Investigation of Rate of Growth¹

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Until comparatively recently, the feeling of security in our supposedly inexhaustible timber resources induced but little concern relative to problems other than that of fire protection. But with the bursting of this bubble, coupled with an ever-increasing demand upon the remaining supply of merchantable material, the necessity for a comprehensive stock-taking became apparent. The limitation of our wood-capital is now becoming evident, and this is creating concern relative to its accretion and reproduction; sooner or later too, these must form the basis of forest management. Finally, present status determined, the forester must direct his attention to the solution and application of methods of treatment required to produce optimum rate of growth.

Interest in the question of accretion or rate of growth is becoming general among timberland owners from coast to coast. Without definite information on rate of growth and mortality, there is no means of determining when a virgin stand is ready for the axe, when it has ceased growing at a profitable rate. Again, there are second growth stands of spruce, large enough for pulpwood, but growing at such a rapid rate, with little or no mortality, that it would be un-sound business practice to cut them immediately.

But at present, the operator is perhaps more vitally concerned about the accretion on his cut-over lands. He wants to know how soon the material, too small when he logged, will yield a profitable return; whether the desirable species are likely to maintain their position in the association; and the relative rate of growth of the various members of the association. In the event that working plans call for removal of the stand in two operations, information appertaining to the increment will be essential in controlling the first cut. Any management plan demands such a statement to prevent overcutting.

The spruce budworm and similar insect-attacks have given cause for concern. It is vitally important to know how the surviving stand recovers from such attacks in order to estimate the future crop.

After a careful study of methods that have been employed in gathering data for an investigation of this nature, it would seem that the line-plot system, aided by a small series of permanent sample plots, is the one most suitable. This method, with local variations, is in use in Europe and United States. By gridironing the area under consideration with sufficient small, single-examination plots, regularly and mechanically distributed, the resultant data will be truly representative, within narrow limits, of the average conditions; and it will also be possible to estimate from time to time, as the survey progresses, the number of such samples that will probably be required to furnish average results within specified limit of error. The line-plot survey will furnish all information necessary for an immediate estimate of rate of growth, if one is satisfied to accept an approximation of mortality.

For such an investigation, a complete stand table, including saplings, is necessary, because trees from the lower groups are continually entering the groups above, and must be accounted for in calculation of increment. Such inclusion does not interfere with arbitrary grouping into merchantable and unmerchantable sizes.

Lacking satisfactory yield tables, dependence must be placed on increment borings for determination of growth. While information from borings covering long periods or the entire life history of the various diameter classes, is interesting, it is simply the growth of the comparatively recent past that may be used in predicting the increment for the future; and it is likewise for a short period only that predictions are justified. It is necessary, therefore, to make borings to cover but ten or at most twenty years. If, during that interval, there has been a period of wide-spread suppression or release throughout the stand, measurements for such period should be separated from those of normal growth. Sufficient borings should be made in each diameter class to ensure average representation, which may be determined by means of a dispersion table.

In taking data for preparation of the stand table, tally must be made of the mortality, although this information can only be an approximation. However, by dating the mortality from some such influencing factor as the last cut, insect attack, serious windfall, and by making a study of the progress of decay as registered in the appearance of wood and bark, an estimate sufficiently accurate for a preliminary prediction may be made. Cognizance must be taken of the fact that such influencing factors will probably cause abnormality of mortality, so that for more reliable information dependence must be placed on records from permanent sample plots covering a period of years.

Data must be taken for the preparation of a diameter-height curve for each species and each type. It will also be desirable to collect data for a bark-thickness curve, although the form-class volume tables issued by the Dominion Forest Service are based on general bark thickness throughout the range of the species in Canada; and if the local bark thickness does not vary materially, no adjustment will be required. Measurements must be taken to determine average form-class should form-class tables be desired.

Suitable volume tables must be obtained embracing all diameter-classes, and showing contents in total cubic volume, and probably in some merchantable unit as well. Finally, a stand table of the reproduction is essential. This table should include a tally, by numbers and height-classes, of all material below the one-inch diameter class, material which cannot conveniently be included in the general stand table.

Contrary to general opinion, the work of compilation is not less than that of collecting the data.

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A diameter-height curve for each species and type is necessary; and, if form-class volume tables are to be used, the average form-class can be determined.

Inasmuch as volume tables are usually prepared to read in full-inch diameter and ten-foot height classes, and the increment is seldom represented by an even diameter or height-class, provision must be made for interpolated reading of the volume tables. The regular procedure is to proportion mathematically the difference between adjacent diameter-classes and adjacent height-classes, a somewhat lengthy method. In the *Journal of Forestry*, May, 1926, page 547, W. H. Meyer, of Northeastern Forest Experiment Station, has described in some detail the use of double logarithmic paper for the purpose of reading interpolated values. The method also makes it possible to read multiple values directly. Mr. Mulloy has cited the outstanding possibilities of this use of double logarithmic paper in the December issue of the *Chronicle*.

An analysis of the bark thickness and borings is the next logical stage. Should the bark thickness be found to correspond closely with that used in the volume tables, no adjustment is necessary. Otherwise, the correction must be made to satisfy local requirements. While there will undoubtedly be considerable variation in the growth rate between individual trees, irregularity will generally iron out when sufficient borings have been taken. It is sometimes found that the difference or rate of growth between diameter-classes is insignificant, and therefore the one growth figure applies to every diameter-class. But, in general, this condition does not exist, a curve rising towards the middle diameter-classes being obtained. But if through shortage or irregularity of data, difficulty is experienced in obtaining a satisfactory curve, recourse may be had to the moving average, principle by two, three or more diameter-classes; e.g., by averaging classes 1, 2, and 3; classes 2, 3, and 4; classes 3, 4, and 5, and so on. Another method is to group two or three diameter-classes with the idea of accepting a single rate of growth for each class in this particular group. However, before undertaking any grouping method, all the material should be rigidly examined by means of a dispersion table for abnormalities, rejecting any that may be found.

The preparation of stand tables is next in order. All stand tables should be on a per acre basis, and each type and species considered separately. Reproduction tables for material less than 0.6" D.B.H. need show only the numbers of seedlings classified by one-foot height-classes.

The main stand table should show the number of trees and total cubic volume for each diameter-class, also for all diameter-classes. In computing the volume, interpolation for heights should be made. No interpolation will be called for in the diameter-classes of the present stand. Any arbitrary division into merchantable and unmerchantable classes in any desired unit, may be made in addition to the above computation of total cubic volume. A similar table should be made for the dead material, and this will complete the compilation of data related to the present status.

To adjust the present stand table to represent conditions ten years ago, and predicted conditions ten years hence, neglecting mortality for the moment, it is only necessary to subtract and add, respectively, the growth measurements for each diameter-class.

compute volumes on the basis of fractional inches by interpolation. Adjustment of numbers of trees will be necessary to accommodate those that entered the one-inch diameter-class during the past decade, and those that may be expected to enter during the coming decade. Subtracting the volume of ten years ago from that of today, the gross increment will be obtained. If, then, the material that has died in the interim be subtracted, the result will be the net increment. In like manner, the predicted gross and net increment for the coming decade may be deduced.

There has been much criticism of methods of presenting rate of growth. In itself, increment per cent is meaningless. For example, accretion may be ten per cent per annum, yet the stand may contain less than a cord per acre. To the average operator, increment in cords or board feet per acre is perhaps the most satisfactory single unit. But here again the answer is indefinite. A stand may produce half a cord per acre per year; but, on a stand of fifty cords, this increment is only one per cent, and therefore not profitable. Nor does the cord unit take into account volume of the lower diameter classes, often no mean potential value. The deduction then is that the growth should be recorded by some double unit as cubic feet-per cent, or cords-per cent. Total cubic volume should always be shown. Merchantable volume in any unit may also be shown if desired.

There has too been considerable controversy as to the proper method of computing per cent. Sven Petrini, Stockholm, discusses the question at some length. He advocates a formula approximately compound interest. However, for investigations of this nature, Pressler's formula is probably sufficiently accurate.

The value of permanent sample plots in conjunction with a line-plot survey, as a means of studying the problem more intensively, with particular reference to mortality, should not be overlooked, and whenever possible, a small series of these should be established. Having made a line-plot survey, and having determined the average stand conditions, the locating of permanent sample plots in areas representative of average conditions may be done by selection from individual line-plots. In general, permanent plots should be not less than one acre each, with from five to ten plots in every series.

All plots should be carefully surveyed, recorded, and mapped. Every tree over 0.5 inches D.B.H. should be tagged and its location shown on a sketch map. The importance of exercising care in making these records cannot be emphasized too strongly. Since sample plots represent such a small percentage of the complete tract, errors become greatly magnified. A single tree incorrectly included, rejected, or measured, may represent an amount equal or greater than the entire increment.

The data collected by permanent sample plots are practically the same as those by line-plot survey, except that increment borings are not required in the former, since growth is determined by comparison of total growth as found at intervals of five or ten years. Methods of compiling and analyzing the data are somewhat at variance with line-plot methods, but unfortunately time does not permit a discussion of them.