of one-tenth or one-quarter acre, established in representative stands, all trees of the species to be studied were cut, analysed for decay content, and carefully measured.

After an area had been selected for study and the sample plot established, the ground vegetation was first analysed, and the plot was typed according to a classification system in use in Quebec. The soil structure was recorded and soil samples of each horizon taken. All trees on the plot were numbered, tallied, and their crown class, form, and health determined. In this study, all spruce and balsam fir trees over

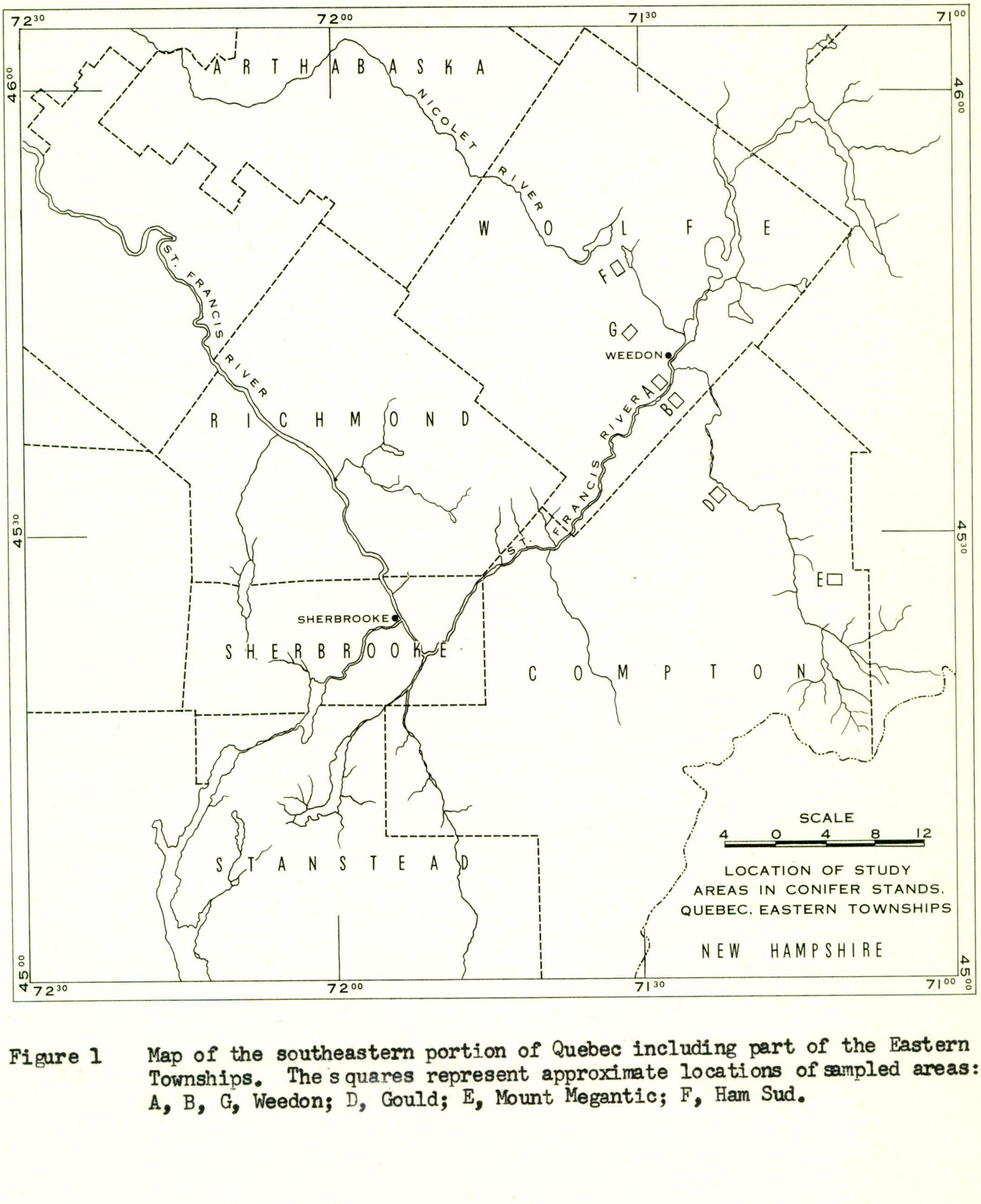

Figure 1 Map of the southeastern portion of Quebec including part of the Eastern Townships. The squares represent approximate locations of sampled areas: A, B, G, Weedon; D, Gould; E, Mount Megantic; F, Ham Sud.

3.5 inches D.B.H. were cut at about 6 inches above the ground and sectioned in four-foot bolts. Data were taken on the total length of the leader, the length of merchantable diameter (to a 3-inch top), diameter and height of the crown. The age of each tree was determined by an annual ring count at breast height. When decay prevented an accurate count, another one was made at the next section and a correction factor based on the age at the same diameter of other trees applied.

The diameter of each bolt was measured outside and inside the bark at each end, and the presence of crotches, scars, wounds, or broken tops which might cause cull was noted. When rot was present, the diameter of the decay column at both ends was carefully measured, graded, and recorded. It was sometimes necessary to split a bolt to find the extent of the rot column. The infection court of each decay was also determined when possible, except for butt rots which usually enter through a root. The type of each decay and, when possible, the probable cause was determined and recorded.

A sample of each rot was collected, numbered, and sent to the laboratory for culturing and identification.

Method of Compilation

In the laboratory, all wood rot samples were examined and corresponding cultures compared with a reference culture collection, before the final diagnosis was made. Soil samples were analysed to determine the percentage of sand, silt, and clay by means of the hydrometer followed by dry sieving. The moisture equivalent and pH of each sample were also obtained.

All volumes in this study are given in cubic feet in conformity with the regulations of the Quebec Department of Lands and Forests for wood scaling on Crown lands.[1] Although the Quebec Rule (Roy) in board feet is also accepted for saw timber, it was not used in this investigation.

The total volume of the tree was subdivided into the volume of the stump from the ground to a height of six inches, the volume of the trunk up to 3.5 inches diameter inside bark, and the volume of the top. The stump volume was found by applying the formula of a cylinder and that of the top was derived from the formula of a cone. For each four-foot bolt of the trunk, the volume was computed after Newton's formula of the neiloid:

$$V = \frac{(B + 4B\frac{1}{2} + b)}{6} L$$

Tables of volume of all possible combinations of diameters were prepared for bolts four feet long and less.

From values obtained in computing the total volume the theoretical merchantable volume of pulpwood was found by eliminating the stump and top volumes. The theoretical merchantable volume for saw timber was determined by adding volumes of all 8, 12, or 16 foot bolts, which could be obtained in the trunk. The minimum saw log diameter for balsam fir is 7 inches at

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1- Official regulations and instructions concerning the scaling of wood cut on Crown lands. Quebec Department of Lands and Forests. 1957.

one end and 4.5 inches at the other, and 10 inches for spruce. External defects of some importance may cause the culling of a length of the saw log.

Actual decay volume was computed, using the same method and the same tables to determine the theoretical cull for pulpwood, The volume of a cylinder of wood with a diameter equal to the larger diameter of the rot at either end of each log was deducted. When this cylinder was more than 50 per cent the volume of the log, the entire log was culled. According to the Quebec scaling regulations, when the volume of the decay cylinder exceeds one-third of the total volume the entire log should be culled . But since our values were always based on the larger diameter of the decay, and not only at one end as is the usual practice, it was necessary to compensate by increasing the decay allowance. From tests it was found that differences between the two methods were not significant.

For saw timber the theoretical cull was obtained by computing the volume of two cylinders, each of which was half the length of the log from the diameter of the decay at each end. When the volume of the decay cylinder was greater than one-third of the merchantable volume,the entire log was culled. In both cases, the net cull volume should also include all losses due to defects other than decay, and the net merchantable volume was the difference between the theoretical merchantable volume and the net cull volume.

Most age or diameter relationships with tree volumes, decay volumes, percentage of cull, and infection incidence are represented by freehand curves and curved values listed in tables. This practice was followed by all those who reported on similar investigations. Several attempts were made to fit these curves mathematically, but with very unsatisfactory results. This was due to the wide dispersion of data, the insufficient number of samples in advanced age classes and the unknown influence of tree mortality, particularly at certain periods of stand development. However, the percentage of cull and gross, and net volumes in relation to age were analysed by the regression line method and tests of significance were made by co-variance analysis. To define the relationships between a number of variables, the method of multiple correlation analysis was also used, but due to the wide dispersion of data, this treatment did not add any useful information to the previous one.

FOREST TYPES AND SITES

The present investigation was carried out in stands located in the southeastern part of Quebec which belongs to the Eastern Townships Section of the St. Lawrence Forest Region of Halliday (10). In this area of upland conifer and mixed wood, stands still occupy large tracts of land, although most of the forests are mainly composed of hardwood. The softwood and mixed wood stands contain mostly balsam fir (*Abies balsamea* (L.) Mill.), red spruce (*Picea rubens* Sarg.), a few white pine (*Pinus strobus* L.), and hemlock (*Tsuga canadensis* L.). Some yellow birch (*Betula lutea* Michx.f.), red maple (*Acer rubrum* L.) and trembling aspen (*Populus tremuloides* Michx.) occasionally enter into the stand composition.

The site quality index, as a measure of relative productive capacity of the area, was not determined from data recorded during this study. Instead, as in all previous studies on decay in conifers carried out by the author in Quebec, the basis for site classification was that obtained by analyses of the ground or lesser vegetation. From various studies on the determination of the productive quality and other characteristics of site by Heimburger, (11), Ray (19), Linteau (14), and others still underway, a forest type classification would seem to provide a better representation of the conditions of the stand than that obtained by any other method. This system is in use by several forest agencies in Quebec and is entering into the current practice in many pulp and paper companies. For similar work carried out since 1938, the author always followed the same method for site description.

The method of vegetation analysis in use is essentially that described by Linteau (14). The frequency of each plant species is determined according to the Raunkiaer principle (18) while the sociability was found according to the Braun-Blanquet scale (4). In Table 1 a summary of the results of this survey is given. The sample plots are distributed into four sites and most plant species found are listed and grouped in strata i.e. trees, tree reproduction, shrubs, herbs, mosses, and hepatics. This table was made with the data collected in 26 sample plots in which 150 plant species were listed. This number was reduced to 27 species commonly found. To simplify the tables the relative importance of a plant or the frequency is represented by a value obtained from this scale:

Frequency	V	Plant found in 81% and more of the sample plots
	IV	- - - 61% - 80% of the sample plots
	III	- - - 41% - 60% - - - -
	II	- - - 21% - 40% - - - -
	I	- - - 1% - 20% - - - -
	0	- not found in any sample plot

The interval of abundance or range of average cover of a plant in one forest type is also given. For the only sample plot of the Hypnum type the data on the abundance and sociability of the characteristic plants are indicated.

In the area where this study of decay of conifers was carried out, four plant associations or forest types were recognized. They were named according to the Cajander method (5 & 6) followed by Heimburger (11), and Linteau (14). They are briefly defined as follows:

Dryopteris-Oxalis Type (Dry-O T)

(Including sample plots nos. 99, 120, 121, 122, 123, and 124)

This is the fern type of Ilvessalo (13) and the Aspidium-Oxalis type Heimburger (11). It was found in the Mount Megantic area on well drained slopes and rich soil. Balsam fir is the dominant tree species mixed with a number of red spruce and occasional yellow and white birch trees and red maple. In this type, the white cedar and the eastern hemlock are lacking in the tree stratum as well as in the tree reproduction layer.

In this type two ferns, Dryopteris spinulosa[1] and D. phegopteris, and Oxalis montana, Cornus canadensis, some Carex sp. and Aster acuminatus

1- Higher plant names from Gray's Manual of Botany. M.L. Fernald Eighth edition. 1950. Moss & Hepathic names from Mosses with a hand-lens. A.J. Grout. 1924.

are the most conspicuous plants, whereas Linnaea borealis, Maianthemum canadense, Dalibarda repens, Gaultheria hispidula, Trientalis borealis, Osmunda cinnamomea and O. claytoniana are totally lacking or rare. The moss flora is poor and represented by small patches of Hylocomium splendens, Calliergon schreberi and others.

In the 6 sample plots of this type, the soil was a loam, a sandy loam, or a fine sand loam, with a silt clay percentage varying between 38 and 54. The moisture equivalence was 15-26, and the pH 4.1 to 5.1. The humus layer average was 4 inches in thickness.

Hylocomium-Oxalis Type (H-O T)

(Sample plots nos. 84 - 91 and 93 - 98)

Also found by Ilvessalo (13) and described by Heimburger (11) and Linteau (14), this type is one of the most common supporting coniferous stands in Quebec. It occurs mainly on flats, on slight slopes, or on poorly drained areas. The dominant tree species is the balsam fir with which red spruce is associated and forms from 2 to about 20 per cent of the tree cover. Yellow and white birch, red maple, white cedar, and eastern hemlock are constantly represented by a few scattered individuals.

Shrubs are not very common in that type, but the ground is covered with a thick carpet of mosses and herbs. Oxalis montana and Hylocomium splendens are the most conspicuous species, but other plants, such as Trientalis borealis, Maianthemum canadensis, Linnaea borealis, Calliergon schreberi and a few others are almost always present in the association. Although some ferns, like Dryopteris spinulosa, are quite constantly found, they occur in small groups or isolated.

In the 14 sample plots classified in this type, the soil was a loam, a loamy fine sand, or a sand, with a percentage of silt clay ranging from 17 to 74 per cent. The moisture equivalence widely varies between 7 and 36 per cent, the pH 3.2 and 5.2. The drainage was usually poor in such areas and the humus layer was 4 to 7 or 8 inches thick.

Hypnum Type (Hyp T)

(Sample plot no. 92)

This forest type, known also as the Calliergon type (Bellefeuille (2) was found in one sample plot established in a small red spruce stand in which balsam fir formed about one-quarter of the tree population. The shrub and herb strata were poor, but mosses such as Calliergon schreberi and Sphagnum sp. covered almost all the ground.

In this location the water table was high and the drainage very poor. The soil, of the loam class, with 58 per cent of silt clay, has a moisture equivalence of 26, and a pH of 4.1. The humus layer was about 4 inches thick.

Bazzania-Oxalis Type (Baz-O T)

(Sample plots nos. 125 - 129)

This type, described by Heimburger (11), is apparently not common. During this study it was found only in one area covered with a virgin and undisturbed stand of old red spruce. It occurred at Ham Sud in Wolfe County, on small ridges. Although red spruce is the dominant species, forming 40 to 65 per cent of the stand, balsam fir also occurs fairly frequently. Yellow birch, white birch, red maple, and hemlock are also found mixed with the two main species. In this forest type, old red spruce trees of about 300 years often support a number of witches'-brooms and are distorted by this parasite. The understory of balsam fir and of red spruce is suppressed for a long time under the cover of old trees.

A few bushes of Vaccinum myrtilloides, Salix spp., and Viburnum lantanoides were found, but Acer spicatum is lacking at the shrub stratum. The ground vegetation is mainly composed of large patches of Bazzania trilobata, admixed with plants such as Dryopteris spinulosa, Dalibarda repens, Chiogenes hispidula, Cornus canadensis, and a few others constantly but poorly poorly represented.

In the four sample plots of this type, the soil was a loam with a silt clay content varying between 25 and 64 per cent, a moisture equivalence ranging between 16 and 63, and a pH of 4.1 to 4.8. The thick humus layer measured between 7 to 17 inches and the drainage was fairly good.

BASIC DATA

Results of this investigation are based on data as presented in Tables 2 and 3. In 26 sample plots, covering a total area of 6.25 acres, a total of 2464 trees were analysed during the field season of 1955 and 1956. In most stands, balsam fir was the dominant species, except in three areas where the proportion of red spruce was larger. The average age of red spruce for all trees was 116 years, but the average by plot varied between 55 and 205 years. For balsam fir, the average age was 62 years in all plots, but only a few trees above 150 years were found. Except in a virgin stand of the Bazzania-Oxalis type, where red spruce trees above 200 years old are common, the number of trees above 100 years, and even older than 70 years, decrease rather suddenly. This is an indication that heavy logging operations were carried out in this settled area, a long time ago.

In all areas examined, 29.2 per cent of the red spruce trees and 52.0 per cent of the balsam fir trees were decayed to some degree. However, in the average, only 6.7 per cent of the merchantable volume of red spruce and 9.6 per cent of that of balsam fir were culled for pulpwood. This proportion, however, reached 17.7 per cent in red spruce and 21.0 per cent in balsam fir in certain plots.

With only 643 red spruce trees, the sampling is somewhat small for a reliable analysis of relationships of decay and certain variables, especially when this number is broken down into four groups. For balsam fir, on the other hand, 1821 trees is a reasonably good sample, for at least the two main forest types found in this area. However, it should be noted that the number of trees above the 70-79 age class falls down rapidly. The principal reason for this could be partly ascribed to the cutting carried out 60 or 70 years ago in those stands. It is also possible that mortality due to natural causes has also decimated the balsam fir after 60 or 70 years of age. This important aspect of the problem is not analysed in the present report, but should be investigated soon in this Province.

FUNGI CAUSING DECAY IN LIVING TREES

Relative Importance

The organisms isolated in pure culture from samples of decayed wood collected during this study were the same as found in the past in other areas of this Province and reported in other eastern provinces (Basham et al. (1). In Table 4, they are listed separately for red spruce and balsam fir according to forest types.

It should be noted first that all butt rots have caused about 60 per cent and trunk rots about 40 per cent of the decay incidence in both balsam fir and red spruce. For both species, the occurrence of white rots is two or three times higher than brown rots in tree basis. As already observed by some authors, Corticium galactinum is the most important fungus causing butt rot in both species. While most of the trunk rots encountered in balsam fir are caused by Stereum sanguinolentum, the decay incidence in red spruce trunk is partly due to Fomes pini and Stereum sanguinolentum infection.

On the basis of volume, Stereum sanguinolentum is responsible for almost 70 per cent of the decay in balsam fir and Fomes pini is associated with 65 per cent of the total loss by decay in red spruce. In both species, Corticium galactinum is the cause of 12 to 15 per cent of the volume of butt rots. Except in the Hypnum type, in which the small sampling is largely composed of young trees, the proportion of incidence of each type of rot follows about the same trend given for all types. Therefore, Corticium galactinum, causing a white butt rot, and Stereum sanguinolentum, causing red heart rot, are responsible for almost 85 per cent of the decay volume in balsam fir. In red spruce, more than 77 per cent of the decay volume is the result of the attack by Fomes pini and Corticium galactinum. In the past, the white butt rot was mostly attributed to Poria subacida (17) but recent studies (1) have shown that other fungi were more important.

Infection Courts

During this investigation the infection courts of decay in conifers were determined in most instances. Avenues of entrance of decay organisms found during this study are listed in Table 5.

As already known from other studies, the origin of the majority of butt rotting fungi for both red spruce and balsam fir is in the roots, and a small number of scars on the stump. On the other hand, most of the trunk rots have gained entrance to the tree through branch stubs and scars. In balsam fir, however, branch stubs are the most important infection court of Stereum sanguinolentum, since more than 70 per cent of the resulting decays have entered through this type of wound.

RED SPRUCE

Before attempting to determine the influence of decay in the stand yield and maturity, information derived from individual trees should be first presented. The relationship between tree growth and decay with age and diameter, for each tree species in the main forest types, would give a first picture of the tree condition at a given period and such information may be used later to define stand maturity and recommend forest practices for decay control.

All relationships on red spruce are based on the 643 trees analysed in this area. Evidently, this number is too small to be acceptable as representative of the true condition of this species in one region. The statistical value of such a small sampling is still less adequate when trees are distributed in four different forest sites. Nevertheless, data on hand were used to obtain percentage and curved values on decay in relation to age and diameter and indications of the condition of red spruce with regard to decay in this area.

DECAY IN RELATION TO AGE

Incidence of Decay

As shown in Table 6, the percentage of trees with decay increases more or less gradually with age; on account of the small sampling, however, results are rather irregular when trees are distributed by forest types. With a better distribution by age class, as in the Bazzania-Oxalis type, it can be seen that before 190 years less than 50 per cent of the red spruce trees are infected with decay organisms, the majority of which produce butt rots. No other conclusion can be drawn from this first group of data.

Losses in Volume

A general view of the tree growth in volume and the decay development in relation to age was obtained from red spruce trees of all types and the computed curved values presented in Table 7. By inspection of these figures, it would appear that the total net volume and the net merchantable volume for pulpwood continue to increase up to 300 years in red spruce. In Table 8, the curved values computed from graphs (Figs. 2, 3, 4, 5, 6, and 7) indicate that merchantable, cull, and net volumes for pulpwood for a given age are somewhat different according to types. For instance, at 200 years, the cull volume for pulpwood is 1.83 c.f. in the average tree growing in the Baz-O T, 1.10 c.f. in the Dry-O T, and 2.83 in the H-O T. When considering the net volume for pulpwood, these figures indicate that in the Baz-O T 23.5 c.f. are expected at 200 years, 20.46 in Dry-O T, and only 14.6 in the H-O T. Although the sampling is too scanty in the higher age classes, red spruce growing under the conditions prevailing in the H-O T would seem to be more defective. This is apparent also in the percentage of cull volumes given in Table 9. As an example, the cull volume for pulpwood at 140 years in the H-O T is 8.4 per cent, 6.8 per cent in the Baz-O T, 1.8 per cent in the Dry-O T, and 22.8 per cent in the Hyp T.

It seems evident from the data on hand that decay increases with age in red spruce. A closer examination of data would reveal that tree growth is much faster in the Dry-O T than in the two other main sites, at least until 150 years. Furthermore, the decay factor emphasizes the advantage of the Dry-O T over the others since the decay volume is less important at a given age in trees growing in this type than in others.

Correlation Analyses

All curves on volume-age relationships presented above are freehand and based on age class averages. Whether such estimations of net cull percentage and volume recovery are valid in red spruce of different forest types should be tested. For this purpose, the regression line for each group of data was fitted and the co-variance analysis made according to the method followed by Davidson (7). Since the distribution of trees by age class is not uniform throughout the range of sampling, data from 60 to 200 years only were computed. Regression equations of cull percentage relationships with age are presented in Table 10 and the corresponding regression lines given in Fig. 8.

For each forest type, the linear relationship of age and cull percentage is apparently different, particularly between red spruce in the Dry-O T and that in the H-O T and the Hyp T. However, the co-variance analysis between all types or between any two types have shown (Table 10) that both adjusted means and regression co-efficients do not differ significantly. The main reason for this poor result was attributed to the insufficient sampling. However, tests of significance between red spruce in the Dry-O T and the H-O T have yielded almost positive results. It should be mentioned here that age is a worth-while variable for the percentage cull for trees in all sites (F = 6.99). Therefore, the statistical analysis of data available has indicated only a positive relationship between age and cull percentage, but has failed to show significant differences between red spruce growing in four different forest types.

DECAY IN RELATION TO DIAMETER

It is usually accepted that decay or cull is more closely related to age than to diameter. In spite of this fact and of the small sample in red spruce, available data were arranged by diameter classes. From results presented in Tables 11 to 14 and in Figures 9 to 12, it was found that decay and cull volumes or percentages increased with diameter at breast height. It should be noted also that while the pulpwood cull levelled to about 1 per cent in red spruce of Dry-O T at 10 inches in diameter, 7.1 per cent is found in Baz-O T, 8.7 per cent in H-O T, and 5.0 per cent Hyp T. The same trend of differences continues in higher diameters, but the net volume is about the same in all the types and even slightly better in the Baz-O T. These last results would indicate an inadequate correlation of diameter with decay, particularly in the higher diameters. This may be due to the paucity of sampling, but also to the variation of age in each diameter class. As shown in Fig. 13 and in Table 15, the average age is much higher for a given diameter in the Baz-O T than in the three others. Furthermore, the standard deviation for each diameter class (Table 15) and average deviations are evidently too extensive to be reliable. Therefore, the estimate of decay or cull volumes on the basis of tree diameter would seem premature until a larger sample is available.

BALSAM FIR

As with red spruce, results for balsam fir are based on individual trees. This procedure indicates the condition of the average tree for each age or diameter class with regard to its total merchantable, decay, and cull volumes. Data from 1821 trees are divided into four distinct forest types, one of which, the Hypnum type, is of little use on account of the fewness of data.

DECAY IN RELATION TO AGE

Incidence of Decay

Decay incidence in balsam fir increases with age as shown in Table 16. Except in the Dry-O T, decay is not common in the young age classes up to 40 years, but already 35 to 66 per cent of the trees analysed exhibited traces of rot in the 40 to 49 age class. In the Baz-O T a rather high proportion of balsam fir is infected, mostly by butt rots in the early stage. Although the incidence of decay rises very rapidly in most balsam fir stands, some differences are apparent on site of the Dry-O T. In this group, 66.7 per cent of the trees sampled were infected in the 90 to 99 age class, whereas, more than 90 per cent of those of the two other types contained some measure of decay at the same age. Such a divergence, however, is not consistent in other age classes and is not very significant.

Losses in Volume

In Tables 17 to 20 and in Figures 14 to 18, curved values on volume relationships with age are presented. When data from all sites are computed (Table 21), the decay volume at 100 years reaches about 8 per cent, the cull volume for pulpwood almost 15 per cent, and that for saw timber 18 per cent. Broken down into three forest type data, the curved values, when compared, become significantly different (Table 21). For instance, the decay percentage at 100 years is 3.5 in Dry-O T, almost 12 in H-O T, and 8.7 in Baz-O T. The same variation occurs between cull volumes of each type. When net volumes of each type at a given age are compared, contrasts are still more apparent. At 60 years, the gross merchantable volume for pulpwood is 7.85 c.f. in the Dry-O T, 5.28 in the Baz-O T, and 6.05 in the H-O T and the net volume is 7.4 c.f. in the Dry-O T, 4.6 in the Baz-O T and 5.50 in the H-O T. At 100 years the average balsam fir trees growing on the Dry-O T would produce a net volume of almost 15 c.f. whereas in two other types about 10 c.f. would occur. Spaulding and Hansbrough (20) in New England, and Davidson (8) in New Brunswick, have already observed about the same differences between sites, divided, however, in a more arbitrary way.

This first analysis of volume-age relationships indicates that the maximum net volume of balsam fir is reached at 140 years in the Dry-O T at 110 years in the Baz-O T, and 100 years in the H-O T.

Correlation analyses

With a much larger sample of balsam fir than of red spruce, better results were expected from statistical analysis. In order to avoid as much as possible sources of errors, data computations were restricted to age range of 50 to 149 years and later of 50 to 119 years. A first group of results, from regression lines computations and co-variance analyses of pulpwood cull percentages in relation with age, are presented in Table 22 and in Fig. 19.

As with red spruce, the cull percentage increases with age in all forest types and in all types. The tests of significance by the co-variance analysis has shown (Table 22) very significant correlation between age and cull for all types. However, significant differences between the adjusted means and the regression coefficient were found only between two forest types: Dry-O T and H-O T and the adjusted means of Baz-O T and Dry-O T. Other forest types combinations have failed to show significant differences between them. This could be explained by the poor sample in certain sites or simply ascribed to the lack of wide enough dissimilarities between them.

The validity of this type of analysis of cull percentage may be questioned, however, since only part of the sample has a cull factor. Is it permissible, therefore, to compute data from a number of samples with a zero value? Differences between forest types may be due to the number of trees with decay or to the amount of cull in infected trees. The analysis of data from infected trees only was not carried out because the results would not provide very useful information on the true differences between two sites with regard to cull percentages. At this point, it was considered that more reliable representations of true differences could be obtained by the analysis of the gross merchantable and the net merchantable volumes for pulpwood instead of the cull percentage. Therefore the computation of such data from the two main forest types of the area was made and the following results recorded, the regression lines being presented in Fig. 20.

Regression line equations and tests of significance between the gross and net merchantable volumes in balsam fir in two types

Type	Merchantable volume	Regression line equation
Dry-O	Gross	$Y = -3.462 + 0.1872 X$
Dry-O	Net	$Y = -2.89 + 0.1716 X$
H-O	Gross	$Y = -4.682 + 0.1773 X$
H-O	Net	$Y = -$ ~~2.89 + 0.1716 X~~ 2.29 + 0.1304 X

Tests of Significance

Gross merchantable volume of 50 - 119 year trees

Adjusted means F = 39.23 (Foi = 6.64)
Regression coefficients F = 0.2555 (Foi = 6.64)

Net merchantable volume of 50 - 119 year trees

Adjusted means F = 49.70 (Foi = 6.64)
Regression coefficients F = 4.08 (Foi = 6.64)

Adjusted mean gross merchantable volume

H-O T = 6.26
Dry-O T = 8.09

Adjusted mean net merchantable volume

H-O T = 5.75
Dry-O T = 7.22

Differences at 100 years old of the net merchantable volume 24.7%.

These results indicate significant differences between both the gross and the net volumes of the two types. However, such differences were found only in the adjusted means and not, as expected, in the slope of the regression line. Adjusted means of the gross and net merchantable volumes are also different in the two types. At 100 years, the mean gross merchantable volume in the Dry-O T would be 14.5 per cent higher than that in the H-O T and the mean net merchantable volume would be 24.7 per cent higher in Dry-O T than in the other type. Therefore, at 100 years, 14.5 per cent of the difference in volume is due to the tree growth and about 10 per cent to decay. On such a sound basis, it is therefore well established that balsam fir grows faster and with less decay in the Dry-O T of forest than in H-O T.

An attempt was also made to define by the multiple correlation analysis, the relations between the cull volume (Y) and tree characteristics, such as gross merchantable volume (A), age (B), height (C), diameter (D). First, the correlation coefficient obtained was 0.5966 and a regression line of the following equation was Y = - .2077 A + .0323B + - .0246C + - 4.5592D for H-O T. The regression coefficient with age only being .0.5882 would mean that other variables do not add any to the correlation with cull volume. In Dry-O T, the coefficient of regression is 0.4657 with all characteristics and 0.3218 with age only. The regression line equation was Y = 0.0334 A + 0.0043B + (-0.0167C) + .0118D - 0.1914. Therefore, it is felt this long and tedious method would not provide very useful information.

DECAY IN RELATION TO DIAMETER

As with red spruce, data on the various volumes were computed in relation to diameter. Curves were drawn (Figs. 21, 22, 23) and curved values presented in Tables 23, 24, 25. Although it is generally accepted that decay is more closely related to age than to diameter, the percentage between balsam fir in Dry-O T and the two others are considered here. For instance, the average tree of 10 inches in diameter would have 4.5 per cent of cull for pulpwood in Dry-O T, 14.0 per cent in Baz-O T, and 10.9 per cent in H-O T. It is curious to note that about the same amount of net volume would be found at a diameter of 10 inches in Dry-O T and in H-O T, but the difference of the net volume of balsam fir growing in the two types would be apparent at 14 inches.

Such results would indicate a rather inadequate correlation between cull and diameter. As shown in Table 26 and Fig. 24, the average age is much higher for a given diameter in Baz-O T than in the two others up to 12 or 13 inches. As for red spruce, the standard deviation of age for each diameter class and the average standard deviation in each forest type are evidently too extensive. Therefore, even in the H-O T with an average standard deviation of 11.6 the estimate of cull volume on the basis of tree diameter is not reliable enough, although better than for red spruce.

PATHOLOGICAL ROTATION

In the preceding pages, attempts were made to determine and assess relationships between decay or cull factors with age and diameter in the various sites encountered. Now, it should be considered how these results can be utilized to reduce losses due to decay. Except for the avoidance of man-made wounds and those occurring through the activities of animals, it is accepted generally that the best mean of control of tree decay is to log trees before losses equal the annual gain in sound merchantable wood through growth. This stage, usually called the pathological cutting age, should be determined for each species of every site and region. Other factors, such as stand history and mortality rate, may also modify the productive potentialities of a stand. Therefore, they must be equally considered before the pathological rotation is calculated.

When considering the maximum net merchantable volume for pulpwood and saw-log production of the average tree in any one forest type, the following figures were derived from the previously presented tables:

Forest type	Species	Age of the maximum net volume	
		Pulpwood	Sawlog
Dry-O	Red spruce	200 +	180 +
	Balsam fir	140	140
H-O	Red spruce	180	200 +
	Balsam fir	110	110
Baz-O	Red spruce	300 +	300 +
	Balsam fir	120	120
Hyp	Red spruce	120	140 +

These results would indicate that except in the Hyp T, red spruce can grow up to 200 and even to 300 years before losses from decay become equal to the annual increment. In most cases, balsam fir would grow for 100, 120, and even 140 years before it reaches, in the average, its pathological maturity. However, these figures do not give the best information in regard to the proper management of spruce-fir stands. The net periodic and mean annual increment would present better information for determining the cutting age. In Tables 27 and 28 and in Figs. 25 and 26, net increment data of red spruce and balsam fir in 4 forest types of the Eastern Townships are given for this purpose.

On this basis, it will be found, by inspection of tables and figures, that red spruce reaches its maximum periodic increment between 80 to 160 years and balsam fir between 70 to 100 years according to the forest types. In the two main sites of this area red spruce would reach its maximum rate of growth at 100 years in Dry-O T and 120 years in H-O T. This period may be extended to 160 years in the less frequent Baz-O T. It should be noted also that balsam fir would reach the maximum of the periodic increment curve at 70 years in the H-O T and the Baz-O T and at 90 years in the Dry-O T.

Immediately, this suggests a general rule to follow in the preparation of the cutting schedule. These results indicate that selective cutting in stands up to 70 years old in the H-O T, should be carried out to utilize balsam fir before it is too defective and to have red spruce growing 30 to 50 years more. In the Dry-O T, however, it would be better to cut both species at about 90 to 100 years since red spruce would reach its maximum net increment at 100 years and balsam fir at 90 years.

The above figures were all derived from the computation of data of individual trees, some of which were over mature at the time of analysis. In the preparation of the management plan, it is more likely that the yield per acre, during a given period, should also be considered. In fact, the age of maturity and the maximum period of growth of individual trees do not give the required information concerning biological factors which cause mortality in stands.

During this as well as other similar investigations carried out in this Province, irregularities in the growth curves of balsam fir were noticed at certain ages. In most cases, the average balsam fir shows a rapid increase of growth up to 70 or 80 years when a decrease in increment occurs. This is followed again by another period of rapid growth and later by a decrease in the increment rate. When considering the decay volume curve, about the same trend was noticed. Such cyclical fluctuations in the growth and the decay development, were already observed in Douglas fir by Boyce and Wagg (3). This was attributed to the heavy dying and fall of rapid growing trees at certain critical periods of the tree life. The same condition, which apparently occurs in balsam fir stands, should be thoroughly investigated. The cause and mortality incidence in relation to age and growth rate should also be determined and computed. When a better knowledge of this important phase of the stand evolution is gained, it would then be possible to determine with greater accuracy, the effects of decay in the average tree and even in stands. Without such information, it would seem premature to determine the cutting age of any tree species in each forest type. Until such time, data are available on the effect of tree mortality in stands stock, the period of maximum net volume could only be guessed to the closest ten years.

Another approach to the problem of pathological cutting schedule was proposed by J.E. Bier in an unpublished study. According to this method, the age of maturity of the stand could be determined by the frequency of trees of merchantable size by age class per acre and by the net yield per acre in relation to age.

Results of the computation of data available for two forest types, as given in Table 29, would indicate first that in both types the number of trees per acre is rapidly dropping after 50 or 60 years. This may be partly due to cuttings carried out some 50 or 60 years ago in this area and partly to the natural mortality. On the other hand, when considering the mean annual increment, the gross maximum increment in the stand is reached at 100 years in the H-O T and at 110 years in the Dry-O T. The net maximum increment would not increase in rate after 80 or even 70 years in the H-O T, but this stage would be reached at 90 or 100 years in the Dry-O T.

With its deficiencies, particularly the influence of mortality in stand yield, this investigation would suggest that the pathological cutting could be fixed around 70 years in H-O T and at 90 years in Dry-O T.

DISCUSSION

This study was carried out as part of an investigation project on decay in conifers, initiated in 1938 in the Province of Quebec and temporarily left aside in 1945. Its main objective is to provide the forest industries and forest land owners with practical information on decay development in standing timber and on the resulting losses in relation to age and diameter for each commercial species growing in the common forest types of the main forest regions of this Province. The present report covers the results of two field seasons work carried out in 1954 and 1955 in the Eastern Townships in cooperation with the Forestry Department of the St. Lawrence Corporation, East Angus Division.

In this area, spruce-fir stands were found most frequently in two forest types: the Hylocomium-Oxalis type and the Dryopteris-Oxalis type. Except in one virgin stand of the Bazzania-Oxalis type, some cuttings have been made 60 or 70 years ago in most of the areas sampled. This, in conjunction with the natural mortality, has caused a drop in the number of older trees.

A number of fungi, already isolated in other areas of the Province and the country, were found associated with decay of balsam fir and red spruce. It has been determined that *Stereum sanguinolentum* was the cause of 70 per cent of the decay volume of balsam fir and *Fomes pini* had produced 65 per cent of decay losses in red spruce. In both species, however, the most frequent butt rotting agent was *Corticium galactinum*. In other areas, the most common infection court of trunk rots was branch stubs while butt rots have originated mainly in roots.

Although the sampling in red spruce was too scanty, particularly in certain forest types studied, relationship of decay or cull volume to age was established. However, by correlation analysis, no significant difference of the cull percentage on age was detected between trees growing in the four forest types recognized. This was ascribed mainly to the poor sampling. In spite of this deficiency, there are indications that decay does not cause important losses in red spruce before 200 years in many sites. In the Hylocomium-Oxalis type, however, it was found that 5.5 per cent of the volume of this species should be culled at 100 years. Diameter as a variable related to decay was considered to be a poor factor as already determined in other similar studies. This is emphasized again by the extensive age deviation for each diameter class.

The relationships between age and the decay volume of balsam fir was established statistically. The results of co-variance analyses have also demonstrated significant differences between two forest types with regard to the cull percentage. However, it was considered that more reliable results could be obtained with the gross and net volumes treated statistically. Effectively, these analyses have demonstrated highly significant differences of regression in the gross and net volumes of balsam fir growing in the H-O T and the Dry-O T. A difference of 24.7 per cent at 100 years between the net volume of balsam fir in the two forest types was determined. Such a difference is partly due to the rate of growth (14.5 per cent) and partly to the decay development (10.2 per cent).

With regard to the diameter, as a related factor for decay, it was considered that the relationship was not reliable enough, although the sampling was much better than with red spruce.

Depending on the forest type and with the data available, it would appear that red spruce reached its net maximum periodic increment between 80 and 160 years and balsam fir between 70 and 100 years in the Eastern Townships. From a practical standpoint, this result would suggest the selective cutting of balsam fir before it reaches 70 years in H-O T whereas red spruce could be left standing 40 or 50 years longer. In the Dry-O T, it would be preferable to cut both species between 90 and 100 years. In both cases, however, the effect of tree mortality on the stocking was not taken into account due to lack of information on this aspect of the problem.

In this interim report, the use of the data presented for inventory purposes was not critically discussed. This should be done later and presented in a paper covering several forest regions of the Province. For the time being, cull percentages given in tables in relation with age and diameter could be used to improve the precision of cruising data.

This investigation also included a study on the influence of site on butt rot development. Various soil factors were measured in each sample plot and a butt rot index was devised in order to eliminate the variation of age classes. This preliminary study is not dealt within the present report

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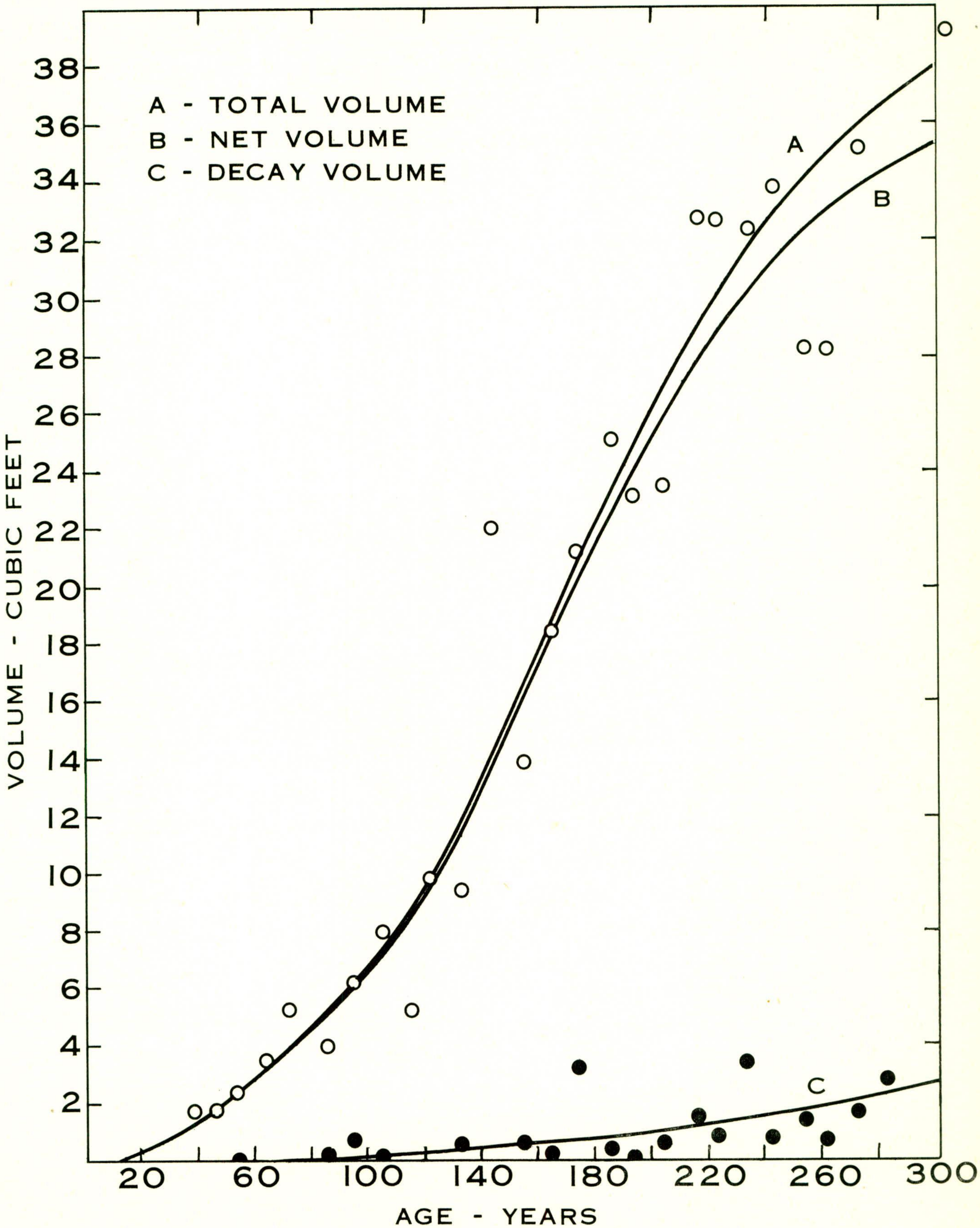
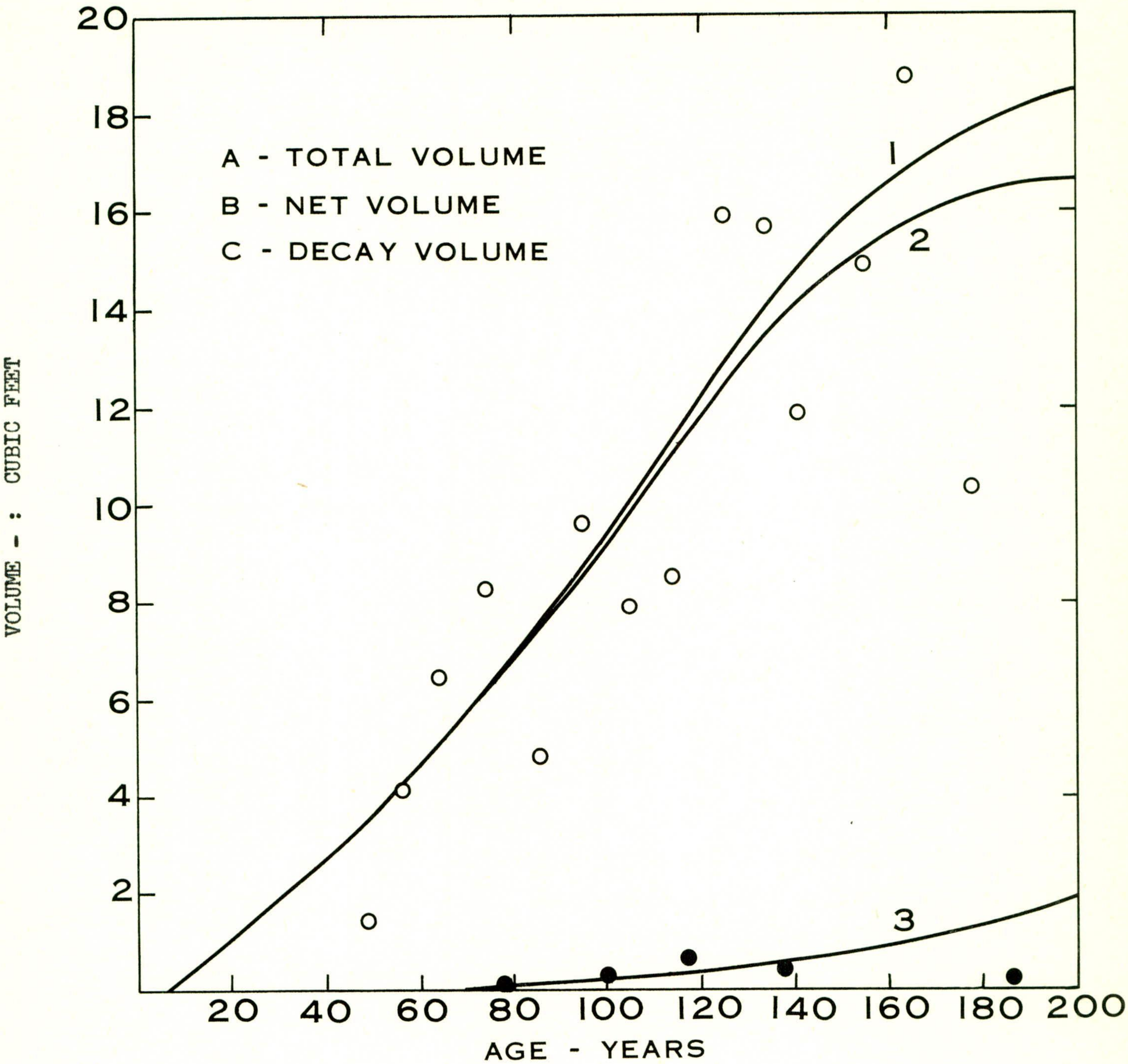
Figure 2 Relation between age, total volume, net volume and decay volume in red spruce in Bazzania-Oxalis type.



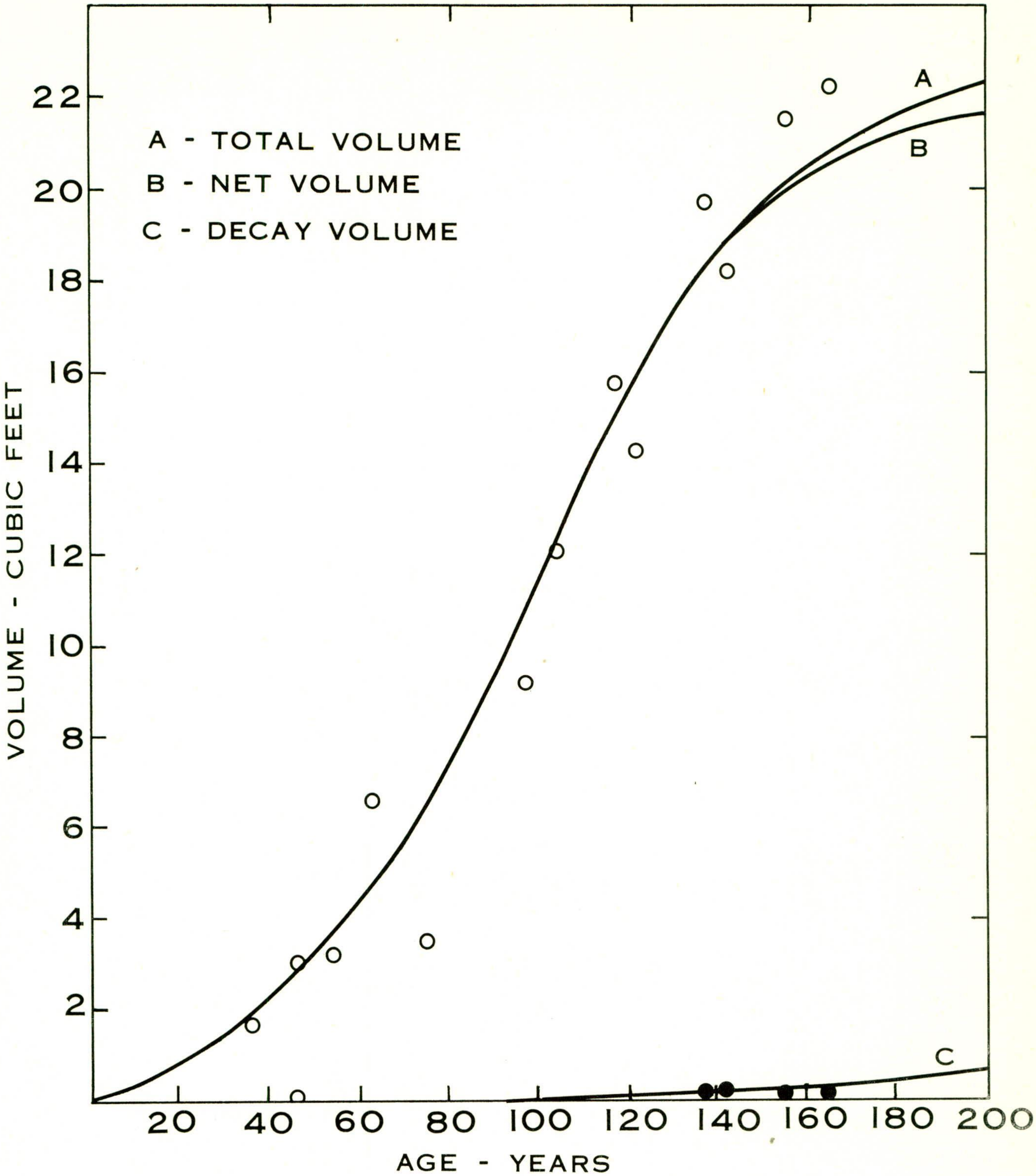
A - TOTAL VOLUME
B - NET VOLUME
C - DECAY VOLUME
A
B
C
VOLUME - CUBIC FEET
38
36
34
32
30
28
26
24
22
20
18
16
14
12
10
8
6
4
2
20
60
100
140
180
220
260
300
AGE - YEARS

Figure 3 Relation between age, total volume, net volume and decay volume in red spruce in Hylocomium-Oxalis type.



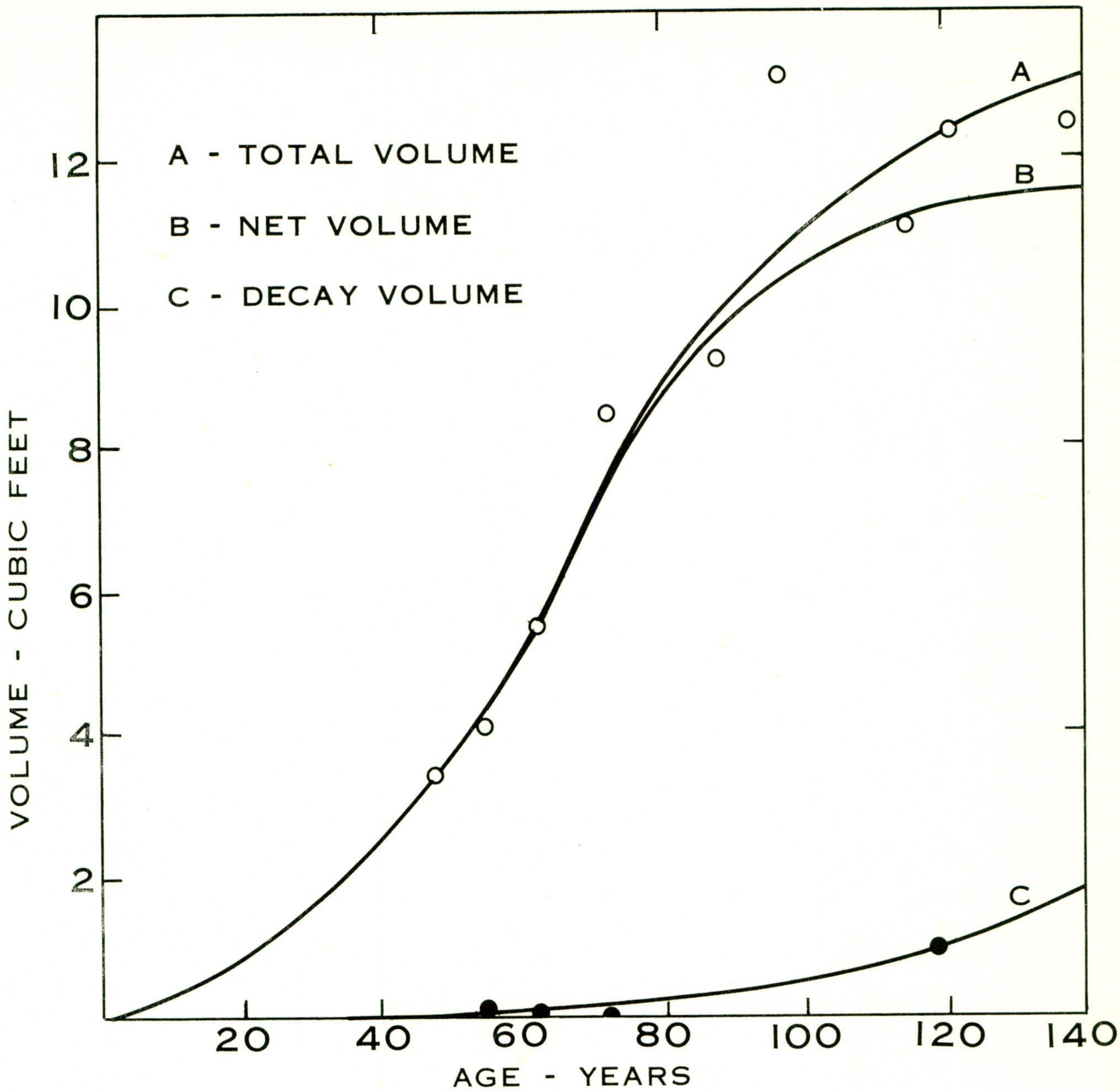
A - TOTAL VOLUME
B - NET VOLUME
C - DECAY VOLUME
1
2
3
VOLUME - : CUBIC FEET
AGE - YEARS
20
18
16
14
12
10
8
6
4
2
20 40 60 80 100 120 140 160 180 200

Figure 4 Relation between age, total volume, net volume and decay volume in red spruce in Dryopteris-Oxalis type.



A - TOTAL VOLUME
B - NET VOLUME
C - DECAY VOLUME
VOLUME - CUBIC FEET
22
20
18
16
14
12
10
8
6
4
2
20
40
60
80
100
120
140
160
180
200
AGE - YEARS
A
B
C

Figure 5 Relation between age, total volume, net volume and decay volume in red spruce in Hypnum type.



A - TOTAL VOLUME
B - NET VOLUME
C - DECAY VOLUME
A
B
C
VOLUME - CUBIC FEET
2
4
6
8
10
12
20
40
60
80
100
120
140
AGE - YEARS

Figure 6 Relation between age, gross and net merchantable volumes for pulpwood, and cull volume in red spruce in four forest types.

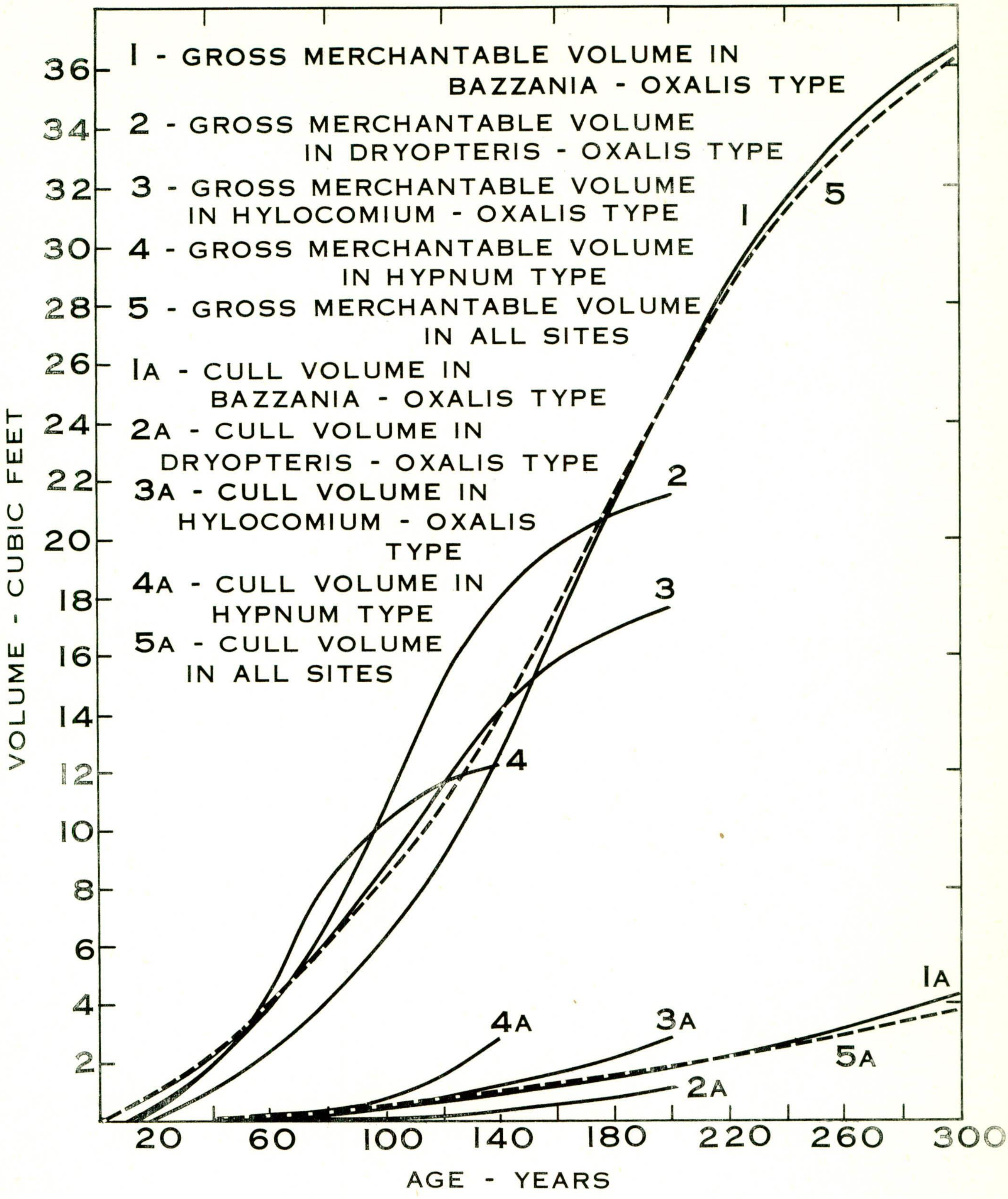
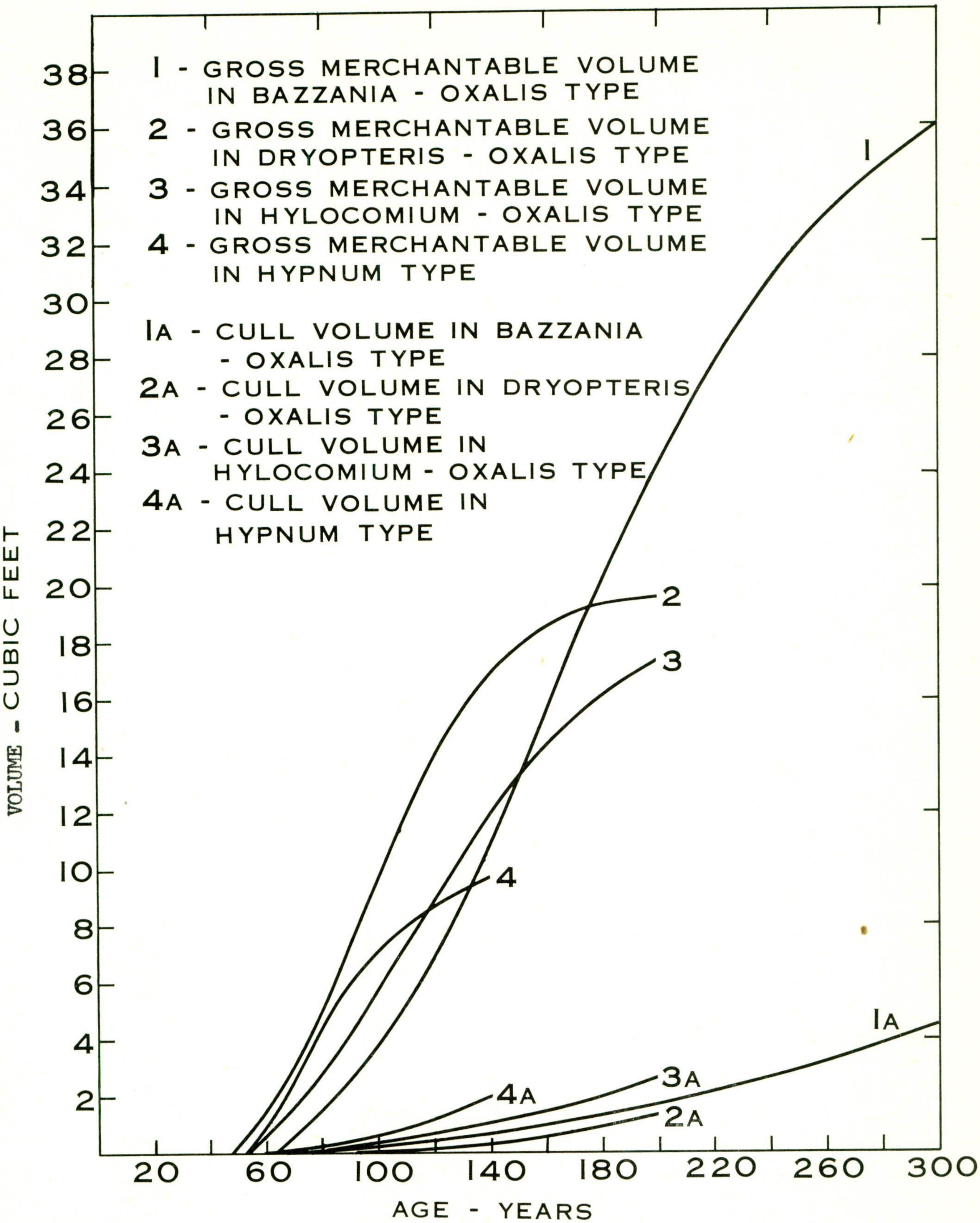

1 - GROSS MERCHANTABLE VOLUME IN BAZZANIA - OXALIS TYPE
2 - GROSS MERCHANTABLE VOLUME IN DRYOPTERIS - OXALIS TYPE
3 - GROSS MERCHANTABLE VOLUME IN HYLOCOMIUM - OXALIS TYPE
4 - GROSS MERCHANTABLE VOLUME IN HYPNUM TYPE
5 - GROSS MERCHANTABLE VOLUME IN ALL SITES
1A - CULL VOLUME IN BAZZANIA - OXALIS TYPE
2A - CULL VOLUME IN DRYOPTERIS - OXALIS TYPE
3A - CULL VOLUME IN HYLOCOMIUM - OXALIS TYPE
4A - CULL VOLUME IN HYPNUM TYPE
5A - CULL VOLUME IN ALL SITES
VOLUME - CUBIC FEET
AGE - YEARS
36
34
32
30
28
26
24
22
20
18
16
14
12
10
8
6
4
2
20
60
100
140
180
220
260
300
1
2
3
4
5
1A
2A
3A
4A
5A

Figure 7   Relation between age, gross and net merchantable volumes for saw timber and cull volume in red spruce in four forest types.



1 - GROSS MERCHANTABLE VOLUME IN BAZZANIA - OXALIS TYPE
2 - GROSS MERCHANTABLE VOLUME IN DRYOPTERIS - OXALIS TYPE
3 - GROSS MERCHANTABLE VOLUME IN HYLOCOMIUM - OXALIS TYPE
4 - GROSS MERCHANTABLE VOLUME IN HYPNUM TYPE
1A - CULL VOLUME IN BAZZANIA - OXALIS TYPE
2A - CULL VOLUME IN DRYOPTERIS - OXALIS TYPE
3A - CULL VOLUME IN HYLOCOMIUM - OXALIS TYPE
4A - CULL VOLUME IN HYPNUM TYPE
VOLUME - CUBIC FEET
38
36
34
32
30
28
26
24
22
20
18
16
14
12
10
8
6
4
2
20
60
100
140
180
220
260
300
AGE - YEARS
1
2
3
4
1A
2A
3A
4A

Figure 8 Linear regression between cull volume percentage and age in red spruce in four forest types.

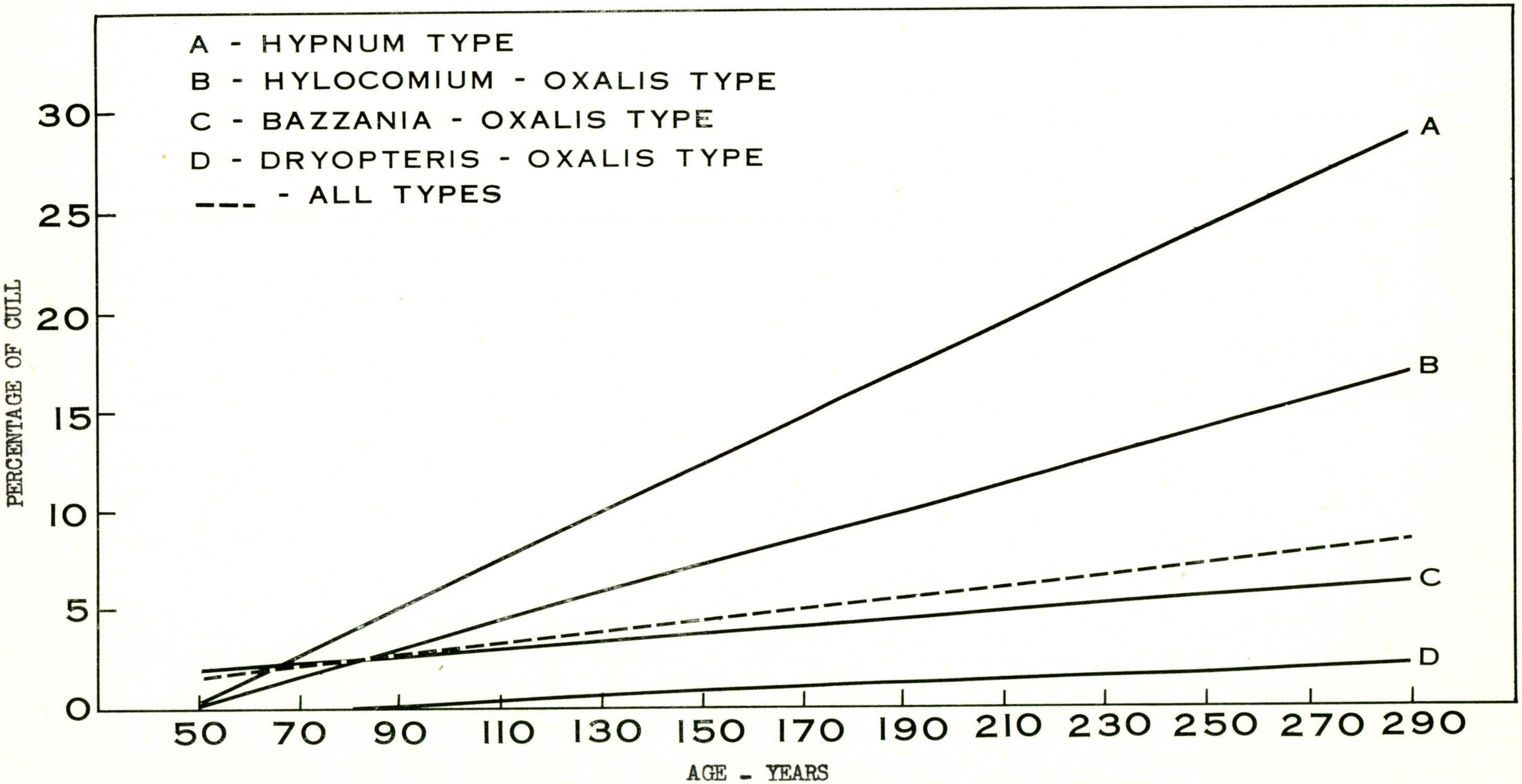
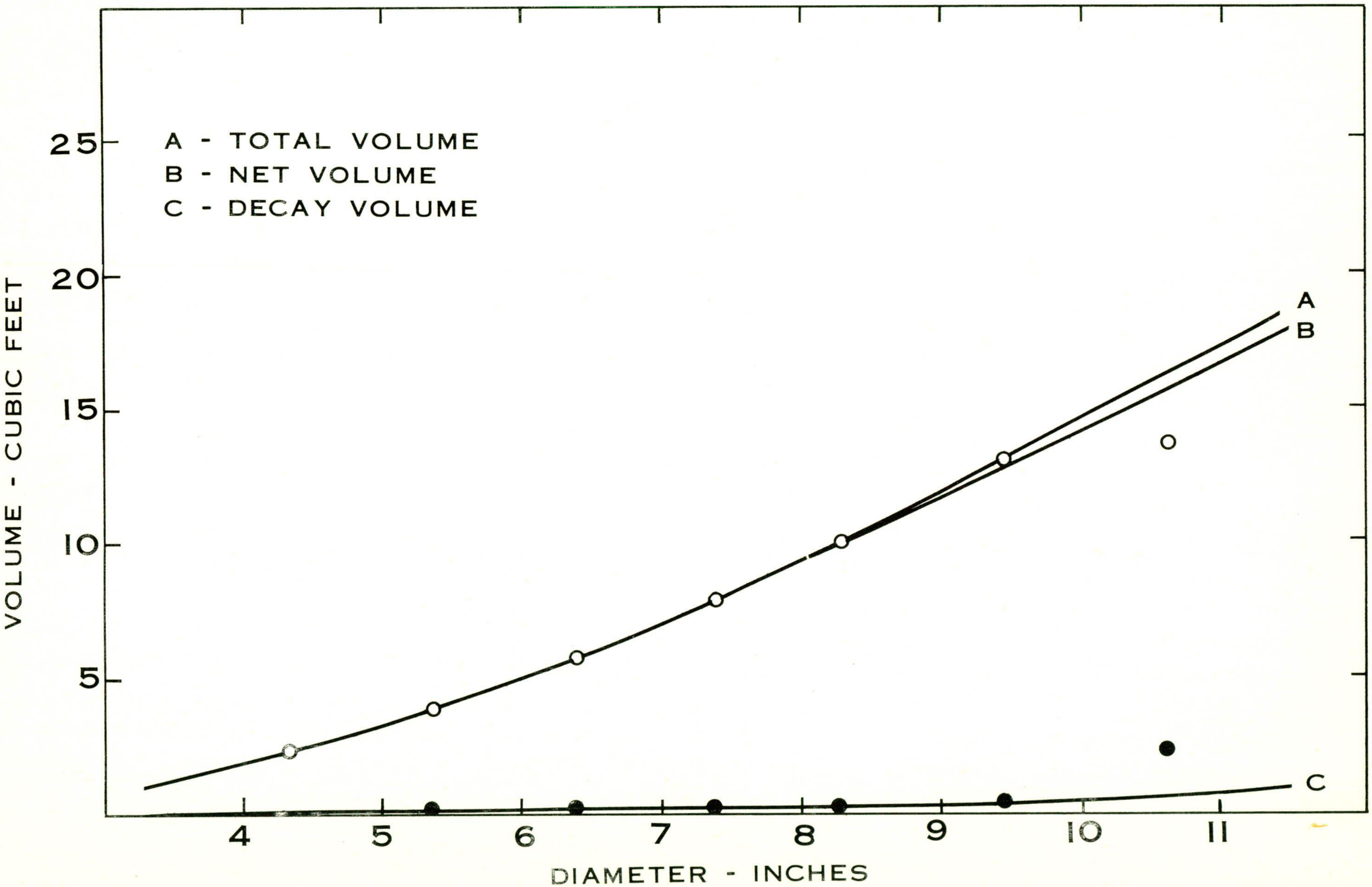

A - HYPNUM TYPE
B - HYLOCOMIUM - OXALIS TYPE
C - BAZZANIA - OXALIS TYPE
D - DRYOPTERIS - OXALIS TYPE
--- - ALL TYPES
PERCENTAGE OF CULL
0
5
10
15
20
25
30
50
70
90
110
130
150
170
190
210
230
250
270
290
AGE - YEARS
A
B
C
D

Figure 9 Relation between diameter (D.B.H.), total volume, net volume and decay volume in red spruce in Hypnum type.



A - TOTAL VOLUME
B - NET VOLUME
C - DECAY VOLUME
VOLUME - CUBIC FEET
25
20
15
10
5
A
B
C
4
5
6
7
8
9
10
11
DIAMETER - INCHES

Figure 10 Relation between diameter (D.B.H.), total volume, net volume and decay volume in red spruce in Hylocomium-Oxalis type.

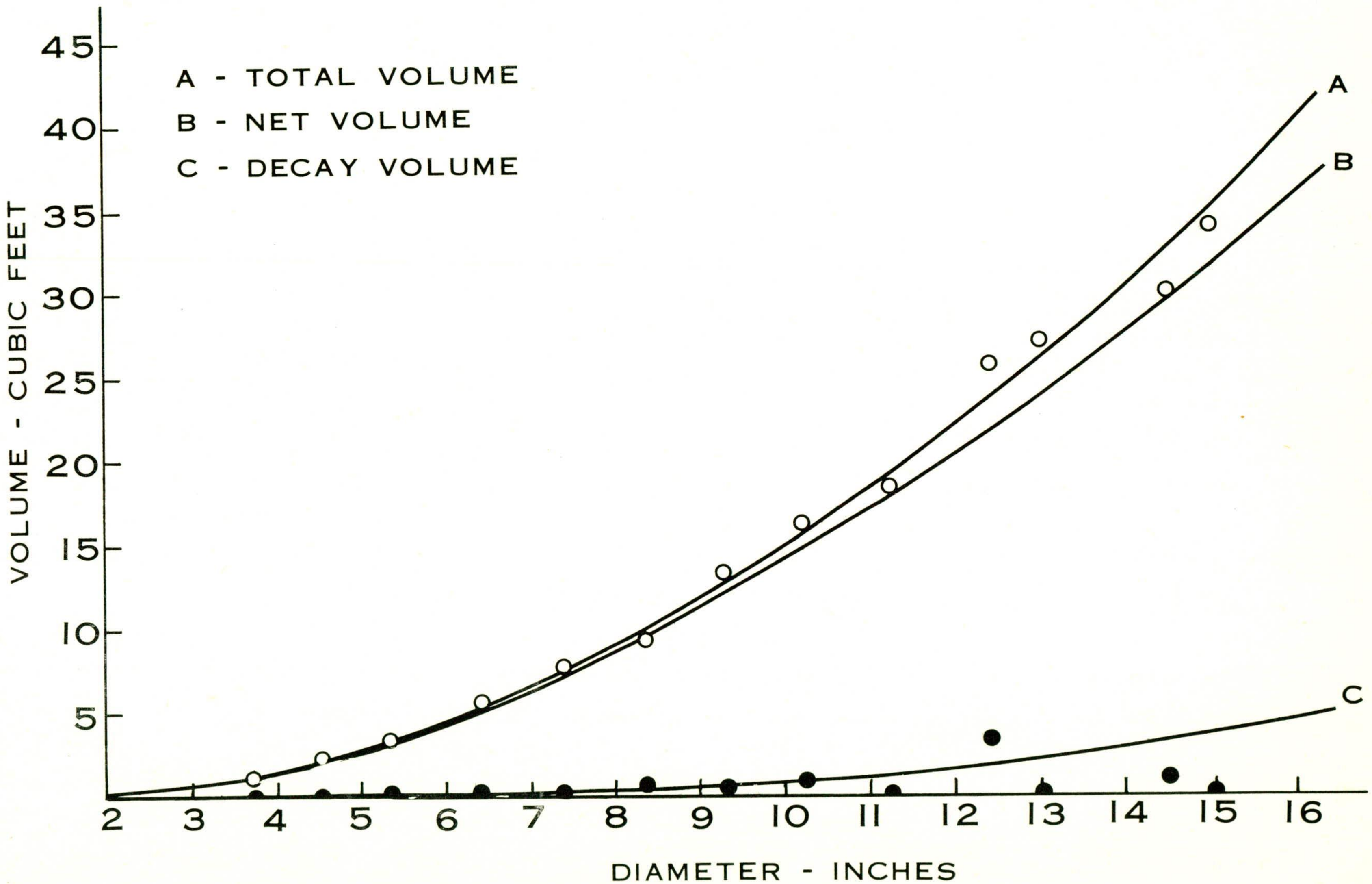
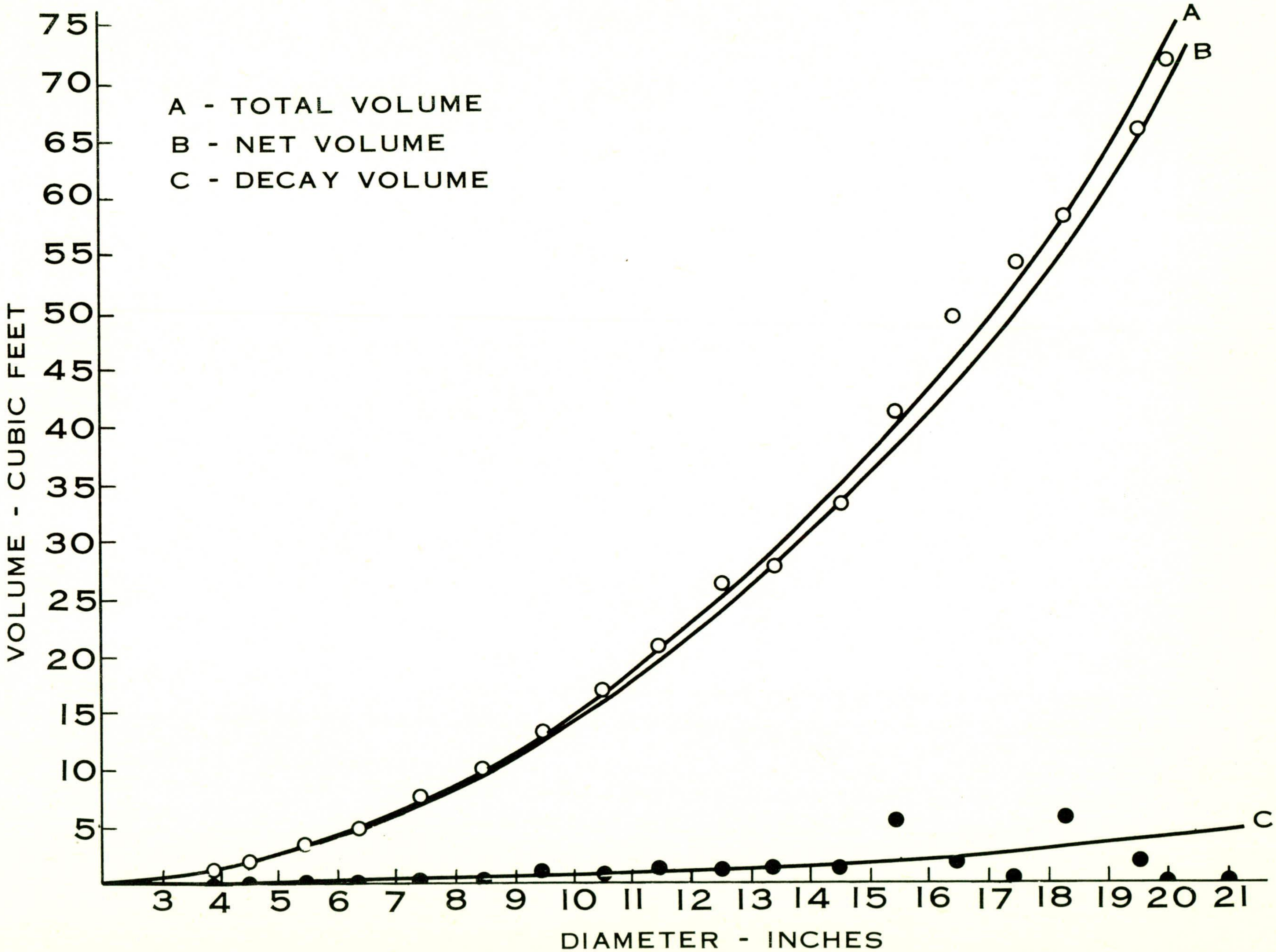
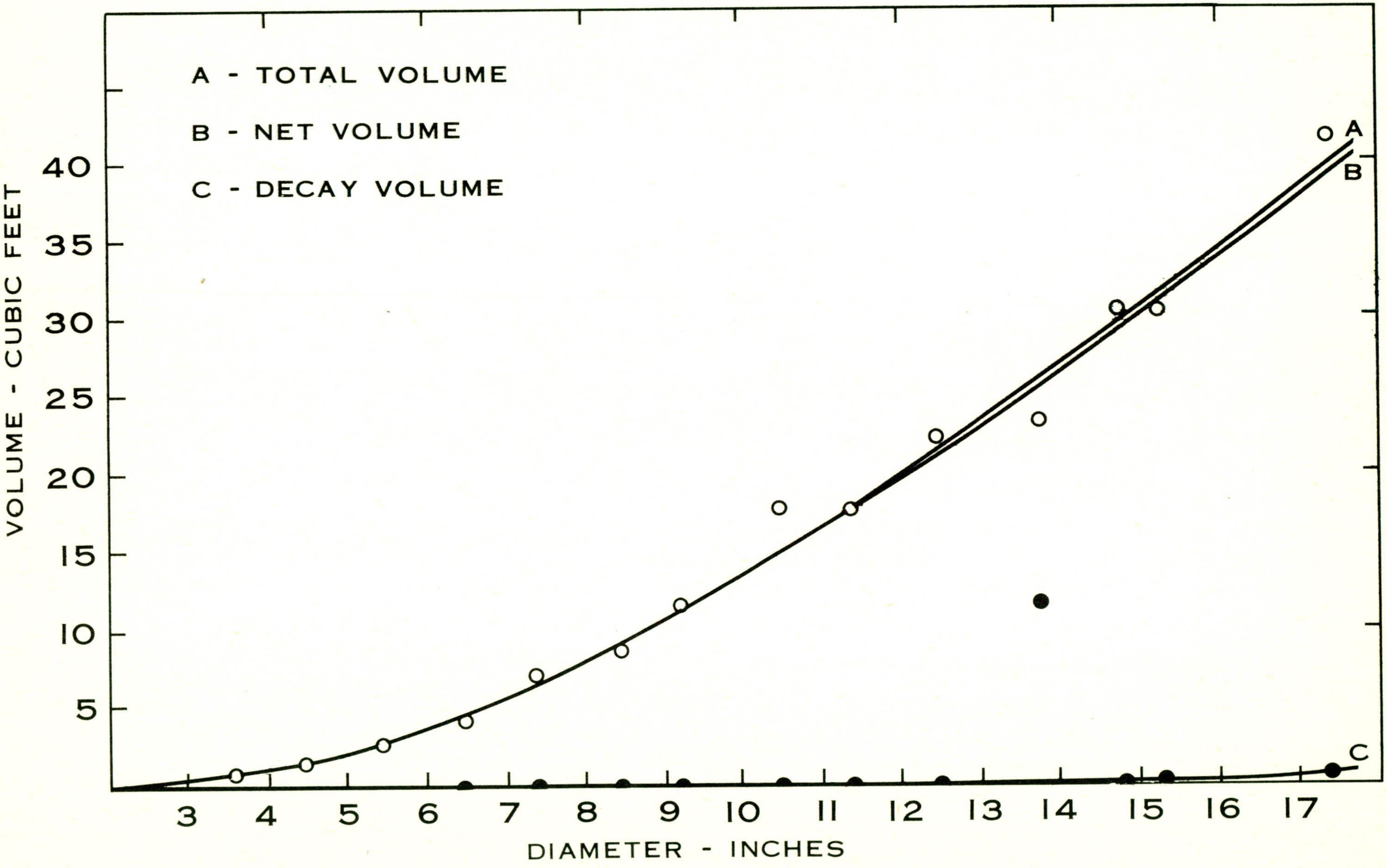

A - TOTAL VOLUME
B - NET VOLUME
C - DECAY VOLUME
A
B
C
VOLUME - CUBIC FEET
45
40
35
30
25
20
15
10
5
2 3 4 5 6 7 8 9 10 11 12 13 14 15 16
DIAMETER - INCHES

Figure 11 Relation between diameter (D.B.H.), total volume, net volume and decay volume in red spruce in Bazzania-Oxalis type.



A - TOTAL VOLUME
B - NET VOLUME
C - DECAY VOLUME
VOLUME - CUBIC FEET
DIAMETER - INCHES
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5
3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21
A
B
C

Figure 12 Relation between diameter (D.B.H.), total volume, net volume and decay volume in red spruce in Dryopteris-Oxalis type.



A - TOTAL VOLUME
B - NET VOLUME
C - DECAY VOLUME
VOLUME - CUBIC FEET
40
35
30
25
20
15
10
5
A
B
C
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
DIAMETER - INCHES

Figure 13 Relation between diameter at breast height and age in red spruce in four forest types.

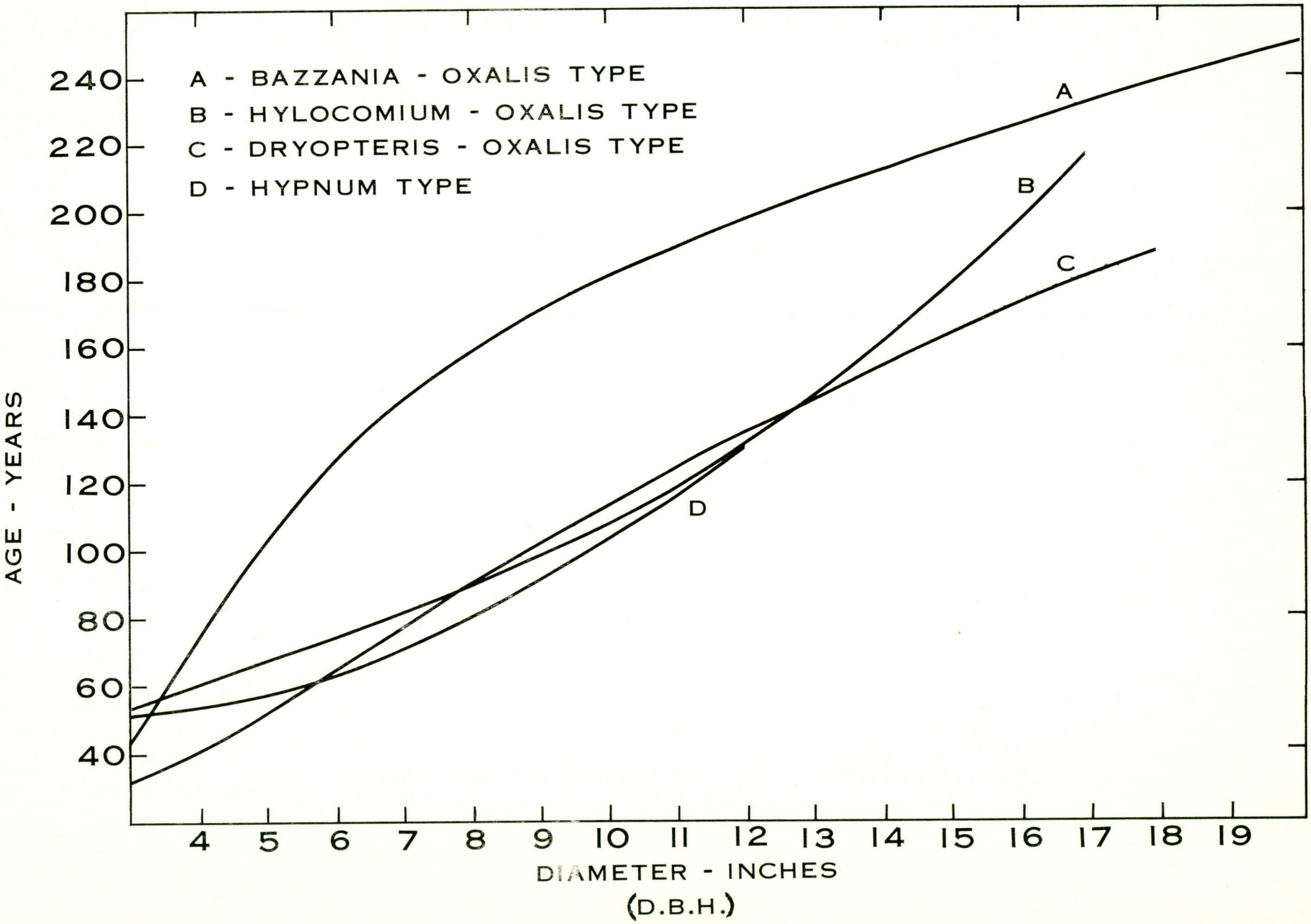

A - BAZZANIA - OXALIS TYPE
B - HYLOCOMIUM - OXALIS TYPE
C - DRYOPTERIS - OXALIS TYPE
D - HYPNUM TYPE
AGE - YEARS
240
220
200
180
160
140
120
100
80
60
40
A
B
C
D
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
DIAMETER - INCHES
(D.B.H.)

Figure 14 Relation between age, total volume, net volume and decay volume in balsam fir in Bazzania-Oxalis type.

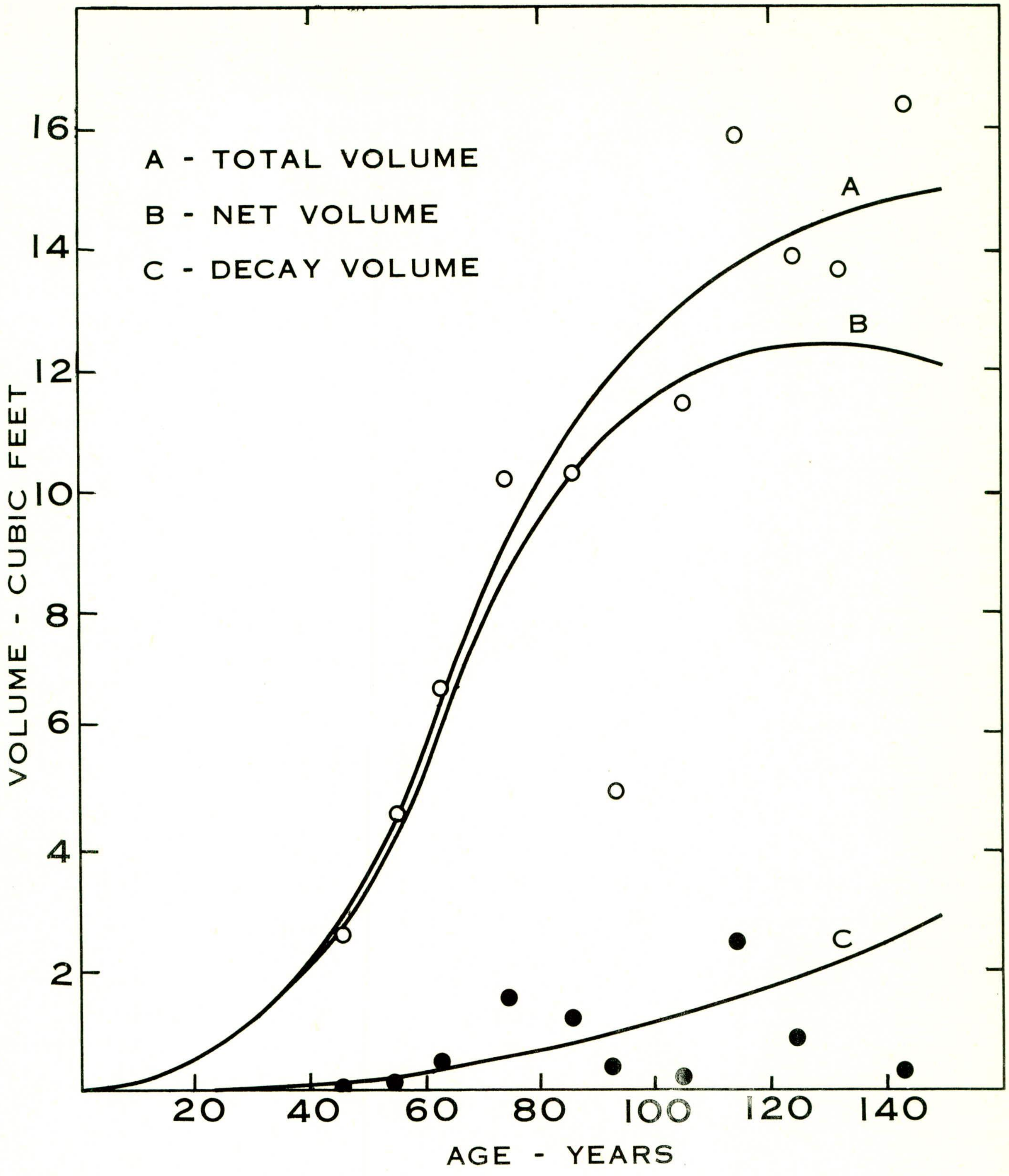
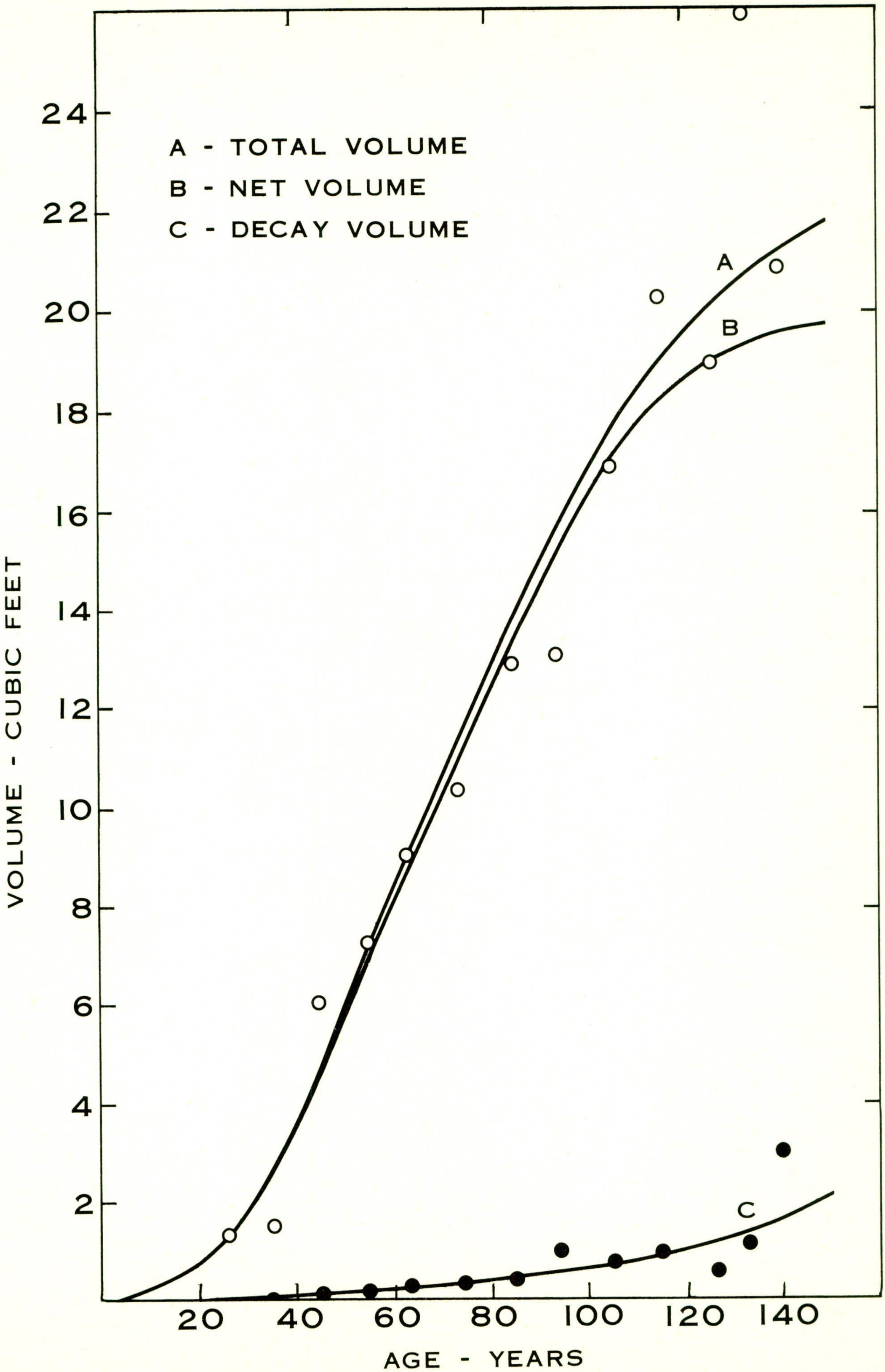
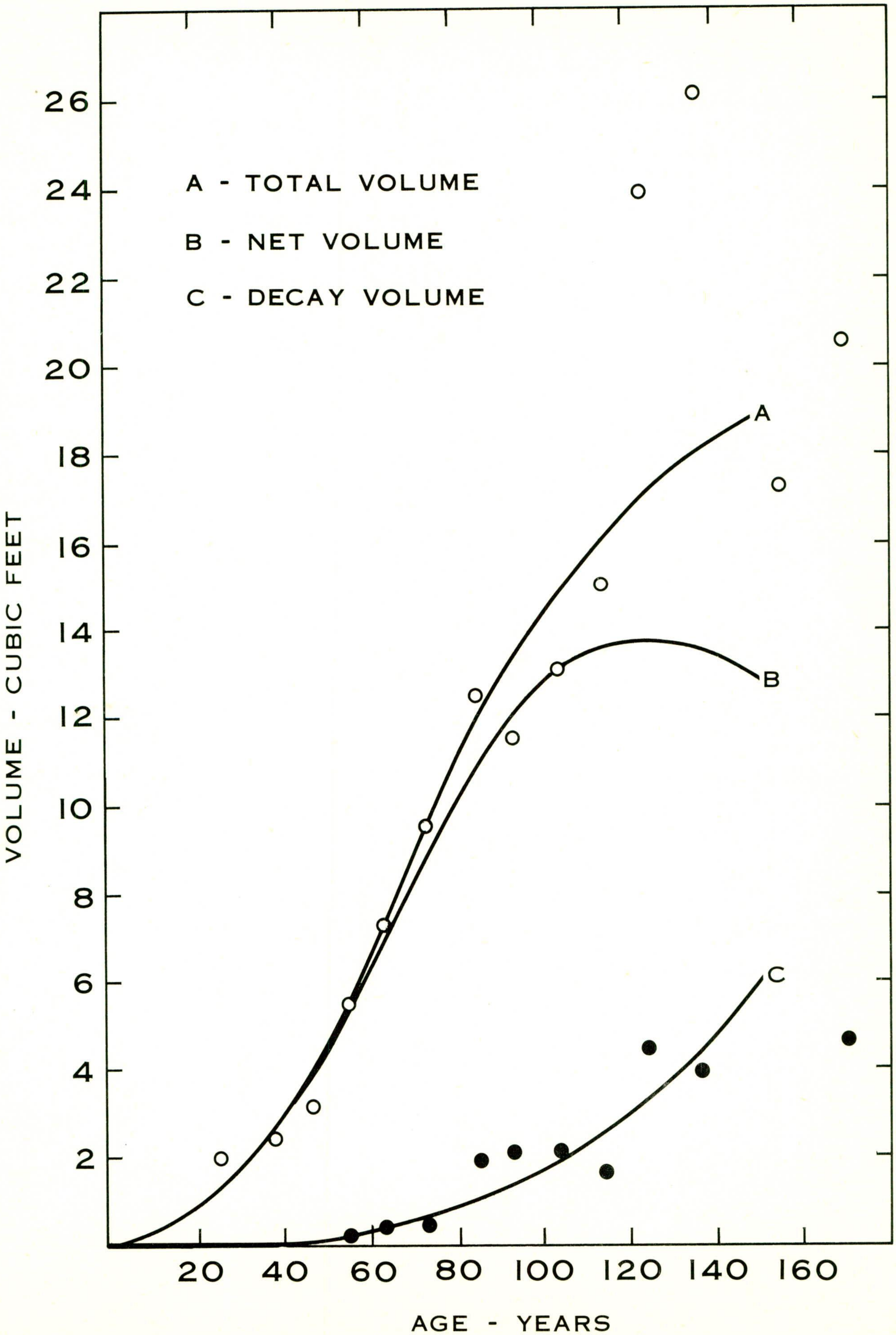

A - TOTAL VOLUME
B - NET VOLUME
C - DECAY VOLUME
A
B
C
VOLUME - CUBIC FEET
16
14
12
10
8
6
4
2
20
40
60
80
100
120
140
AGE - YEARS

Figure 15 Relation between age, total volume, net volume and decay volume in balsam fir in Dryopteris-Oxalis type.



A - TOTAL VOLUME
B - NET VOLUME
C - DECAY VOLUME
A
B
C
VOLUME - CUBIC FEET
2
4
6
8
10
12
14
16
18
20
22
24
20
40
60
80
100
120
140
AGE - YEARS

Figure 16 Relation between age, total volume, net volume and decay volume in balsam fir in Hylocomium-Oxalis type.



A - TOTAL VOLUME
B - NET VOLUME
C - DECAY VOLUME
VOLUME - CUBIC FEET
AGE - YEARS
2
4
6
8
10
12
14
16
18
20
22
24
26
20
40
60
80
100
120
140
160
A
B
C

Figure 17 Relation between age, gross and net merchantable volumes for pulpwood and cull volume in balsam fir in four forest types.

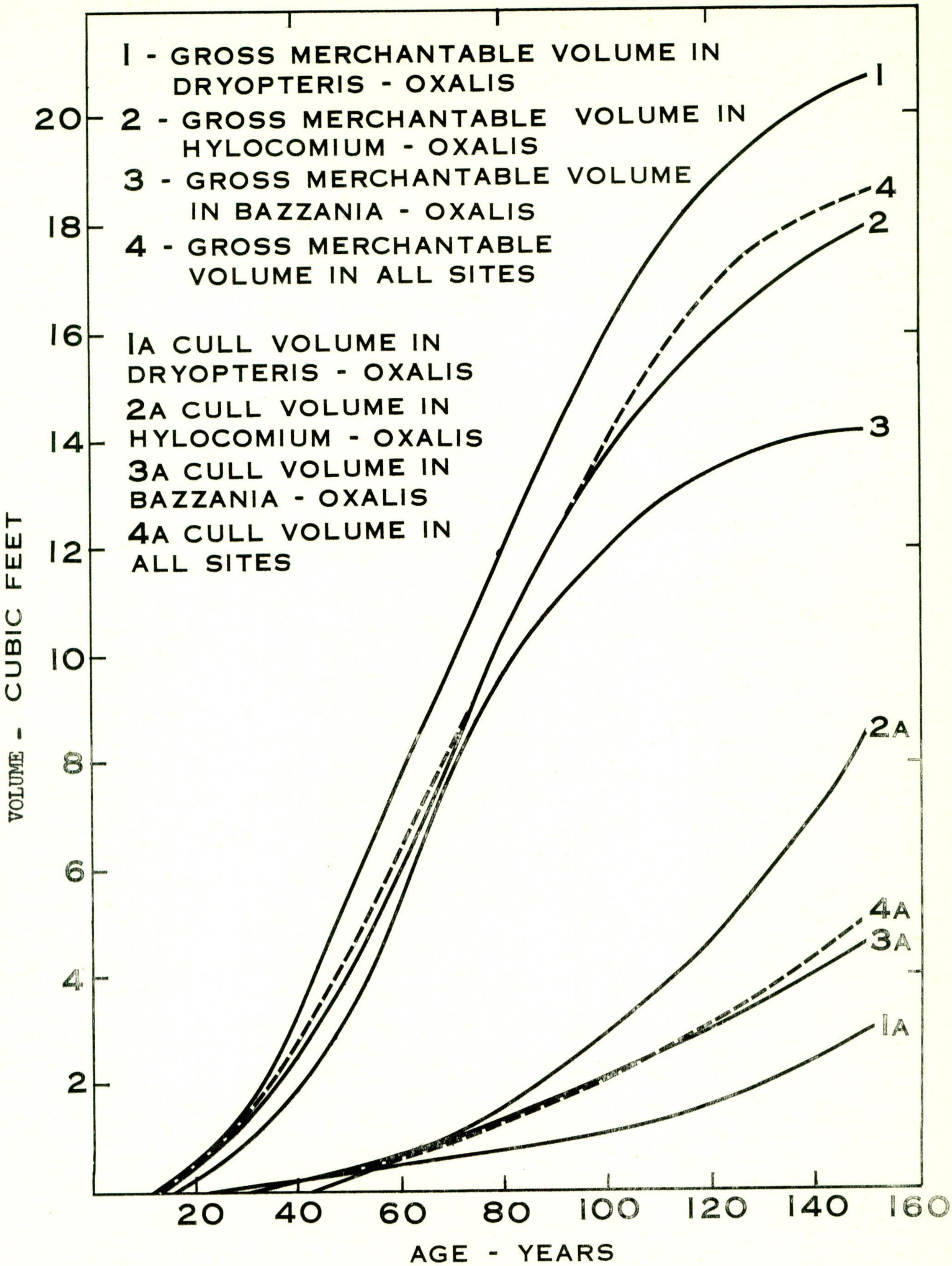

I - GROSS MERCHANTABLE VOLUME IN DRYOPTERIS - OXALIS
2 - GROSS MERCHANTABLE VOLUME IN HYLOCOMIUM - OXALIS
3 - GROSS MERCHANTABLE VOLUME IN BAZZANIA - OXALIS
4 - GROSS MERCHANTABLE VOLUME IN ALL SITES
IA CULL VOLUME IN DRYOPTERIS - OXALIS
2A CULL VOLUME IN HYLOCOMIUM - OXALIS
3A CULL VOLUME IN BAZZANIA - OXALIS
4A CULL VOLUME IN ALL SITES
VOLUME - CUBIC FEET
AGE - YEARS
20
18
16
14
12
10
8
6
4
2
20
40
60
80
100
120
140
160
I
4
2
3
2A
4A
3A
IA

Figure 18 Relation between age, gross and net merchantable volumes for saw timber and cull volume in balsam fir in four forest types.

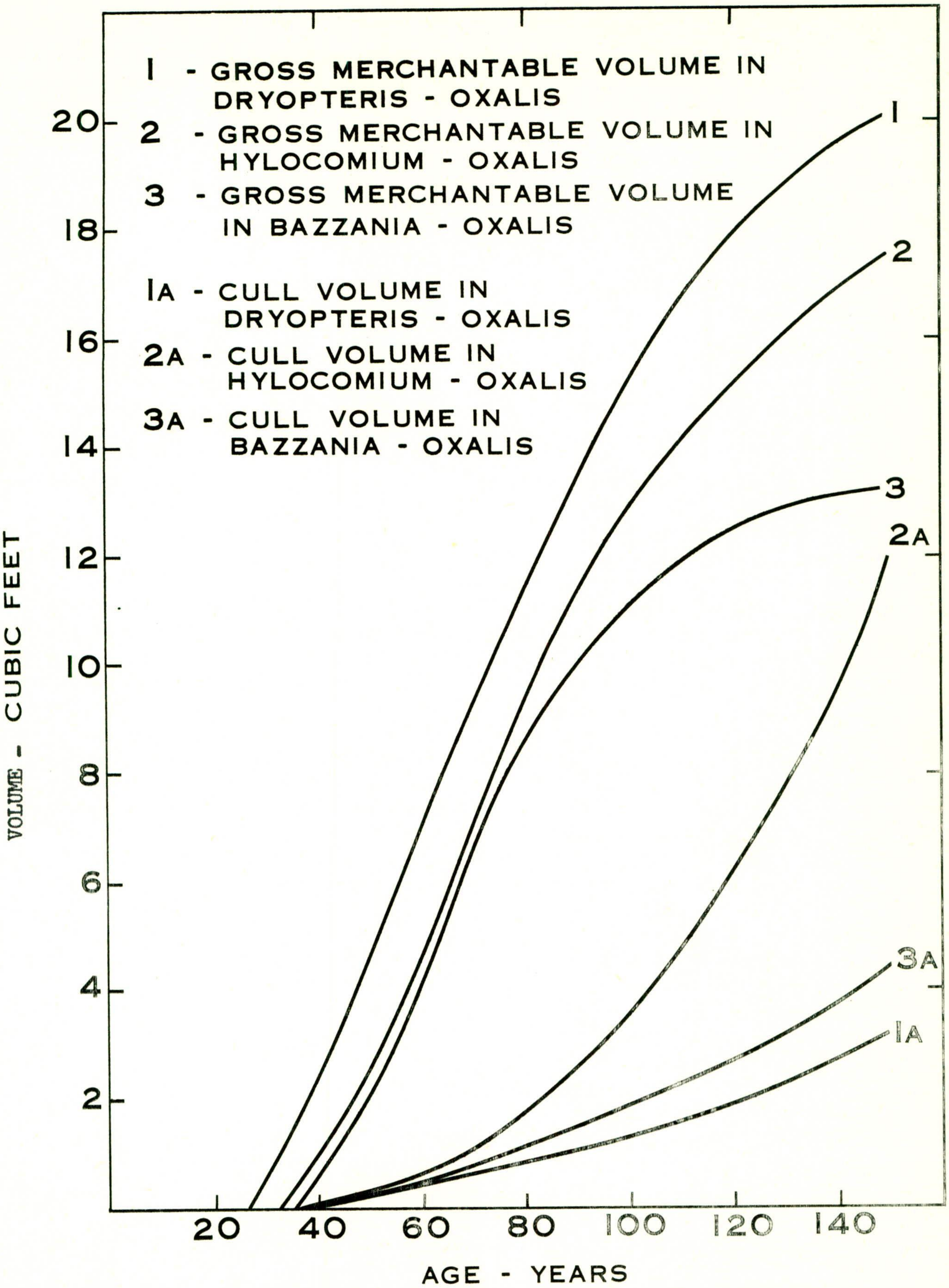
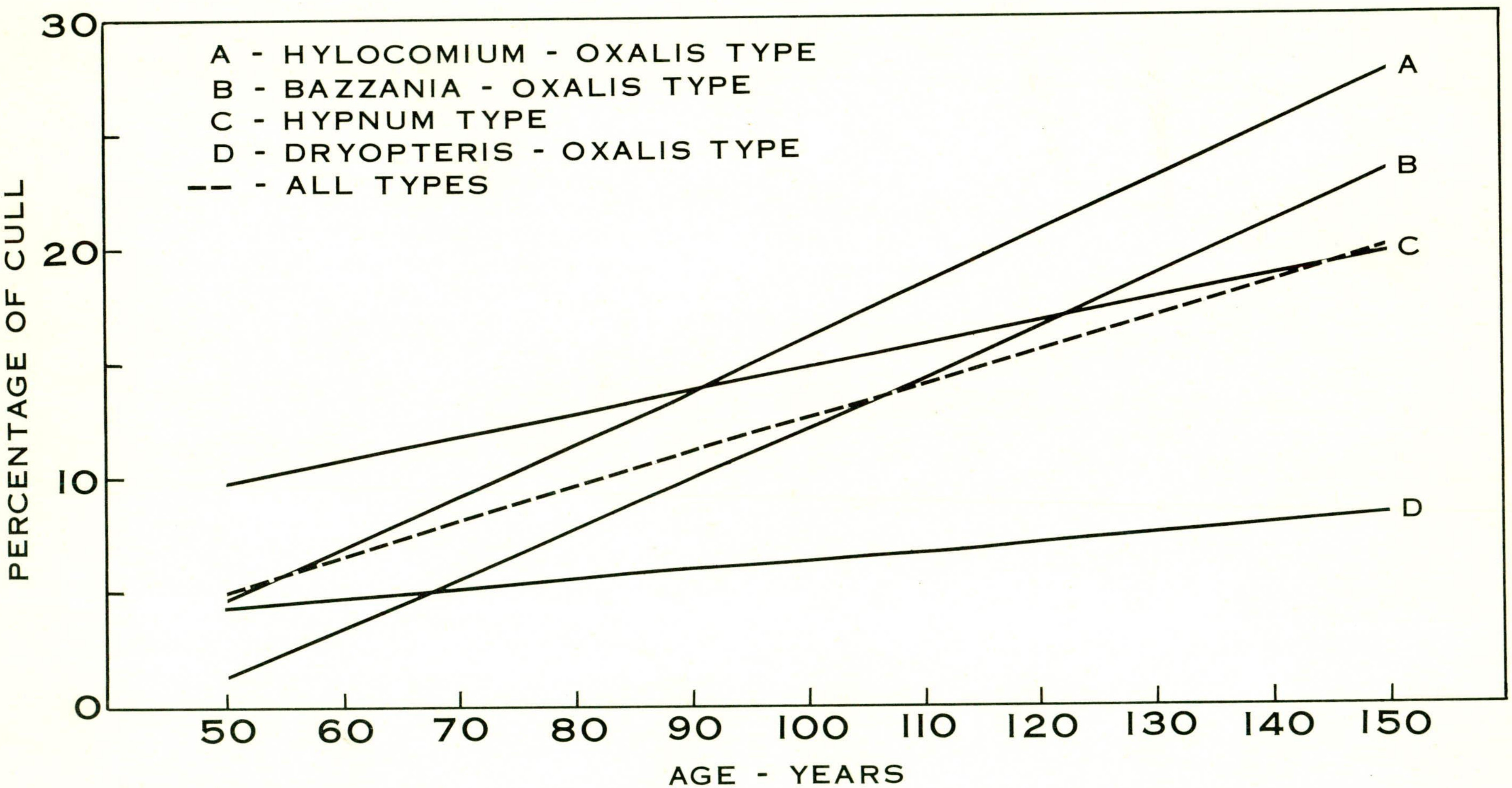

I - GROSS MERCHANTABLE VOLUME IN DRYOPTERIS - OXALIS
2 - GROSS MERCHANTABLE VOLUME IN HYLOCOMIUM - OXALIS
3 - GROSS MERCHANTABLE VOLUME IN BAZZANIA - OXALIS
IA - CULL VOLUME IN DRYOPTERIS - OXALIS
2A - CULL VOLUME IN HYLOCOMIUM - OXALIS
3A - CULL VOLUME IN BAZZANIA - OXALIS
VOLUME - CUBIC FEET
AGE - YEARS
20
18
16
14
12
10
8
6
4
2
20
40
60
80
100
120
140
I
2
3
2A
3A
IA

Figure 19 Linear regression between cull volume percentage and age in balsam fir in four forest types.



A - HYLOCOMIUM - OXALIS TYPE
B - BAZZANIA - OXALIS TYPE
C - HYPNUM TYPE
D - DRYOPTERIS - OXALIS TYPE
-- - ALL TYPES
A
B
C
D
30
20
10
0
PERCENTAGE OF CULL
50
60
70
80
90
100
110
120
130
140
150
AGE - YEARS

Figure 20 Linear regression between gross merchantable volume, net merchantable volume and age in balsam fir in two forest types.

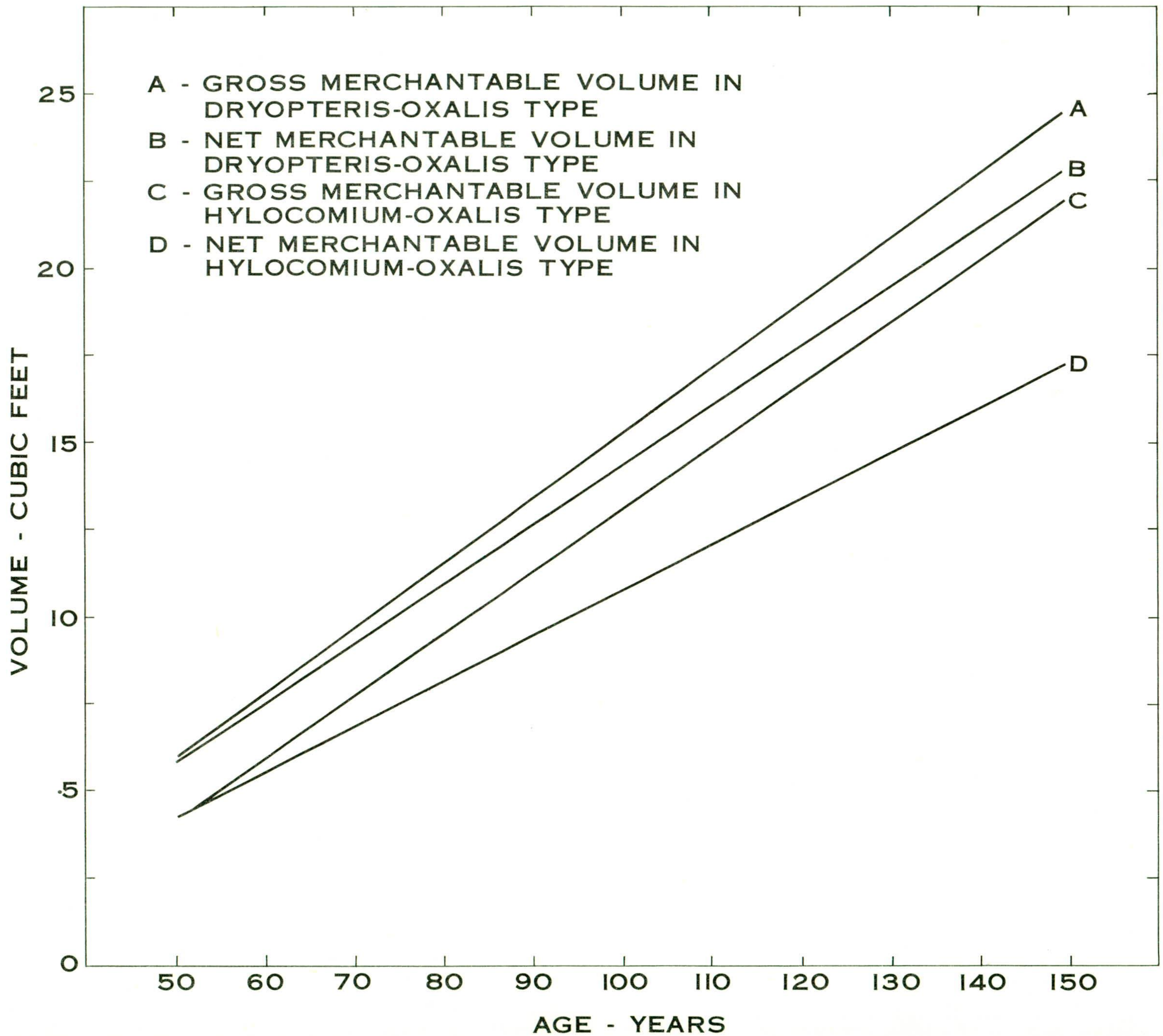

A - GROSS MERCHANTABLE VOLUME IN DRYOPTERIS-OXALIS TYPE
B - NET MERCHANTABLE VOLUME IN DRYOPTERIS-OXALIS TYPE
C - GROSS MERCHANTABLE VOLUME IN HYLOCOMIUM-OXALIS TYPE
D - NET MERCHANTABLE VOLUME IN HYLOCOMIUM-OXALIS TYPE
A
B
C
D
VOLUME - CUBIC FEET
25
20
15
10
5
0
50
60
70
80
90
100
110
120
130
140
150
AGE - YEARS

Figure 21 Relation between diameter (D.B.H.), total volume, net volume and decay volume in balsam fir in Hylocomium-Oxalis type.

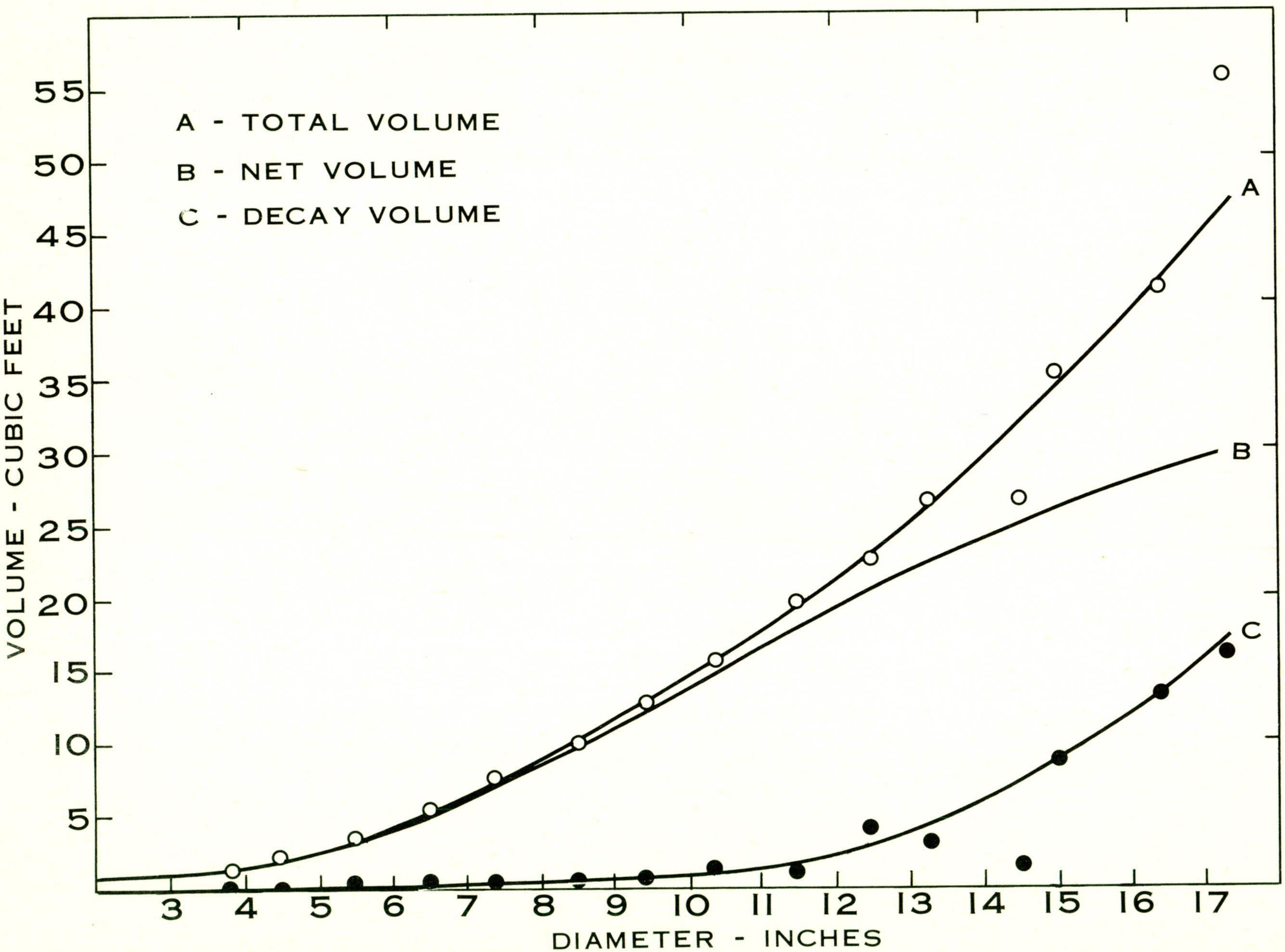

A - TOTAL VOLUME
B - NET VOLUME
C - DECAY VOLUME
A
B
C
VOLUME - CUBIC FEET
55
50
45
40
35
30
25
20
15
10
5
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
DIAMETER - INCHES

Figure 22 Relation between diameter (D.B.H.), total volume, net volume and decay volume in balsam fir in Dryopteris-Oxalis type.

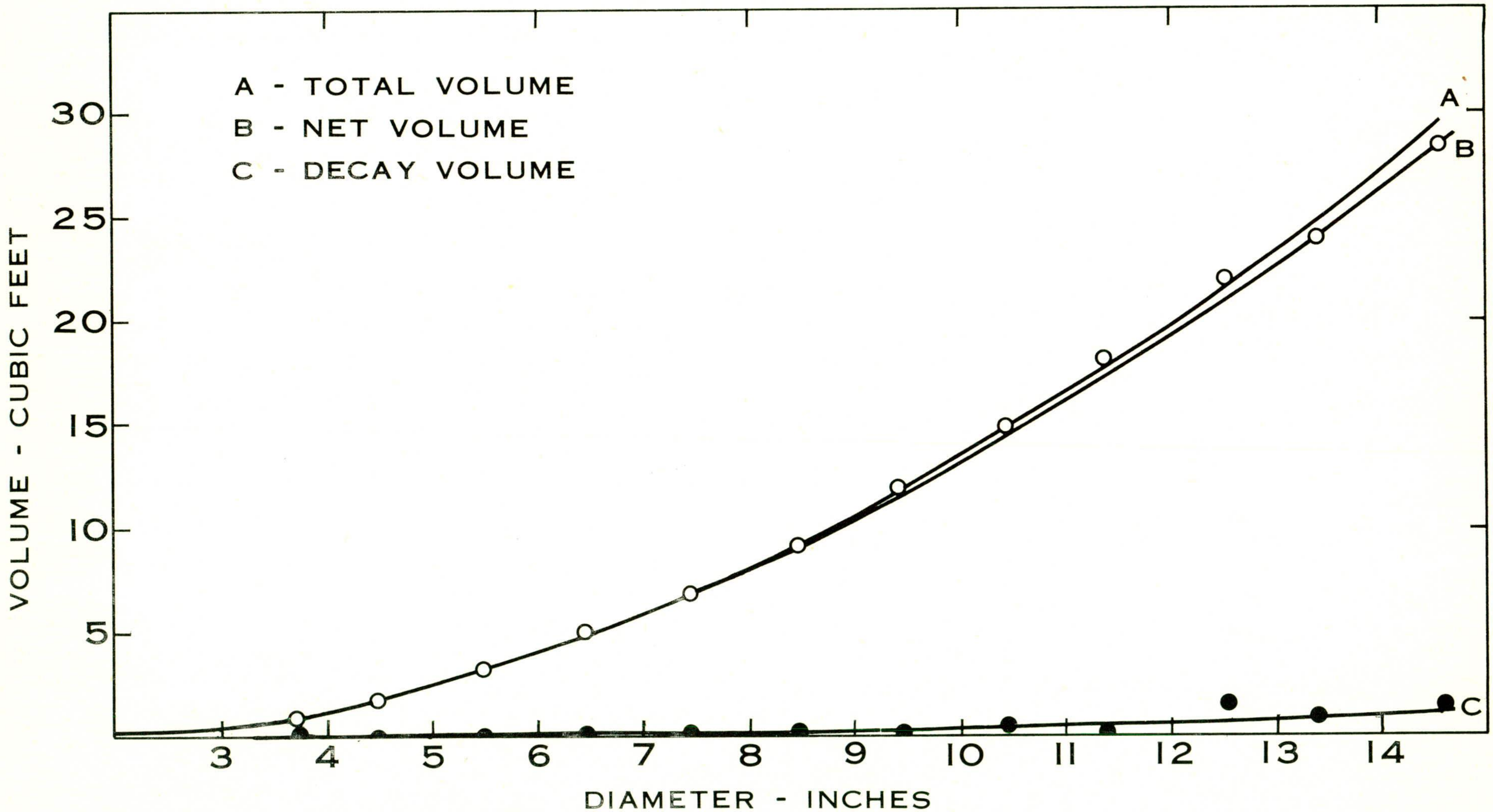

A - TOTAL VOLUME
B - NET VOLUME
C - DECAY VOLUME
VOLUME - CUBIC FEET
30
25
20
15
10
5
3
4
5
6
7
8
9
10
11
12
13
14
DIAMETER - INCHES
A
B
C

Figure 23 Relation between diameter (D.B.H.), total volume, net volume and decay volume in balsam fir in Bazzania-Oxalis type.

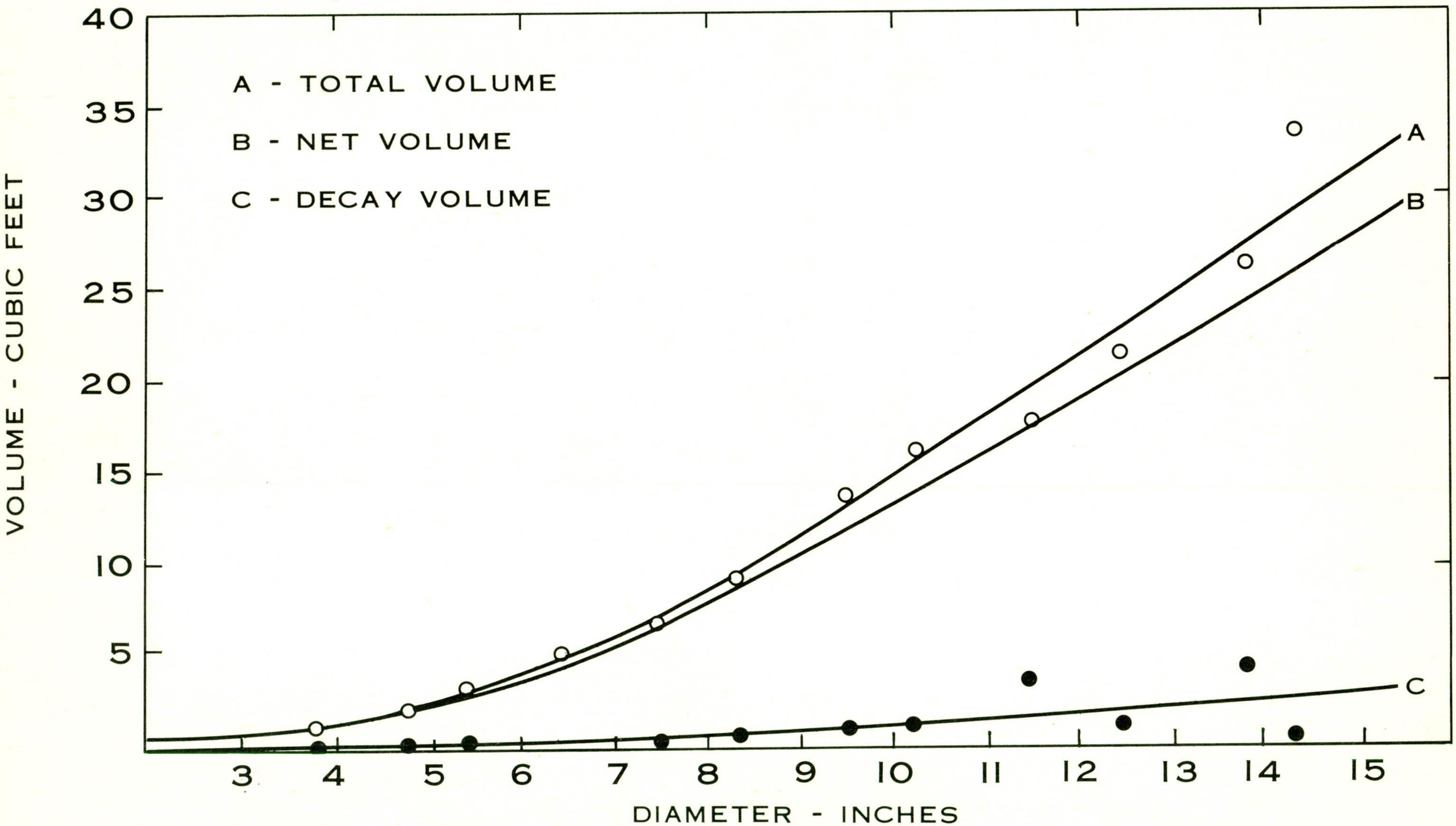

40
35
30
25
20
15
10
5
VOLUME - CUBIC FEET
A - TOTAL VOLUME
B - NET VOLUME
C - DECAY VOLUME
A
B
C
3
4
5
6
7
8
9
10
11
12
13
14
15
DIAMETER - INCHES

Figure 24 Relation between diameter at breast height and age in balsam fir in four forest types.

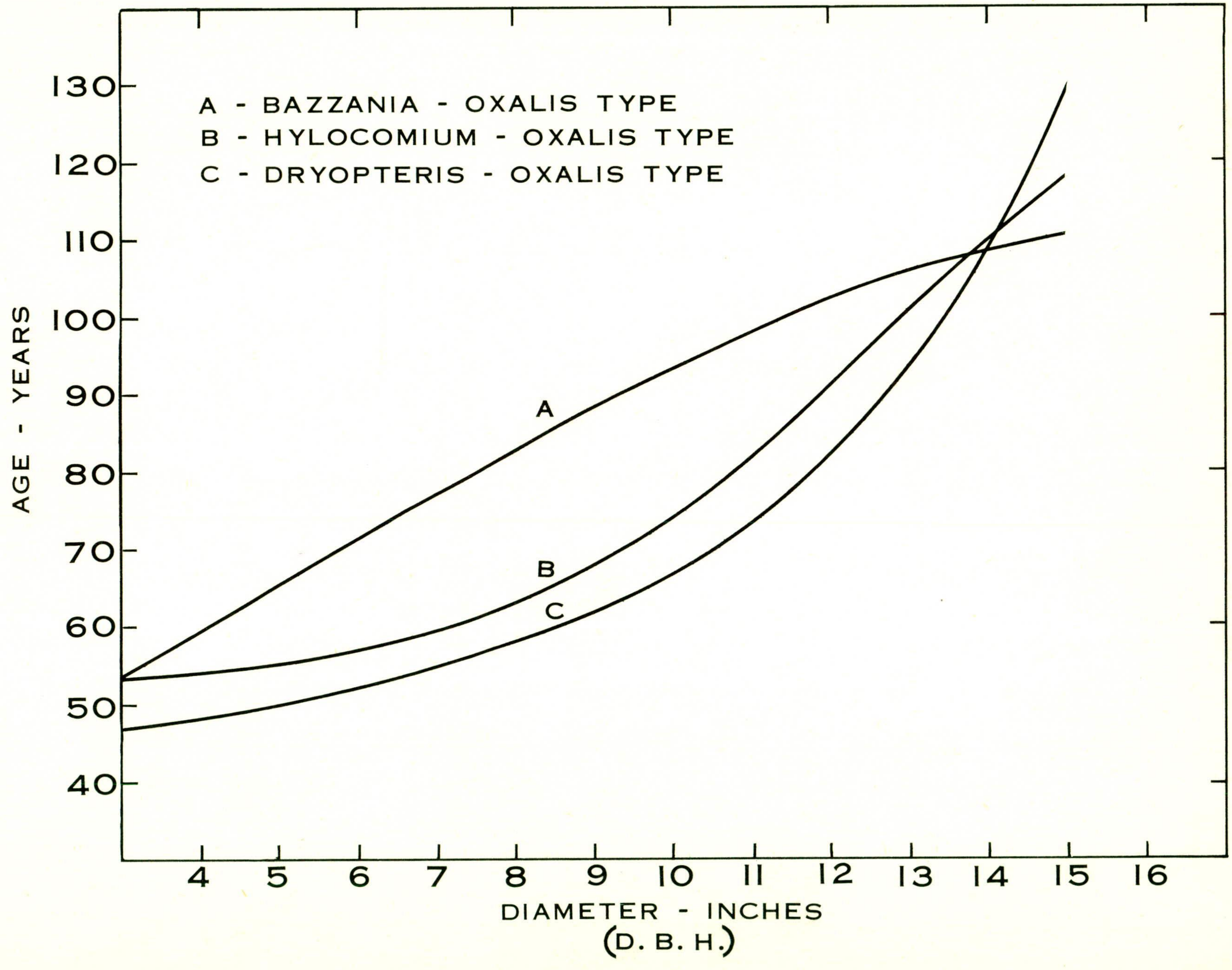

A - BAZZANIA - OXALIS TYPE
B - HYLOCOMIUM - OXALIS TYPE
C - DRYOPTERIS - OXALIS TYPE
AGE - YEARS
130
120
110
100
90
80
70
60
50
40
A
B
C
4
5
6
7
8
9
10
11
12
13
14
15
16
DIAMETER - INCHES
(D. B. H.)

Figure 25 Periodic and mean annual net increment in red spruce in four forest types.

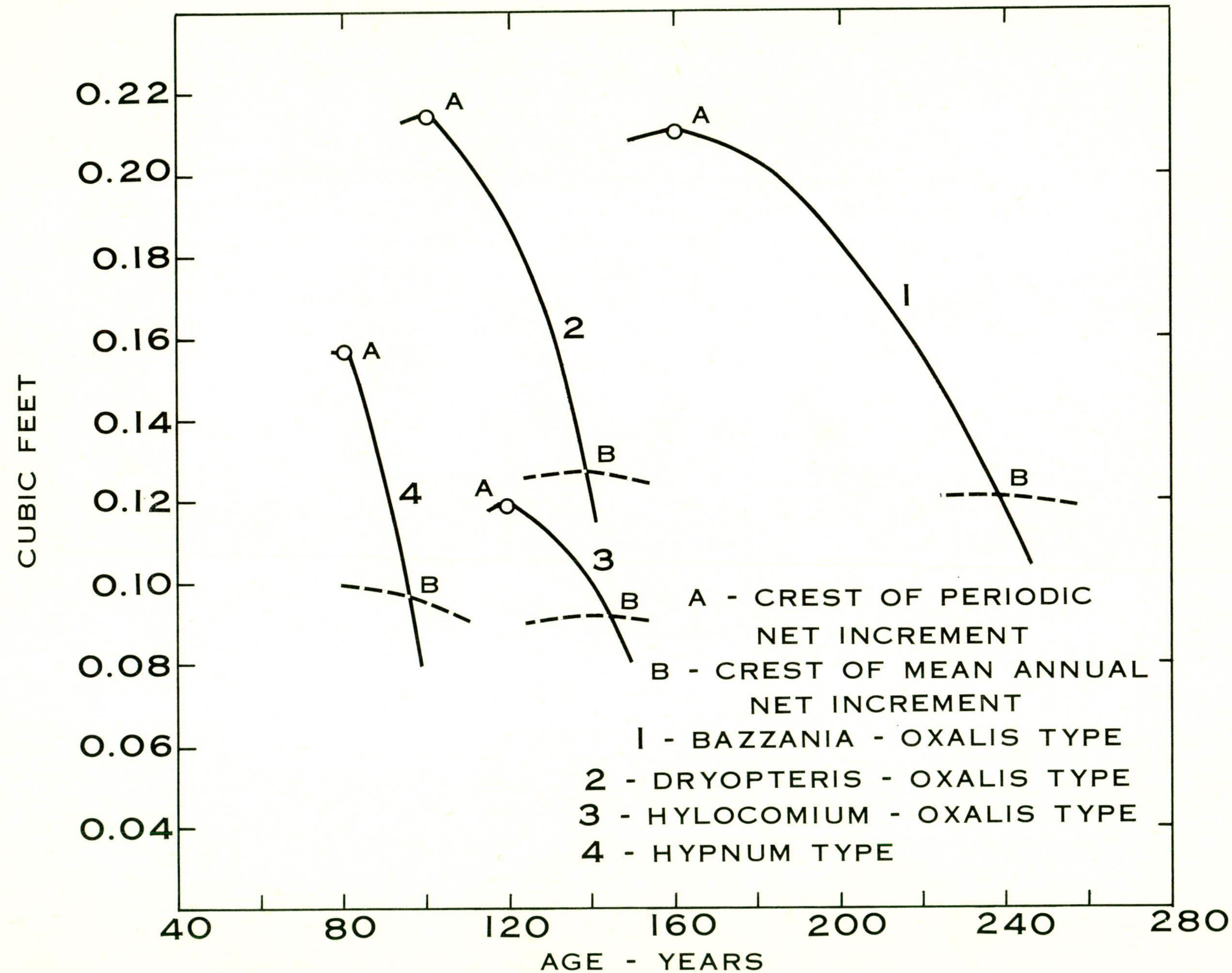

CUBIC FEET
0.22
0.20
0.18
0.16
0.14
0.12
0.10
0.08
0.06
0.04
40
80
120
160
200
240
280
AGE - YEARS
A
B
1
2
3
4
A - CREST OF PERIODIC NET INCREMENT
B - CREST OF MEAN ANNUAL NET INCREMENT
1 - BAZZANIA - OXALIS TYPE
2 - DRYOPTERIS - OXALIS TYPE
3 - HYLOCOMIUM - OXALIS TYPE
4 - HYPNUM TYPE

Figure 26 Periodic and mean annual net increment in balsam fir in three forest types.

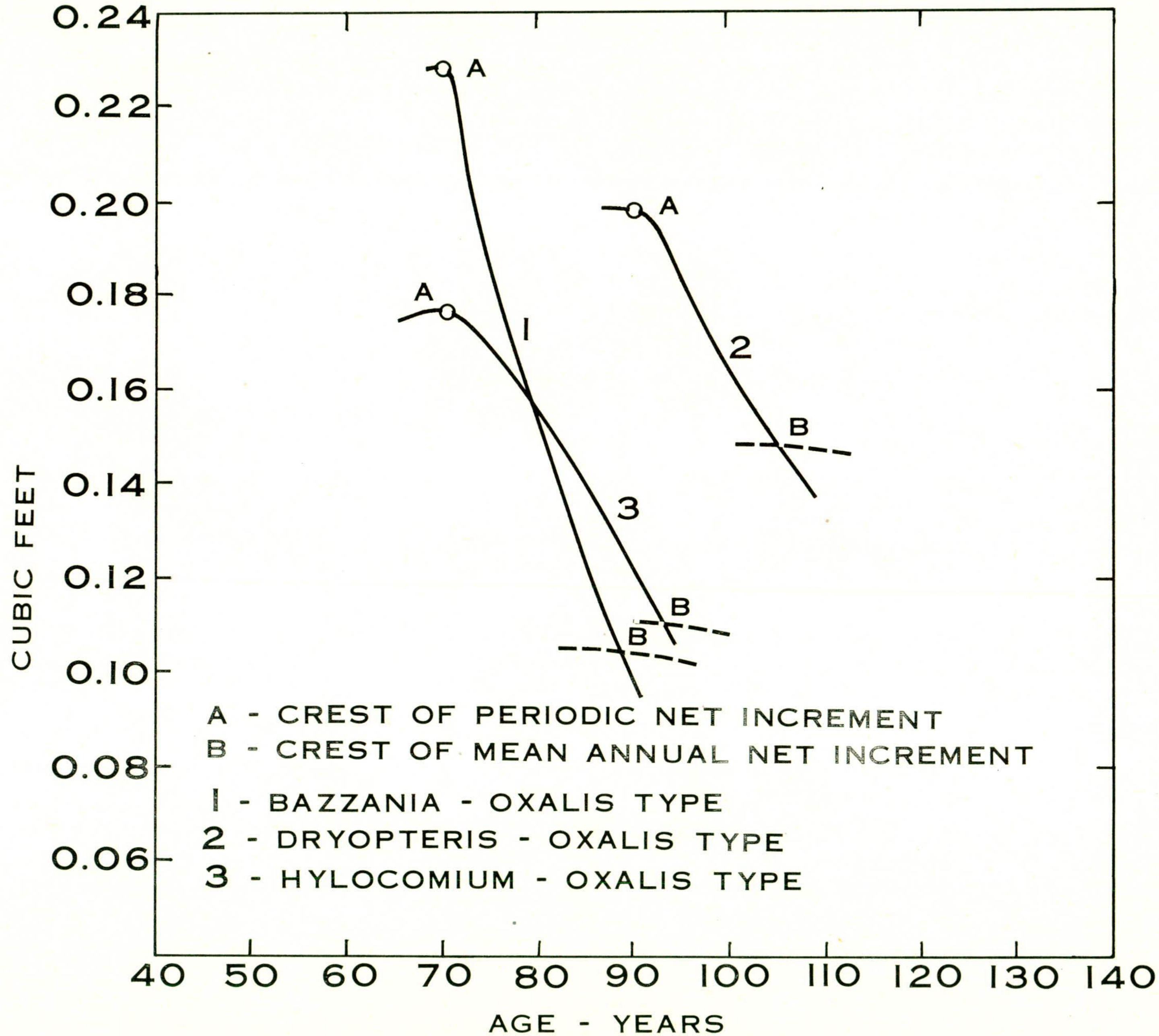

0.24
0.22
0.20
0.18
0.16
0.14
0.12
0.10
0.08
0.06
CUBIC FEET
40
50
60
70
80
90
100
110
120
130
140
AGE - YEARS
A
B
1
2
3
A - CREST OF PERIODIC NET INCREMENT
B - CREST OF MEAN ANNUAL NET INCREMENT
1 - BAZZANIA - OXALIS TYPE
2 - DRYOPTERIS - OXALIS TYPE
3 - HYLOCOMIUM - OXALIS TYPE

Table 1 Summary of Vegetation Analyses in Four Forest Types
Eastern Townships of Quebec

Vegetation Type	Hypnum		Hylocomium-Oxalis		Dryopteris-Oxalis		Bazzania-Oxalis	
Sample Plot No.	92		84 to 91 93 to 98		99 and 120 to 124		125 to 129	
	A.*	S.*	F.*	A. int.*	F.	A. int.	F.	A. int.
Trees								
Abies balsamea (L.) Mill.	1	1	V	(2-4)	V	(4-4)	V	(1-2)
Picea rubens Sarg.	4	4	V	(.-1)	V	(x-1)	V	(2-4)
Betula lutea Michx.f.			V	(.-2)	V	(x-1)	V	(.-1)
Acer rubrum L.			III	(0-x)	III	(0-x)	V	(.-1)
Tsuga canadensis (L.) Carr.			III	(0-x)	0		III	(0-x)
Thuja occidentalis L.	.	.	III	(0-1)	0		0	
Betula papyrifera Marsh.			II	(0-x)	V	(0-1)	V	(.-x)
Tree reproduction								
Abies balsamea (L.) Mill.	2	3	V	(1-3)	V	(x-2)	V	(x-1)
Picea rubens Sarg.	2	2	IV	(0-1)	V	(0-1)	V	(x-1)
Betula lutea Michx. f.	x	1	V	(0-1)	V	(x-2)	IV	(0-x)
Acer rubrum L.	.	x	V	(0-2)	III	(0-.)	V	(.-x)
Tsuga canadensis (L.) Carr.			III	(0.-2)	0		I	(0-.)
Thuja occidentalis L.	.	.	III	(0-1)	0		II	(0-x)
Shrubs								
Vaccinium myrtilloides Michx.	.	.	III	(0-.)	0		IV	(0-x)
Salix sp. L.			0	0	0		IV	(0-x)
Acer spicatum Lam.			IV	(0-1)	V	(.-x)	0	
Viburnum alnifolium Marsh.			III	(0-x)	V	(x-2)	V	(.-.)
Herbs								
Oxalis montana Raf.			V	(1-4)	V	(4-4)	V	(1-3)
Dryopteris spinulosa (O.F. Muell) Watt	.	.	V	(1-3)	V	(3-4)	V	(.-1)

Table 2 Basic Plot Data for Red Spruce Sampled in the Eastern Townships of Quebec
(Sample Plot Nos: 84 - 93 in 1954; 94 - 99 and 120 - 129 in 1955)

Sample plot No.	Sample plot area (acres)	Total no. of merch. trees	No. of red spruce	Percentage of stand	Average age (years)	D.B.H. (inches)	Trees with decay No.	Trees with decay Percentage	Total volume c.f.	Decay volume c.f.	Percentage of decay	Pulpwood Merch. volume c.f.	Pulpwood Cull volume c.f.	Pulpwood Percentage of cull volume
84	0.25	178	42	23.6	74	6.4	12	28.6	272.3	3.4	1.25	248.8	6.7	2.7
85	0.25	100	11	11.0	99	6.5	3	27.3	60.7	0.1	0.16	55.3	6.3	0.5
86	0.25	168	22	13.1	88	7.6	5	22.7	194.8	1.2	0.6	181.2	4.2	2.3
87	0.25	165	26	15.8	77	6.6	8	30.8	174.9	9.0	5.1	159.2	17.9	11.2
88	0.25	138	3	2.3	91	8.6	0	0	36.5	0	0.0	34.3	0.0	0.0
89	0.25	99	7	7.1	108	9.4	2	28.6	97.5	6.1	6.25	92.6	10.6	11.4
90	0.25	156	15	9.6	79	7.3	1	6.7	116.1	0.4	0.34	107.9	0.6	0.6
91	0.25	137	6	4.4	73	6.4	0	0	32.5	0.0	0.0	29.5	0.0	0.0
92	0.25	162	103	63.6	66	6.2	21	20.4	602.2	15.1	2.5	541.8	24.7	4.6
93	0.25	134	6	4.5	96	9.2	1	16.7	83.8	1.1	1.3	78.9	1.6	2.0
94	0.25	87	14	16.1	122	8.2	2	14.3	141.6	5.8	4.1	135.2	7.4	5.5
95	0.25	139	14	10.1	73	7.1	3	21.3	110.3	10.3	9.3	104.5	18.5	17.7
96	0.25	130	19	14.6	86	8.7	2	10.5	152.3	1.5	1.0	144.3	2.8	1.9
97	0.125	68	9	13.2	71	5.5	0	0	37.8	0.0	0.0	34.9	0.1	0.3
98	0.125	71	6	8.4	97	8.2	2	33.3	58.3	0.1	0.2	55.6	0.6	1.1
99	0.25	100	6	6.0	55	5.3	0	0	22.7	0.0	0.0	20.4	0.0	0.0
120	0.25	120	5	4.2	126	10.4	1	20.0	75.8	0.0	0.0	72.9	0.5	0.7
121	0.25	117	22	18.8	68	6.8	2	9.1	141.3	0.0	0.0	131.9	1.1	0.8
122	0.25	114	12	10.5	55	6.4	1	1.8	66.2	0.1	0.2	61.4	1.6	2.6
123	0.25	198	14	7.1	106	9.2	5	4.7	187.2	13.5	7.2	178.6	23.8	13.3
124	0.25	104	13	12.5	96	6.9	3	3.1	99.6	0.4	0.4	94.3	1.9	2.0
125	0.25	125	49	39.2	124	9.2	14	28.6	822.1	11.9	1.4	795.2	24.6	3.1
126	0.25	126	43	34.1	141	9.7	17	39.5	791.2	32.9	4.1	764.3	58.6	7.7
127	0.25	116	74	63.8	178	10.0	26	35.1	1272.0	42.3	3.3	1225.8	77.4	6.3
128	0.25	81	52	64.2	205	11.7	29	55.8	1434.2	122.3	8.5	1396.4	173.4	12.4
129	0.25	132	50	37.8	182	10.5	28	56.0	993.9	31.3	3.1	962.3	54.9	5.7
Total	6.25	2464	643				188		8077.8	308.8		7707.5	513.5	
Average				29.2	116	8.3		29.2			3.8			6.7

Table 3 Basic Plot Data for Balsam Fir Sampled in the Eastern Townships of Quebec
(Sample Plot Nos: 84 - 93 in 1954; 94 - 99 and 120 - 129 in 1955)

Sample plot		Total no. of merch. trees	No. of balsam fir	Percentage of stand	Average age (years)	D.B.H. (inches)	Trees with decay		Total volume c.f.	Decay volume c.f.	Percentage of decay	Pulpwood		
No.	area (acres)						No.	Percentage				Merch. volume c.f.	Cull volume c.f.	Percentage of cull volume
84	0.25	178	101	56.8	65	6.0	73	72.3	557.2	38.0	6.7	498.7	63.8	12.8
85	0.25	100	27	27.0	62	6.0	18	66.6	130.1	8.4	6.4	115.4	14.4	12.5
86	0.25	168	115	68.4	55	6.1	36	31.3	596.4	15.8	2.7	529.6	28.1	5.3
87	0.25	165	128	78.1	62	5.6	41	31.8	569.0	12.0	2.1	494.6	21.0	4.3
88	0.25	138	94	68.0	53	6.5	21	22.3	573.3	12.2	2.1	516.7	20.3	3.9
89	0.25	99	62	62.6	58	7.7	26	42.0	627.0	48.2	7.7	585.5	82.0	14.0
90	0.25	156	122	78.2	57	6.3	54	44.2	724.0	24.4	3.4	653.1	46.1	7.1
91	0.25	137	82	59.9	58	6.4	44	53.6	460.4	39.5	8.6	412.6	74.3	18.0
92	0.25	162	47	29.0	66	6.0	15	31.9	241.4	8.0	3.3	214.2	12.0	5.6
93	0.25	134	90	67.1	58	6.4	42	46.9	477.2	17.0	3.6	426.1	27.4	6.4
94	0.25	87	47	74.0	84	8.5	35	74.5	515.9	56.8	11.0	490.6	96.1	19.6
95	0.25	139	85	61.1	56	7.1	41	48.2	649.0	12.5	2.0	603.5	30.1	5.0
96	0.25	130	94	72.3	62	6.2	83	88.3	787.3	67.6	8.6	745.8	123.0	16.5
97	0.125	68	42	61.8	69	7.6	31	73.8	373.3	40.8	10.9	355.3	72.3	14.8
98	0.125	71	43	60.6	68	7.9	27	62.8	407.2	17.3	4.2	387.1	32.0	8.3
99	0.25	100	71	71.0	51	8.6	54	76.0	745.2	30.8	4.1	709.6	62.1	8.8
120	0.25	120	86	71.6	64	8.0	52	60.5	809.6	18.7	2.3	766.5	37.7	4.9
121	0.25	117	70	59.8	62	7.8	43	61.4	574.1	25.9	4.5	541.4	50.2	9.3
122	0.25	114	70	61.4	59	7.8	41	58.6	569.2	12.2	2.1	535.2	32.9	6.1
123	0.25	198	124	62.6	57	6.8	45	36.3	802.8	12.6	1.5	744.4	30.1	4.0
124	0.25	105	74	72.1	64	7.3	21	28.0	583.2	13.8	2.4	548.3	29.3	5.3
125	0.25	125	33	26.4	78	7.5	23	69.7	296.7	28.6	9.8	275.4	47.4	17.2
126	0.25	126	34	27.0	85	8.2	24	70.6	356.4	30.5	8.5	339.1	50.7	15.0
127	0.25	116	15	12.9	77	6.8	9	66.7	98.2	4.3	4.4	91.6	7.8	8.5
128	0.25	81	22	27.2	82	6.0	16	72.7	103.1	10.4	10.1	95.1	20.0	21.0
129	0.25	132	41	31.1	74	7.3	32	78.0	352.7	36.2	10.3	334.5	63.6	19.1
Total	6.25	2,464	1,820				947		12,964.9	642.6		12,009.9	1,175.0	
Average				73.9	62	7.0		52.0			4.96			9.6

Table 4 Percentage of Incidence of Decay Infection and Decay Volume Caused by the Different Fungi in Red Spruce and Balsam Fir in the Eastern Townships of Quebec

Organism	Red spruce										Balsam fir									
	All sites		H-O T		Dry-O T		Baz-O T		Hyp T		All sites		H-O T		Dry-O T		Baz-O T		Hyp T	
	N.	Vol.	N.	Vol.	N.	Vol.	N.	Vol.	N.	Vol.	N.	Vol.	N.	Vol.	N.	Vol.	N.	Vol.	N.	Vol.
White Butt Rots																				
Poria subacida (Pk.) Sacc.	3.9	1.1	2.2	0.1	6.7	5.0	3.4	1.0	8.3	0.7	9.4	5.0	12.2	5.5	5.6	5.3	2.7	2.5	18.7	8.7
Corticium galactinum (Fr.) Burt	25.	12.3	24.4	12.3	20.0	3.6	26.	12.2	20.8	21.9	33.5	14.7	32.5	13.2	39.3	24.4	24.8	10.6	43.7	12.5
Odontia bicolor (Fr.) Brés.	1.7	0.4	4.5	1.6			1.5	0.2			2.7	1.2	3.2	1.1	1.8	0.7	2.7	2.4		
Polyporus tomentosus Fr.	4.5	2.1	4.4	4.6			5.5	2.0	4.2		0.2				0.3	0.1			6.3	
Polyporus dualis Pk.	0.8	0.5					1.4	0.6			0.8						1.4			
Polyporus borealis Fr.	0.4	0.0	2.2	0.1							0.4		0.4	0.2	0.3	0.1	0.7			
Armillaria mellea (Fr.) Quél.											0.5		0.8	0.0	0.3					
Unknown	7.0	0.7	6.7	1.8	6.7		8.3	3.7			4.0	0.7	2.9	0.4	6.1	1.2	4.7	0.6	6.3	11.3
Total	42.8	19.5	44.4	20.5	33.4	8.6	44.7	19.7	33.3	22.6	50.7	21.8	51.9	20.4	53.7	31.8	35.6	16.1	75.0	32.5
Brown Butt Rots																				
Polyporus balsameus Pk.	3.5	3.2	4.4	9.0			3.4	1.5	4.2	3.3	3.4	2.2	4.5	2.8			5.4	2.4		
Polyporus schweinitzii Fr.											0.4	0.3	0.4	0.3	0.3	0.3	0.7	0.2		
Coniophora puteana (Fr.) Karst.	6.6	5.6	8.9	9.0			7.0	5.6	4.2	1.9	5.2	2.0	5.8	2.1	1.2	0.4	11.4	3.6		
Merulius himantioides Fr.	2.6	2.1					4.8	2.6		1.3	2.1	1.2	2.0	0.5	1.2	1.3	4.7	3.5		
Unknown	5.2	0.9	4.5	4.4	13.4		4.8	0.4	4.2		0.9	0.5	0.8	0.1	1.6	2.4		0.1		
Total	17.9	11.8	17.8	22.4	13.4	0.0	19.4	11.1	12.6	6.5	12.0	6.2	13.6	5.8	4.3	4.4	22.2	9.8		
Butt Rots Total	60.7	31.3	62.2	42.9	46.8	8.6	64.1	30.8	45.9	29.1	62.7	28.0	65.5	26.2	58.0	36.2	57.8	25.9	75.0	
Trunk Rots																				
Stereum sanguinolentum Alb. & Schw.	14.0	2.8	13.3	4.4	13.3	1.4	11.7	1.8	29.1	17.2	34.0	69.7	31.0	72.3	39.3	57.4	38.3	73.2	25.0	67.5
Fomes pini (Thore.) Lloyd	17.4	65.1	15.6	52.6	13.3	85.7	17.2	66.8	25.0	53.7	1.0	1.6	1.5	1.0	0.3	5.3	0.7			
Fomes pinicola (Sw.) Cke.	1.5	0.5					2.1	0.6			0.6	0.3	0.1		1.2	1.0	1.2	0.7		
Stereum chaillettii Pers.											0.1	0.1	0.1	0.1						
Brown rot, unknown	1.7	0.2	2.2		13.3	3.6	0.7				0.6	0.2	0.5	0.3	0.3		1.3	0.1		
Other, unknown	3.9	0.1	6.7	0.1	13.3	0.7	2.8				1.0	0.1	1.3	0.1	0.9	0.1	0.7	0.1		
Total	39.3	68.7	37.8	57.1	53.2	91.4	35.9	69.2	54.1	70.9	37.3	72.0	34.5	73.8	42.0	63.8	42.2	74.1	25.0	67.5

Table 5 Infection Courts of Decay Infection in Red Spruce and Balsam Fir in the Eastern Townships of Quebec (Number of Infections)

Organism	Red spruce						Balsam fir						Grand total
	Roots	Scars	Branch stubs	Damaged tops	Unknown	Total	Roots	Scars	Branch stubs	Damaged tops	Unknown	Total	
Root and Butt Rots													
Poria subacida	8	1				9	112	1			1	114	123
Odontia bicolor	3	1				4	31	1			1	33	37
Corticium galactinum	56	1				57	398	7			4	409	466
Polyporus borealis	1					1	5					5	6
Polyporus tomentosus	8	3				11	2					2	13
Polyporus dualis		2				2							2
Armillaria mellea							6					6	6
Polyporus balsameus	6	2				8	41					41	49
Polyporus schweinitzii							5					5	5
Coniophora cerebella	13	2				15	61	2				63	78
Merulius himantioides	7					7	26					26	33
Unknown, brown cubical	9	2				11	11					11	22
Unknown	14	2				16	44	5				49	65
Trunk Rots													
Stereum sanguinolentum		20	9	1	2	32		84	297	27	7	415	447
Fomes pini		15	23	1	1	40		3	5	1	4	13	53
Fomes pinicola			1		2	3		2	1		4	7	10
Stereum chailletii									1			1	1
Unknown, brown cubical		3			1	4		4	3			7	11
Unknown		8	1			9		5	7		1	13	22
Total	125	62	34	2	6	229	742	114	314	28	22	1,220	1,449

Table 6 Relation of Percentage of Decay Incidence to Age According to Forest Types in Red Spruce in the Eastern Townships of Quebec

	All Types				Bazzania-Oxalis Type				Dryopteris-Oxalis Type				Hylocomium-Oxalis Type				Hypnum Type			
Age class	No. of trees	Decay	Trunk rot	Butt rot	No. of trees	Decay	Trunk rot	Butt rot	No. of trees	Decay	Trunk rot	Butt rot	No. of trees	Decay	Trunk rot	Butt rot	No. of trees	Decay	Trunk rot	Butt rot
30-49	29	3.5	3.5	00.0	5	0.0	0.0	0.0	21	4.8	4.8	-	2	0.0	0.0	0.0	1	0.0	0.0	-
60-69	253	13.0	5.1	8.3	36	11.1	8.3	2.8	25	4.0	4.0	-	107	13.1	4.7	9.3	85	16.4	4.7	11.7
70-89	32	12.5	0.0	12.5	8	12.5	0.0	12.5	3	0.0	0.0	-	15	13.3	0.0	13.3	6	16.7	0.0	16.7
90-109	46	28.8	8.7	2.2	14	28.5	14.3	14.3	3	0.0	0.0	-	28	28.6	7.1	25.0	1	100.0	0.0	100.0
110-129	59	33.9	13.5	25.4	17	5.9	0.0	5.9	4	25.0	0.0	25.0	29	44.8	20.7	31.0	9	55.5	22.2	44.4
130-149	35	25.7	11.4	17.1	17	17.6	5.9	11.8	7	41.3	28.6	14.3	10	30.0	10.0	30.0	1	-		
150-169	38	39.5	13.6	34.2	25	36.0	8.0	32.0	7	71.4	42.9	57.1	6	16.7		16.7				
170-189	32	43.7	15.6	28.1	30	46.7	16.7	30.0	0	0.0	0.0	0.0	2							
190-209	29	58.6	17.2	44.8	28	60.7	17.9	46.4	1		0.0		0							
210-229	35	68.6	17.1	54.3	34	67.6	17.6	52.9	1	100.0		100.0	0							
230-249	24	69.1	29.1	50.0	24	69.1	29.1	50.0					0							
250-269	14	57.1	29.2	42.8	13	53.8	30.8	38.5					1	100.0		100.0				
270-289	14	71.4	42.8	57.1	14	71.4	42.8	57.1												
290-309	3	66.7	0.0	66.7	3	66.7	0.0	66.7												
Total	643				268				72				200				103			

Table 7 Relation of Volume (Cubic Feet) to Age
Average Total and Decay Volumes, Gross Merchantable, Cull and Net Volumes per Tree
for Pulpwood and Saw Timber
(Curved Values)
Red Spruce in the Eastern Townships of Quebec - All Types - Basis 643 Trees

Age (years)	Total volume	Decay volume	Total net volume	Pulpwood: Gr. merch. volume	Pulpwood: Net cull volume	Pulpwood: Net merch. volume	Saw timber: Gr. merch. volume	Saw timber: Net cull volume	Saw timber: Net merch. volume
30-49	2.62	0.00	2.62	2.27	0.03	2.24	0.00	0.00	0.00
50-69	4.55	0.05	4.50	4.15	0.13	4.02	1.30	0.08	1.22
70-89	6.65	0.18	6.47	6.20	0.32	5.88	3.75	0.24	3.51
90-109	8.95	0.32	8.63	8.45	0.53	7.92	6.35	0.42	5.93
110-129	11.50	0.45	11.05	10.95	0.73	10.22	9.10	0.62	8.48
130-149	14.60	0.62	13.98	14.00	0.99	13.01	12.35	0.89	11.47
150-169	18.48	0.77	17.71	17.83	1.24	16.59	16.33	1.16	15.17
170-189	22.60	0.97	21.63	21.90	1.54	20.36	20.55	1.50	19.05
190-209	26.40	1.18	25.22	25.65	1.90	23.75	24.45	1.85	22.60
210-229	29.50	1.40	28.10	28.70	2.27	26.43	27.65	2.26	25.39
230-249	32.00	1.70	30.30	31.15	2.78	28.37	30.20	2.83	27.37
250-269	34.10	2.05	32.05	33.20	3.27	29.93	32.35	3.35	29.00
270-289	35.90	2.40	33.50	34.95	3.83	31.12	34.20	4.00	30.20
290-309	37.30	2.85	34.45	36.30	4.53	31.77	35.65	4.75	30.90

Table 8 Relation of Volume (Cubic Feet) to Age
Average Total and Decay Volumes, Gross Merchantable,
Net and Cull Volumes per Tree for Pulpwood and Saw Timber
Red Spruce in the Eastern Townships of Quebec
(Curved Values)

Age (years)	Total volume	Decay volume	Pulpwood: Gross merch. volume	Pulpwood: Cull volume	Pulpwood: Net merch. volume	Saw timber: Gross merch. volume	Saw timber: Cull volume	Saw timber: Net merch. volume
			Bazzania-Oxalis type - basis 268 trees					
40	1.30	0.00	1.05	0.03	1.02	0.00	0.00	0.00
60	2.80	0.00	2.50	0.08	2.42	0.00	0.00	0.00
80	4.55	0.08	4.20	0.23	3.97	1.50	0.09	1.41
100	6.70	0.15	6.28	0.38	5.90	3.93	0.25	3.68
120	9.50	0.28	9.02	0.60	8.42	6.97	0.46	6.51
140	13.20	0.42	12.65	0.86	11.79	10.90	0.73	10.17
160	17.80	0.60	17.18	1.17	16.01	15.68	1.05	14.63
180	22.25	0.82	21.56	1.49	20.07	20.26	1.38	18.88
200	21.15	1.05	25.39	1.83	23.56	24.24	1.75	22.49
220	29.70	1.28	28.86	2.20	26.66	27.86	2.14	25.72
240	32.60	1.58	31.68	2.62	29.06	30.76	2.65	28.11
260	24.60	1.93	33.90	3.18	30.72	33.05	3.23	29.82
280	36.60	2.28	35.50	3.73	31.77	34.70	3.83	30.87
300	38.00	2.72	36.80	4.40	32.40	36.04	4.57	31.47
			Dryopteris-Oxalis type - basis 71 trees					
40	2.30	0.00	1.98	0.02	1.96	0.00	0.00	0.00
60	4.35	0.00	3.98	0.04	3.94	1.40	0.00	1.40
80	7.40	0.00	6.98	0.06	6.92	5.00	0.00	5.00
100	11.50	0.01	11.00	0.09	10.91	9.85	0.06	9.79
120	15.75	0.07	15.19	0.19	16.00	14.10	0.19	13.91
140	18.70	0.13	18.07	0.30	17.77	16.92	0.35	16.57
160	20.50	0.24	19.80	0.47	19.33	18.48	0.59	17.89
180	21.60	0.43	20.84	0.74	20.10	19.26	0.93	18.33
200	22.30	0.70	21.46	1.10	20.36	19.55	1.40	18.15
			Hylocomium-Oxalis type - basis 199 trees					
40	2.75	0.00	2.31	0.00	2.31	0.00	0.00	0.00
60	4.65	0.00	4.17	0.06	4.11	0.65	0.00	0.00
80	6.85	0.06	6.33	0.24	6.09	2.80	0.12	2.68
100	9.40	0.19	8.84	0.49	8.35	5.75	0.37	5.38
120	12.20	0.40	11.60	0.82	10.78	9.05	0.70	8.35
140	14.75	0.64	14.11	1.18	12.93	12.10	1.06	11.04
160	16.55	0.96	15.87	1.63	14.24	14.40	1.50	12.90
180	17.72	1.35	17.00	2.20	14.80	16.07	2.02	14.05
200	18.47	1.83	17.67	2.83	14.54	17.32	2.66	14.66
			Hypnum type - basis 103 trees					
40	2.55	0.00	2.03	0.00	2.03	0.00	0.00	0.00
60	5.10	0.05	4.54	0.09	4.45	0.95	0.08	0.87
80	8.80	0.16	8.20	0.30	7.90	4.75	0.25	4.50
100	10.95	0.45	10.34	0.80	9.54	7.10	0.65	6.45
120	12.30	1.00	11.62	1.58	10.04	8.65	1.27	7.38
140	13.10	1.75	12.25	2.80	9.45	9.70	2.00	7.70

Table 9 Relation of Percentage of Decay and Cull Volumes to Age according to Types
Red Spruce in the Eastern Townships of Quebec
(Based on Curved Values)

	All types			Dry-O T			H-O T			Baz-O T			Hyp T		
Age (years)	Decay	Cull pulp	Cull saw	Decay	Cull pulp	Cull saw	Decay	Cull pulp	Cull saw	Decay	Cull pulp	Cull saw	Decay	Cull pulp	Cull saw
40	0.0	1.3	0	0	0.5	0	0	0	0	0	2.9	0	0	0	0
60	1.1	3.1	6.1	0	0.7	0	0	1.4	0	0	3.2	0	1.0	2.0	4.2
80	2.7	5.2	6.4	0	0.8	0	0.9	3.8	4.3	1.7	5.7	6.0	1.8	3.7	5.3
100	3.6	6.1	6.6	0.1	0.9	0.6	2.0	5.5	6.4	2.2	6.0	6.4	4.4	7.7	9.1
120	3.9	6.6	6.8	0.4	1.2	1.3	3.3	7.1	7.7	2.9	6.6	6.6	8.1	12.6	14.7
140	4.2	7.0	7.1	0.7	1.8	2.1	4.4	8.4	8.8	3.2	6.8	6.7	13.4	22.8	20.6
160	4.2	7.0	7.1	1.2	2.5	3.2	5.8	10.4	10.4	3.4	6.9	6.7			
180	4.3	7.0	7.3	2.0	3.5	4.8	7.6	12.9	12.6	3.7	7.0	6.8			
200	4.5	7.4	7.6	3.1	5.2	7.1	9.9	16.0	15.3	4.0	7.2	7.2			
220	4.7	7.9	8.5							4.3	7.6	7.7			
240	5.3	8.9	9.4							4.8	8.3	8.6			
260	6.0	9.8	10.4							5.5	9.4	9.8			
280	6.5	10.9	11.7							6.2	10.5	11.0			
300	7.6	12.5	13.3							7.1	11.9	12.7			

Table 10 Regression Line Equations and Tests of Significance by Co-Variance Analysis of Cull Percentage in Red Spruce in Four Forest Types in the Eastern Townships of Quebec 60 - 200 years

Forest types	Regression equation	Test of significance
Hylocomium-Oxalis	Y = 0.07 X - 3.33	Percentage of cull: F = 1.25 (Foi = 3.83) N S *
Dryopteris-Oxalis	Y = 0.009 X - 0.47	Age: F = 6.99 (Foi = 3.83) S *
Bazzania-Oxalis	Y = 0.02 X + 0.68	Regression coefficient: F = 1.16 (Foi = 3.83) N S
Hypnum	Y = 0.12 X - 5.94	
All types	Y = 0.03 X - 0.27	

Types compound	Test of significance of adjusted means.	Test of significance of regression coefficients
H-O & Hyp	F = 0.70 (Foi = 6.76) N S	F = 0.58 (Foi = 6.76) N S
H-O & Baz-O	F = 0.82 (Foi = 6.73) N S	F = 1.43 (Foi = 6.76) N S
H-O & Dry-O	F = 4.11 (Foi = 6.76) N S	F = 1.45 (Foi = 6.80) N S
Dry-O & Baz-O	F = 1.13 (Foi = 6.81) N S	F = 0.06 (Foi = 6.80) N S
Dry-O & Hyp	F = 5.54 (Foi = 6.93) N S	F = 4.20 (Foi = 6.92) N S
Baz-O & Hyp	F = 0.55 (Foi = 6.76) N S	F = 1.79 (Foi = 6.76) N S

*N S: not significant
*S: significant

Table 11 Relation of Volume (Cubic Feet) to Diameter in Red Spruce in the Eastern Townships of Quebec
Hypnum Type - Basis 103 Trees
(Curved Values)

Diameter (inches)	Total volume	Decay volume	Net volume	% of Decay volume	Pulpwood Gross merch. volume	Pulpwood Cull volume	Pulpwood Net volume	Pulpwood % of Cull volume	Saw timber Gross merch. volume	Saw timber Cull volume	Saw timber Net volume	Saw timber % of Cull volume
4.0	1.80		1.80		1.28		1.28					
5.0	3.32		3.32		2.77	0.01	2.76	0.4				
6.0	5.12	0.05	5.07	1.0	4.54	0.11	4.43	2.4	1.08	0.03	1.05	2.8
7.0	7.20	0.08	7.12	1.1	6.58	0.19	6.39	2.9	2.50	0.09	2.41	3.6
8.0	9.50	0.13	9.37	1.4	8.84	0.30	8.54	3.4	6.25	0.25	6.00	4.0
9.0	11.85	0.22	11.63	1.9	11.16	0.44	10.72	3.9	9.75	0.40	9.35	4.1
10.0	14.50	0.42	14.08	2.9	13.78	0.69	13.09	5.0	12.95	0.57	12.38	4.4
11.0	17.40	0.70	16.70	4.0	16.64	1.03	15.61	6.2	16.10	0.81	15.29	5.0

Table 12 Relation of Volume (Cubic Feet) to Diameter in Red Spruce in the Eastern Townships of Quebec
Hylocomium-Oxalis Type - Basis 199 Trees
(Curved Values)

Diameter (inches)	Total volume	Decay volume	Net volume	% of decay volume	Pulpwood: Gross merch. volume	Pulpwood: Cull volume	Pulpwood: Net volume	Pulpwood: % of cull volume	Saw timber: Gross merch. volume	Saw timber: Cull volume	Saw timber: Net volume	Saw timber: % of cull volume
3.0	0.60		0.60		0.16							
4.0	1.52	0.04	1.48	2.6	1.07	0.06	1.01	5.6				
5.0	2.85	0.08	2.77	2.9	2.39	0.14	2.25	5.9				
6.0	4.55	0.14	4.41	3.1	4.07	0.25	3.82	6.1				
7.0	6.70	0.22	6.48	3.3	6.20	0.39	5.81	6.3	1.40	0.10	1.30	7.1
8.0	9.15	0.35	8.80	3.8	8.61	0.57	8.04	6.8	5.60	0.42	5.08	7.5
9.0	11.95	0.52	11.43	4.4	11.37	0.86	10.51	7.6	9.58	0.74	8.84	7.7
10.0	15.10	0.75	14.35	5.0	14.45	1.25	13.20	8.7	13.30	1.22	12.08	9.2
11.0	18.50	1.07	17.43	5.8	17.77	1.78	15.99	10.0	16.90	1.85	15.05	10.9
12.0	22.20	1.50	20.70	6.8	21.37	2.46	18.91	11.5	20.65	2.62	18.03	12.7
13.0	26.20	2.05	24.15	7.8	25.27	3.32	21.95	13.1	24.70	3.55	21.15	14.4
14.0	30.40	2.73	27.67	9.0	29.35	4.35	25.00	14.8	28.90	4.68	24.22	16.2
15.0	35.20	3.55	31.65	10.1	34.00	5.59	28.41	16.4	33.70	6.00	27.70	17.9

Table 13 Relation of Volume (Cubic Feet) to Diameter in Red Spruce in the Eastern Townships of Quebec
Bazzania-Oxalis Type - Basis 268 Trees
(Curved Values)

					Pulpwood				Saw timber			
Diameter (inches)	Total volume	Decay volume	Net volume	% of decay volume	Gross merch. volume	Cull volume	Net volume	% of cull volume	Gross merch. volume	Cull volume	Net volume	% of cull volume
3.0	0.40	0.00	0.40		0.12		0.11					
4.0	1.45	0.04	1.41	2.7	1.16	0.07	1.09	6.4				
5.0	2.70	0.10	2.60	3.7	2.40	0.16	2.24	6.6				
6.0	4.30	0.18	4.12	4.2	3.97	0.27	3.70	6.8				
7.0	6.25	0.28	5.97	4.5	5.87	0.41	5.46	7.0	2.95	0.21	2.74	7.2
8.0	8.55	0.39	8.16	4.6	8.11	0.57	7.54	7.0	6.75	0.49	6.26	7.3
9.0	11.40	0.52	10.88	4.6	10.89	0.78	9.11	7.1	10.12	0.74	9.38	7.3
10.0	14.70	0.68	14.02	4.6	14.12	1.00	13.12	7.1	13.42	1.00	12.42	7.4
11.0	18.50	0.86	17.64	4.6	17.84	1.27	16.57	7.1	17.20	1.27	15.93	7.4
12.0	22.50	1.05	21.45	4.6	21.75	1.58	20.18	7.2	21.16	1.57	19.59	7.4
13.0	27.20	1.26	25.94	4.6	26.36	1.90	24.46	7.2	25.80	1.94	23.86	7.5
14.0	32.20	1.50	30.70	4.7	31.26	2.25	29.01	7.2	30.73	2.30	28.43	7.5
15.0	37.40	1.75	35.65	4.7	36.37	2.67	33.70	7.3	35.85	2.72	33.13	7.6
16.0	43.00	2.05	40.95	4.8	41.87	3.08	38.79	7.3	41.32	3.14	38.18	7.6
17.0	49.20	2.40	46.80	4.9	47.97	3.53	44.44	7.3	47.35	3.65	43.70	7.7
18.0	56.00	2.80	53.20	5.0	54.66	4.07	50.59	7.4	53.93	4.21	49.72	7.8
19.0	63.90	3.30	60.60	5.2	62.42	4.70	52.72	7.4	61.55	4.86	56.69	7.9
20.0	73.60	3.85	69.75	5.2	71.95	5.39	65.56	7.5	70.92	5.67	65.25	8.0

Table 14 Relation of Volume (Cubic Feet) to Diameter in Red Spruce in the Eastern Townships of Quebec
Dryopteris-Oxalis Type - Basis 71 Trees
(Curved Values)

Diameter (inches)	Total volume	Decay volume	Net volume	% of decay volume	Pulpwood				Saw timber			
					Gross merch. volume	Cull volume	Net volume	% of cull volume	Gross merch. volume	Cull volume	Net volume	% of cull volume
3.0	0.70		0.70		0.39		0.39					
4.0	1.15	0.00	1.15		0.83		0.83					
5.0	2.20	0.00	2.20		1.87		1.87		1.00	0.01	0.99	1.0
6.0	3.70	0.71	3.69	0.3	3.36	0.02	3.34	0.5	2.55	0.03	2.52	1.2
7.0	5.72	0.02	5.70	0.4	5.26	0.04	5.22	0.7	4.63	0.07	4.57	1.5
8.0	8.07	0.03	8.04	0.4	7.68	0.06	7.62	0.8	6.98	0.11	6.87	1.6
9.0	10.70	0.05	10.65	0.5	10.37	0.10	10.27	1.0	9.75	0.16	9.59	1.6
10.0	13.58	0.07	13.51	0.5	13.09	0.15	12.94	1.1	12.36	0.21	11.98	1.7
11.0	16.50	0.09	16.41	0.6	15.92	0.19	15.73	1.3	15.12	0.27	14.62	1.8
12.0	19.62	0.12	19.50	0.6	18.89	0.26	18.63	1.4	18.00	0.35	17.35	1.9
13.0	23.07	0.15	22.92	0.7	22.14	0.33	21.18	1.5	20.94	0.48	20.08	2.3
14.0	26.72	0.21	26.51	0.7	25.25	0.44	24.81	1.7	23.09	0.69	21.90	2.9
15.0	30.50	0.29	30.21	1.0	28.94	0.59	28.35	2.0	24.30	1.04	23.61	4.3
16.0	34.35	0.40	33.95	1.2								
17.0	38.20	0.53	37.67	1.4								

Table 16 Relation of Percentage of Decay Incidence to Age According to Sites
Balsam Fir in the Eastern Townships of Quebec

Age class	Bazzania-oxalis, 145 trees				Dryopteris-oxalis, 496 trees				Hylocomium-oxalis, 1133 trees			
	No. of trees	Percentage of Decay	Percentage of Trunk rot	Percentage of Butt rot	No. of trees	Percentage of Decay	Percentage of Trunk rot	Percentage of Butt rot	No. of trees	Percentage of Decay	Percentage of Trunk rot	Percentage of Butt rot
20-29	-	-	-	-	1	-	-	-	2	-	-	-
30-39	-	-	-	-	10	30.0	10.0	20.0	8	-	-	-
40-49	12	66.7	8.3	66.7	116	50.9	19.0	38.8	94	35.1	6.4	30.9
50-59	33	54.5	15.1	45.4	231	43.3	19.5	29.4	566	41.0	16.1	31.6
60-69	23	65.2	30.4	56.5	64	59.4	29.7	42.2	324	61.1	21.9	50.9
70-79	21	66.7	42.9	52.4	21	66.7	28.7	42.8	71	73.2	32.4	59.2
80-89	10	70.0	50.0	50.0	12	75.0	50.0	33.3	13	76.9	30.8	61.5
90-99	11	90.9	54.5	54.5	9	66.7	44.4	44.4	15	93.3	60.0	73.3
100-109	8	87.5	87.5	50.0	7	71.4	42.9	71.4	17	76.5	64.7	58.8
110-119	10	100.0	70.0	80.0	11	81.8	63.6	63.6	15	73.3	73.3	53.3
120-129	10	70.0	50.0	60.0	11	81.8	72.7	72.7	6	100.0	66.6	66.6
130-139	5	100.0	60.0	80.0	2	100.0	100.0	100.0	2	100.0	100.0	100.0
140-149	2	100.0	100.0	100.0	1	100.0	100.0	100.0				

Table 15 Relation Between Diameter and Age in Red Spruce in the Eastern Townships of Quebec According to Forest Types

Diameter (inches)	H-O T No. of trees	H-O T Average age (curved)	H-O T St. dev.	Dry-O T No. of trees	Dry-O T Average age (curved)	Dry-O T St. dev.	Baz-O T No. of trees	Baz-O T Average age (curved)	Baz-O T St. dev.	Hyp T No. of trees	Hyp T Average age (curved)	Hyp T St. dev.	Total no. of trees
3	4	54.0	27.0	9	32	8.9	2	43	18.4		51.5		15
4	24	61.0	11.9	12	41	8.5	35	74	35.7	20	53.5	4.5	91
5	39	67.5	20.7	16	52	16.2	26	103	49.4	28	57.5	6.5	109
6	38	74.3	22.1	6	65	29.5	19	127	60.4	31	63.0	11.5	94
7	33	82.0	27.5	3	78	64.5	17	145	53.6	11	71.0	24.9	64
8	22	90.0	31.7	4	90	82.0	16	159	56.2	3	81.0	9.4	45
9	14	99.0	27.3	6	102	46.0	15	171	41.3	6	92.0	32.0	41
10	11	108.0	15.1	2	113	21.2	14	181	46.7	3	104.0	7.6	30
11	9	119.0	29.1	4	124	41.4	19	189	43.9	1	116.0		33
12	3	131.0	24.4	6	134	19.7	22	197	48.6		130.0		31
13	1	146.0		1	144		20	205	37.6				22
14	1	161.0		1	154		18	212	32.8				20
15	1	178.0		1	163.5		17	219	86.2				19
16					172.5		12	226	29.0				12
17				1	180.5		7	232	63.0				8
18					188.0		5	238	46.8				5
19							2	244	7.1				2
20							1	250					1
21							1						1
Total	200			72			268			103			643
Av. st. dev.			23.0			28.2			43.2			12.7	

Table 17 Relation of Volume (Cubic Feet) to Age
Average Total and Decay Volumes, Gross Merchantable Volumes, Cull and Net Volumes
Per Tree for Pulpwood and Saw Timber, (Curved Values)
Balsam Fir in the Eastern Townships of Quebec
All Types - Basis 1821 Trees

						Pulpwood				Saw Timber			
Age (years)	No. of trees	Total volume	Decay volume	Net volume	% of decay	Gross merch. volume	Cull volume	Net volume	% of cull	Gross merch. volume	Cull volume	Net volume	% of cull
20	3	0.90	-	0.90	-	0.45	-	0.45	-	-	-	-	-
30	18	1.90	-	1.90	-	1.43	-	1.43	-	0.10	-	0.10	-
40	223	3.30	0.05	3.25	1.5	2.81	0.10	2.71	3.5	1.53	0.05	1.48	3.3
50	844	4.95	0.12	4.83	2.4	4.44	0.27	4.17	6.1	3.21	0.29	2.92	9.0
60	430	6.80	0.25	6.55	3.7	6.26	0.53	5.73	8.5	5.09	0.62	4.47	12.2
70	121	9.00	0.42	8.58	4.7	8.43	0.85	7.58	10.1	7.32	0.99	6.33	13.5
80	35	11.00	0.62	10.38	5.6	10.40	1.20	9.20	11.5	9.35	1.39	7.96	14.9
90	35	12.85	0.90	11.95	7.0	12.22	1.02	10.60	13.3	11.22	1.87	9.35	16.7
100	34	14.00	1.20	13.40	8.2	13.94	2.05	11.87	14.7	13.00	2.37	10.63	18.2
110	38	16.30	1.58	14.72	9.7	15.61	2.56	13.05	16.5	14.72	2.95	11.77	20.0
120	27	17.55	2.03	15.52	11.6	16.83	3.15	13.68	18.7	16.00	3.61	12.39	22.5
130	9	18.35	2.50	13.85	13.6	17.60	3.76	13.84	21.4	16.83	4.30	12.53	25.5
140	3	18.95	3.03	15.92	16.0	18.17	4.43	13.74	24.4	17.45	5.03	12.42	28.8
150	0	19.40	3.60	15.80	18.6	18.59	5.13	13.46	27.6	17.93	5.80	12.13	32.3
160		19.75	4.20	15.55	21.3	18.91	5.90	13.01	31.2	18.30	6.60	11.70	36.1
170	1												

Table 18 Relation of Volume (Cubic Feet) to Age, Average Total, Decay, Gross Merchantable, Cull and Net Volumes for Pulpwood and Saw Timber According to **Types**
Balsam Fir in the Eastern Townships of Quebec
Bazzania-Oxalis Type - Basis 145 Trees
(Curved Values)

				Pulpwood			Saw timber		
Age (years)	Total volume	Decay volume	Net volume	Gross merch. volume	Cull volume	Net volume	Gross merch. volume	Cull volume	Net volume
40	2.20	0.09	2.11	1.85	0.16	1.69	0.50	0.04	0.46
50	3.30	0.16	3.44	3.21	0.38	2.83	1.90	0.22	1.68
60	5.70	0.27	5.43	5.28	0.64	4.64	4.00	0.48	3.52
70	8.30	0.42	7.88	7.84	0.97	6.87	6.60	0.78	5.82
80	10.20	0.60	9.60	9.70	1.30	8.40	8.50	1.15	7.35
90	11.60	0.83	10.77	11.07	1.68	9.39	9.90	1.50	8.40
100	12.70	1.10	11.60	12.14	2.10	10.04	11.00	1.90	9.10
110	13.50	1.40	12.10	12.90	2.55	10.35	11.80	2.32	9.48
120	14.10	1.72	12.38	13.47	3.04	10.43	12.40	2.77	9.63
130	14.50	2.10	12.40	13.84	3.57	10.27	12.80	3.27	9.53
140	14.80	2.47	12.33	14.10	4.09	10.01	13.10	3.77	9.33
150	15.00	2.92	12.08	14.26	4.70	9.56	13.30	4.35	8.95

Table 19 Relation of Volume (Cubic Feet) to Age, Average Total, Decay, Gross Merchantable, Cull and Net Volumes for Pulpwood and Saw Timber According to Types
Balsam Fir in the Eastern Townships of Quebec
Dryopteris-Oxalis Type - Basis 496 Trees
(Curved Values)

Age (years)	Total volume	Decay volume	Net volume	Pulpwood: Gross merch. volume	Pulpwood: Cull volume	Pulpwood: Net volume	Saw timber: Gross merch. volume	Saw timber: Cull volume	Saw timber: Net volume
30	1.85	0.04	1.81	1.50	0.04	1.46	0.53	0.03	0.50
40	3.70	0.08	3.62	3.30	0.16	3.14	2.53	0.15	2.20
50	6.10	0.14	5.96	5.65	0.30	5.35	4.72	0.30	4.42
60	8.35	0.20	8.15	7.85	0.46	7.39	6.94	0.50	6.44
70	10.45	0.28	10.17	9.89	0.64	9.25	9.01	0.68	8.33
80	12.60	0.36	12.24	11.99	0.77	11.22	11.13	0.86	10.27
90	14.80	0.45	14.35	14.14	0.94	13.20	13.30	1.05	12.25
100	16.70	0.58	16.12	15.98	1.14	14.84	15.17	1.28	13.85
110	18.30	0.72	17.58	17.53	1.35	16.18	16.74	1.52	15.22
120	19.50	0.93	18.57	18.68	1.63	17.05	17.91	1.83	16.08
130	20.45	1.20	19.25	19.58	1.98	17.60	18.83	2.20	16.63
140	21.18	1.60	19.58	20.25	2.45	17.80	19.53	2.70	16.83
150	21.78	2.10	19.68	20.78	3.05	17.73	20.08	3.30	16.78

Table 20 Relation of Volume (Cubic Feet) to Age, Average Total, Decay, Gross Merchantable, Cull and Net Volumes for Pulpwood and Saw Timber According to Types
Balsam Fir in the Eastern Townships of Quebec
Hylocomium-Oxalis - Basis 1132 Trees
(Curved Values)

				Pulpwood			Saw timber		
Age (years)	Total volume	Decay volume	Net volume	Gross merch. volume	Cull volume	Net volume	Gross merch. volume	Cull volume	Net volume
30	1.80	0.00	1.80	1.34	0.00	1.34	0.00	0.00	0.00
40	2.95	0.04	2.91	2.46	0.03	2.43	0.86	0.04	0.82
50	4.50	0.08	4.42	3.98	0.18	3.80	2.48	0.15	2.33
60	6.60	0.28	6.32	6.05	0.55	5.50	4.65	0.58	4.07
70	8.90	0.55	8.35	8.32	1.06	7.26	7.02	1.15	5.97
80	11.03	0.87	10.16	10.42	1.62	8.60	9.22	1.77	7.45
90	12.90	1.24	11.66	12.26	2.24	10.02	11.16	2.49	8.67
100	14.45	1.70	12.95	13.80	2.95	10.85	12.80	3.55	9.25
110	15.67	2.28	13.39	14.97	3.78	11.19	14.07	4.78	9.28
120	16.67	3.00	13.67	15.54	4.75	11.19	15.14	6.20	8.94
130	17.50	3.88	13.62	16.74	5.88	10.86	16.04	7.78	8.26
140	18.25	4.85	13.40	17.46	7.10	10.36	16.84	9.55	7.29
150	18.85	6.00	12.85	18.03	8.50	9.53	17.53	11.55	5.98

Table 21 Relation of Percentage of Decay and Cull Volumes to Age
for Balsam Fir in the Eastern Townships of Quebec

	All Types			Dryopteris-oxalis			Hylocomium-oxalis			Bazzania-oxalis		
Age (years)	Decay	Cull (pulp)	Cull (saw)	Decay	Cull (pulp)	Cull (saw)	Decay	Cull (pulp)	Cull (saw)	Decay	Cull (pulp)	Cull (saw)
20	-	-	-	-	-	-	-	-	-	-	-	-
30	-	-	-	2.1	2.7	5.7	-	-	-	-	-	-
40	1.5	3.5	3.3	2.2	4.9	6.4	1.3	1.2	4.6	4.1	9.1	8.0
50	2.4	6.1	9.0	2.3	5.3	6.8	1.8	4.5	6.0	4.4	11.5	11.6
60	3.7	8.5	12.2	2.4	5.9	7.2	4.2	9.1	12.5	4.7	12.1	12.0
70	4.7	10.1	13.5	2.7	6.5	7.5	6.2	12.8	16.4	5.0	12.4	13.0
80	5.6	11.5	14.9	2.9	6.5	7.7	7.9	15.5	19.2	5.9	13.4	13.5
90	7.0	13.3	16.7	3.0	6.6	7.9	9.6	18.3	22.4	7.2	15.2	15.2
100	8.2	14.7	18.2	3.5	7.1	8.4	11.8	21.4	27.7	8.7	17.3	17.3
110	9.7	16.5	20.0	3.9	7.7	9.4	14.6	25.2	34.0	10.4	19.8	19.7
120	11.6	18.7	22.5	4.8	9.3	10.2	18.0	29.8	41.2	12.2	22.6	22.3
130	13.6	21.4	25.5	5.9	10.1	11.7	22.2	35.0	48.5	14.5	25.8	25.5
140	16.0	24.4	28.8	7.6	12.1	13.8	26.6	40.6	56.6	16.7	29.0	28.8
150	18.6	27.6	32.3	9.7	14.7	16.4	31.8	47.1	65.8	19.5	33.0	32.7

Table 22 Regression Line Equations and Tests of Significance by Co-variance Analysis of Cull Percentage in Balsam Fir in Four Forest Types in the Eastern Townships of Quebec 50 - 119 years

Forest types	Regression equation	Test of significance
Dryopteris-Oxalis	Y = 0.04 X + 2.20	Percentage of cull: F = 7.163 (Foi = 3.78) S *
Hylocomium-Oxalis	Y = 0.23 X - 6.93	Age: F = 46.52 (Foi = 6.65) S
Bazzania-Oxalis	Y = 0.10 X + 4.70	Regression coefficient: F = 5.992 (Foi = 3.78) S
Hypnum	Y = 0.22 X - 9.96	
All types	Y = 0.15 X - 2.54	

Types compound	Test of significance of adjusted means.	Test of significance of regression coefficients
H-O & Hyp	F = 3.7 (Foi = 6.64) N S *	F = 0.87 (Foi = 6.64) N S
H-O & Baz-O	F = 1.97 (Foi = 6.64) N S	F = 4.32 (Foi = 6.64) N S
H-O & Dry-O	F = 13.94 (Foi = 6.64) S	F = 15.80 (Foi = 6.64) S
Dry-O & Baz-O	F = 27.34 (Foi = 6.70) S	F = 1.27 (Foi = 6.70) N S
Dry-O & Hyp	F = 1.46 (Foi = 6.70) N S	F = 2.86 (Foi = 6.70) N S
Baz-O & Hyp	F = 4.01 (Foi = 6.81) N S	F = 0.81 (Foi = 6.80) N S

* S: significant
* N S: not significant

Table 23 Relation of Volume (Cubic Feet) to Diameter in Balsam Fir in the Eastern Townships of Quebec
Hylocomium-Oxalis Type - Basis 1133 Trees
(Curved Values)

						Pulpwood				Saw timber			
Diameter (inches)	No. of trees	Total volume	Decay volume	Net volume	% of decay volume	Gross merch. volume	Cull volume	Net volume	% of cull volume	Gross merch. volume	Cull volume	Net volume	% of cull volume
3.0	38	1.10	0.01	1.09	0.9	0.58	0.04	0.54	7.0				
4.0	218	1.48	0.05	1.43	3.4	0.96	0.07	0.89	7.3				
5.0	257	2.50	0.10	2.40	4.0	1.98	0.15	1.83	7.6	0.25			
6.0	197	4.30	0.18	4.12	4.2	3.73	0.30	3.43	8.0	2.25	0.25	2.00	11.1
7.0	139	6.50	0.28	6.22	4.3	5.97	0.50	5.47	8.4	4.84	0.56	4.28	11.6
8.0	117	8.95	0.42	8.53	4.7	8.39	0.72	7.67	8.6	7.53	0.92	6.61	12.2
9.0	79	11.55	0.58	10.97	5.0	10.96	1.01	9.95	9.2	10.22	1.30	8.92	12.7
10.0	47	14.50	0.86	13.64	5.9	13.87	1.51	12.36	10.9	13.18	1.96	11.22	14.9
11.0	21	17.65	1.25	16.40	7.1	16.97	2.33	14.64	13.7	16.29	2.87	13.42	17.6
12.0	9	21.20	2.12	19.08	10.0	20.44	3.84	16.60	18.8	19.77	4.49	15.28	22.7
13.0	6	25.10	3.70	21.60	14.7	24.25	6.33	17.92	26.1	23.55	7.50	16.05	31.8
14.0	2	29.30	6.00	23.30	20.5	28.33	9.70	18.73	34.2	27.58	12.45	15.13	45.1
15.0	1	34.30	8.62	25.68	25.1	33.18	13.57	19.61	40.9	32.30	19.92	12.38	61.7
16.0	1	39.50	11.80	27.70	29.9	38.20	18.70	19.50	48.9	37.14	29.30	7.84	78.9
17.0	1	45.00	15.60	29.40	34.7	43.48	25.10	18.38	57.7	42.20	39.80	2.40	94.3

Table 24 Relation of Volume (Cubic Feet) to Diameter in Balsam Fir in the Eastern Townships of Quebec
Dryopteris-Oxalis Type - Basis 496 Trees
(Curved Values)

						Pulpwood				Saw timber			
Diameter (inches)	No. of trees	Total volume	Decay volume	Net volume	% of decay volume	Gross merch. volume	Cull volume	Net volume	% of cull volume	Gross merch. volume	Cull volume	Net volume	% of cull volume
3.0	12	0.40		0.40		0.03		0.03					
4.0	58	1.30	0.02	1.28	1.5	0.93	0.03	0.90	3.1				
5.0	61	2.50	0.05	2.45	2.0	2.12	0.07	2.05	3.4	0.98	0.04	0.94	4.0
6.0	85	4.00	0.09	3.91	2.2	3.61	0.13	3.48	3.6	2.60	0.11	2.49	4.1
7.0	76	5.90	0.14	5.76	2.4	5.47	0.21	5.26	3.8	4.58	0.19	4.39	4.2
8.0	76	8.10	0.19	7.91	2.4	7.62	0.30	7.32	4.0	6.82	0.31	6.51	4.5
9.0	44	10.70	0.26	10.44	2.4	10.16	0.44	9.72	4.3	9.42	0.45	8.9[illegible]	4.8
10.0	33	13.60	0.33	13.27	2.4	13.00	0.59	12.41	4.5	12.28	0.60	11.68	5.3
11.0	26	16.60	0.40	16.20	2.4	15.93	0.81	15.12	5.1	15.22	0.87	14.35	5.7
12.0	11	19.80	0.55	19.25	2.8	19.04	1.16	17.88	6.1	18.33	1.30	17.03	7.1
13.0	8	23.20	0.70	22.50	3.0	22.35	1.58	20.77	7.1	21.62	1.78	19.84	8.2
14.0	5	27.20	0.95	26.25	3.5	26.24	2.15	24.09	8.1	25.49	2.40	23.09	9.4
15.0													
16.0													
17.0	1												