ESTIMATION OF STAND VALUE-INCREMENT AND INHERENT VARIABLES

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A b s t r a c t

For the achievement of improved bases for decision-making in regard to regeneration and other cuts, methods have been studied for estimation of the value increment of stands formed by Scots pine and Norway spruce. Since in general information is required in regard to volume increment, stand volume and value simultaneously, the assessment of these factors has also been discussed. The main aim has been that of developing procedures for rapid estimation of these characteristics, but methods utilizing stand tables have also been subjected to scrutiny.

The present paper provides examples of regression functions developed for the purpose from rather extensive material in the southern half of Finland. For key tasks, functions with a comparatively high degree of determination could be found. Estimations of the stand volume and value require only measurement of the basal area, mean diameter and mean height, and information on average timber prices. For the estimation of value increment, the volume increment percentage is determined first. The application of price coefficients then leads to the value increment.

Practical application of the results can be facilitated by the preparation of tables and graphs. Further tests will indicate the mutual importance of different approaches.

1. Introduction

One of the major problems that arise in forest management is concerned with the relative maturity of different stands. With a view to the economic aspects involved, the estimation of stand value increment has been studied in Finland in recent years. An account is given below of the methods now available for the task.

A few characteristic features are to be observed in this connection. Simultaneously with the value increment, information is often required on the stand value; this also applies to the stand volume and the volume increment. Consequently, it seems desirable to discuss the estimation of these in the same process.

Secondly, when methods are in progress of development, not the past, but the coming increment is needed; the question at issue relates to the future performance of stands. Furthermore, in view of the large number of various types of stands, a rapid procedure is necessary, but also more detailed and accurate methods are required.

2. Stand volume

A method commonly applied for volume assessment is utilization of the stand table (i.e., the table indicating the stem numbers by DBH classes). Sample tree measurements are usually the prerequisite for unit volumes. The precision of the method may be expressed by a standard error of estimate of about ± 3 %.

The utilization of BITTERLICH's (1948) angle count method offers a simple means for rapid estimation of the basal area (G). This, and the mean height (H = height of the median basal area tree), as independent variables enable determination of the growing stock volume (V) from the tables of NYYSSÖNEN (1954). The following functions may also be utilized; they indicate the form height F_H which needs multiplication by G to arrive at V. The functions are valid approximately for the height range of 8 to 26 metres.

$$\text{Pine} \quad F_H = 0.4116 - 0.04275\, H^{1\frac{1}{2}} + 0.6359\, H$$

$$\text{Spruce} \quad F_H = 1.3187 + 0.00099\, H^2 + 0.3978\, H$$

$$\text{Birch} \quad F_H = 0.4907 - 0.00137\, H^2 + 0.4556\, H$$

The standard deviation of the dependent variable about the functions does not exceed ± 5 %. In practice, however, the standard error of estimate in application of the method may almost amount to ± 10 %.

3. Stand value

For calculation of stand value, knowledge is necessary of the unit values of stems, or, in the case of a direct standwise estimation, of the stands. Under Finnish conditions, account needs to be paid to the difference in stumpage values of saw timber and pulpwood; the former is clearly higher than the latter.

In another paper, a study was made of the timber assortment relationships and stumpage values of Scots pine and Norway spruce (LAASASENAHO and SEVOLA 1971). The tree data - 1291 pine and 744 spruce stems – were compiled from survey tracts of the national forest inventory. The aim of the computer programs utilized was that of finding the combination of saw timber and pulpwood proportions which maximizes the stem value. In the best functions, the standard errors of some dependent variables, with the assumption of given prices of timber assortments and of saw-logs of different sizes, were:

Variable	Pine	Spruce
Logarithm of stem volume	± 4.1 %	± 3.7 %
Logarithm of stem value	± 8.3	± 6.7
Logarithm of saw-timber volume	±12.2	±11.3

If the stand table and the results of the inherent sample tree measurements are available, the stand value can be computed by application of the results obtained in the above-mentioned study. Either tree unit values or the calculation of timber assortments with the subsequent pricing can be applied. The standard error can be estimated to be in the class of ± 5 %.

In the more direct estimation of stand values, the problem is that of finding the stand unit values, i.e. the price of an average cubic metre of timber. With the tree functions of LAASASENAHO and SEVOLA (1971) as a starting point, the aim was that of explaining the dependence of the stand unit value upon the mean diameter D and the height H, the former being diameter of the median basal area tree. At this stage, the material mainly comprised the permanent sample plots of the Finnish Forest Research Institute. The stumpage value of pine stands was calculated on 520 occasions, and that of spruce stands on 292. From these data calculations were made of the functions indicating stand unit values on the given price relationships. For instance, for the average relationship (saw-timber price in pine 1.95, and spruce 1.65 times that of pulpwood of a given unit of measure) and assuming for saw-timber the stumpage of 1 Finnish mark (Fmk) per cubic foot, the functions of stand unit values are as follows:

Pine:

$$\ln(\text{Fmk/m}^3) = 58.63830 - 12.43702 \ln(D^2H) + 163.10515/DH - 0.34102\ D^{1.5} - 155.08604/D + 1.46844\ D^{1.2} + 13.47104 \ln H$$

Spruce:

$$\ln(\text{Fmk/m}^3) = 2.34024 + 0.002065\ DH - 0.005824\ D^{1.5} - .51046 \ln(H/D) + .002614\ H^{1.5}$$

The multiple correlation coefficient (R) equals 0.997 for pine, and 0.992 for spruce.

Multiplication of the stand unit value by the stand volume results in the stand value. The standard error of estimate in this standwise estimation is about ± 10 %.

4. Volume increment

To date, the commonest methods applied in Finland for estimation of the increment of trees and stands are those presented by ILVESSALO (1948): the present annual growth is estimated as a mean of the last period of 5 or 10 years. Increment borings and height growth are utilized in the most accurate procedure, and tables have been constructed on the basis of extensive material for estimation of the increment percentage for given stand characteristics.

The national forest inventory applies at present techniques in which the growth is calculated from the difference between the volume now, and that 5 years ago (KUUSELA and SALMINEN 1969). In addition, studies have been made for explanation of the growth through regression functions based upon different materials (see KUUSELA and KILKKI 1963, VUOKILA 1965).

None of the results obtained earlier is adequate for the present purpose, partly by reason of the forecast of the coming 5-year period, and partly as a consequence of the variables applied hitherto. Accordingly, some new functions were computed for both tree and stand increment.

In regard to tree functions, an attempt was made to estimate the future d (in 5 years and including bark) by first computing functions for radial increment (p_d), expressed as a compound interest percentage. The data related to 559 pine and 497 spruce trees from various types of stands. In what follows below, i_r equals the radial increment of the previous period of 5 years; the other symbols are d and h, as before.

Pine:

$$\ln p_d = 1.52762 + 0.75608 \ln i_r - 0.74611 \ln d - 0.14548 \ln h$$

Dependent variable: mean = 0.1820, original standard deviation = 0.48172, st. dev. about the function = 0.02037.
R equals 0.80.

Spruce:

$$\ln p_d = 1.91613 + 0.80131 \ln i_r - 0.82507 \ln d - 0.20893 \ln h$$

Dependent variable: mean = 0.35837, original st. dev. = 0.73657, st. dev. about the function = 0.03304. R is equal with 0.90.

The functions computed without i_r, but including some other variables, are clearly inferior.

The functions for estimation of the future h were calculated in a way corresponding to those for the estimation of d (LAURILA 1972). For instance, the height increment percentage can be computed as follows:

$$\lg p_h = 1.76346 + 0.54036 \lg d - 0.63599 (\lg h)^{1.6} - 0.15776 (\lg H_{dom})^{2.3} + 0.16082 \lg G - 0.78171 \lg T$$

Here, T means stand age, and H_{dom} dominant height. R equals 0.91.

Utilization of the above-mentioned functions enables assessment of the future d and h, along with the future volume from sample trees selected to represent the growing stock. The volume increment can be found as the difference between the future and present volumes.

The main data for the <u>stand functions</u> of pine were those measured by NYYSSÖNEN (1954a) and VUOKILA (1965), with some later additions by the author. In total, 347 stands were utilized. The following function indicates the dependence of the volume increment percentage (p_v), compound rate, on some stand variables in the average and better pine sites:

$$\ln p_v \quad -0.98778 - 0.23676 (\ln T)^{1.5} + 1.44852\, V^{\frac{1}{V^{0.3}}} - 0.0001586 (\ln D)^6$$

Dependent variable: mean = 1.33612, original st. dev. = 0.50961, st. dev. about the function = 0.02736. R equals 0.95.

In regard to spruce, as yet the function including D has not been developed; from the aspect of value increment, this is a very important variable. However, the following function indicates the volume increment rate on common spruce sites:

$$\ln p_V = 9.20296 - 1.53946\,(\ln T) - 0.46092\,(\ln V) + 0.002819\,(\ln T \ln V)^2 - 0.00000123 \ln T\, V^2$$

Here, R equals 0.96.

5. Value increment

For trees, the value increment can be calculated as a difference between the present and future values. The procedures for estimation of the future d and h have been outlined in Chapter 4 above. The tree values can be based either upon tree assortments, or upon direct application of the paper by LAASASENAHO and SEVOLA (1971), as in the detailed stand-value estimation given in Chapter 3.

In direct standwise estimation, a different procedure is required for determination of the value increment. The first step is computation of the price coefficients indicating the relationship between the growth rate of value and volume. The data were formed by the permanent sample plots; the numbers of stands were 95 pine, and 89 spruce. For instance, with the mean diameter as the independent variable, the function of the price coefficient (k_p) for an average relationship in pine stands (price of saw timber 1.95 times that of pulpwood) is as follows:

$$\ln(k_p - 1) = -15.58291 + 8.54651\, D^{0.2} - 0.24455\, D^{4.1}/100000$$

Dependent variable (k_p) here means the price coefficient of the future period as a function of the present D. Mean = 0.80833, original st. dev. = 0.36772, st. dev. about the function 0.037727. R equals 0.84.

Multiplication of the volume increment percentage by the price coefficient results in the value increment percentage. The value increment can be assessed in absolute terms by means of the stand value.

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