TREE GRADING WITHOUT THE USE OF CHECK TREES

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INTRODUCTION

A first step in any tree-improvement program is to locate and evaluate individuals to be included in an orchard or breeding system. In forestry in the Southeast, first-generation selections from wild stands or plantations still comprise the majority of selected trees, although second-generation selections are gradually becoming more numerous.

The problem of locating suitable stands from which select candidates can be found is one with which we are all faced. In the Western Gulf Tree Improvement Region many forest landowners have practiced individual tree-selection silviculture for many years. Thus the ideal evenaged dense pure pine stands so desirable for individual superior-tree selections are scarce. The problem of selecting representative check trees in partly cut stands can be quite difficult. Selecting from such stands increases the chance of rejection of some possibly excellent trees, or conversely, the inclusion of some poor trees.

For quite some time the Western Gulf Forest Tree Improvement Program has been interested in the technique used by Goddard and Strickland at the University of Florida for evaluating trees on a common scale. After over a year of grading trees, enough data has been accumulated to apply that technique. 2/

The objective of this paper is to apply the technique to WGFTIP check-tree data in order to develop specific regression formulas to be used for evaluating trees without relying on a 5-check-tree system.

GRADING STANDARDS AT THE UNIVERSITY OF FLORIDA

In developing their grading standards at the University of Florida, Goddard and Strickland have measured a large number of dominant and co-dominant check trees from throughout Florida and South Georgia. They have applied multiple regressions to these data, plotting volume over site index, tree age, and crown size. Thus they have developed formulae for measuring a candidate tree against the average value of check trees growing under similar conditions. With the resulting equations, expected tree volumes can be calculated for given crown measurements, site indexes,

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2/ Goddard, R.E. and R.K. Strickland. 1969. Manual of procedures used in the University of Florida Cooperative Forest Genetic Research Program. Limited Distribution.

and ages. Volume of a candidate tree is then compared to the expected volume of an average tree growing under similar conditions. Dividing by the standard error of regression, they get "Growth-Efficiency Units," which they use to evaluate their trees.

WGFTIP GRADING STANDARDS

As in several other grading systems, the select tree candidate is compared to five check trees growing on the same site. Checks are chosen mostly from the best dominants around the select tree; however, some codominants may also be included. The candidate tree is compared to the average of the five check trees, with percent of superiority weighted in various categories. The form characteristics of straightness, pruning, branch angle, and branch diameter are evaluated along with the volume. In general, volume is weighted more heavily than in several other systems (van Buijtenen, 1969). Growth efficiency is also evaluated by "Crown Index," which is the ratio of crown diameter to DBH, and by "Dry Matter Index," which is an adaptation of the work on growth efficiency by Brown and Goddard (1961) but which includes specific gravity in recognition of its effect on actual fiber production. Specific gravity is separately rated as a quality characteristic.

THE APPLICATION OF MULTIPLE REGRESSION TO WGFTIP DATA

The WGFTIP select tree candidates have been measured against the best dominants and codominants around them. Thus the technique used by Goddard and Strickland could be applied to WGFTIP tree-grading data. The five check trees were used to estimate site index (Schumacher and Coile, 1960) at each select tree site. All the loblolly check trees measured throughout the WGFTIP region were pooled. Data were segregated by site index, crown radius, crown length, and tree age. Multiple regression formulae were computed (Snedecor and Cochran, 1967) using volume as the dependent variable. Volumes were derived from tables developed by the Texas Forest Service.

Errors due to genetic variation in height among stands are still confounded by site differences in the regression formulae because site index is still estimated from trees measured in each stand. Thus genetic differences in height due to stands are still considered as environmental error. However, other differences are averaged over all sampled check trees, which should reduce bias due to estimates based on a non-representative, five-check-tree sample.

RESULTS AND DISCUSSION

Results

Multiple regressions were developed for all data and then segregated by age classes and site indexes, as shown in Table 1. The regression formulae developed are based solely on the accumulated sample check trees used in the Western Gulf Forest Tree Improvement Program. They represent the best trees the sampled stands have produced under given conditions of site index, age, and crown size.

Table 1.--Regression equations for volume as dependent variable against age, crown radius, site index, crown length as independent variables for loblolly pine from Arkansas, Louisiana, Mississippi, Oklahoma, and Texas

Age	Site Index	No. Trees	Equation	R^2	Standard Deviation from Predicted Volume
25-50	70-95	147	Vol.= -112.93 + 1.361 (Age) + 2.208 (Crown Radius) + 0.60 (Site Index) + 0.583 (Crown Length)	.652	$\pm$ 10.33 cu. ft.
	96-124	171	Vol.= -157.75 + 1.553 (Age) + 2.683 (Crown Radius) + 1.155 (Site Index)	.619	$\pm$ 13.38 cu. ft.
51-80	70-95 (78-95) actual	158	Vol.= -89.19 + 0.687 (Age) + 2.548 (Crown Radius) + 0.729 (Site Index) + 0.368 (Crown Length)	.458	$\pm$ 11.15 cu. ft.
	96-124 (96-110) actual	99	Vol.= -241.85 + 1.514 (Age) + 3.022 (Crown Radius) + 1.648 (Site Index) + 0.594 (Crown Length)	.666	$\pm$ 13.58 cu. ft.
Total of all categories					
25-80	70-124	575	Vol.= -135.37 + 1.034 (Age) + 2.739 (Crown Radius) + 0.985 (Site Index) + 0.419 (Crown Length)	.699	$\pm$ 12.68 cu. ft.

If the appropriate formula is used, the values derived from these regression equations will indicate the expected volume of average check trees under given values of site index, age, and crown size. Age and average height of the stand must be determined in the field.

Reliability

The R^2 values in Table 1 indicate how much variation is explained by the regression formulae. In the case of trees 25 to 50 years old growing on both high and low sites, the R^2 values of .652 and .619 respectively are fairly high and predictions are reasonably reliable. So, too, in the case of trees 51-80 years old on high sites and for the formula for all categories. However the lower R^2 values of .458 for trees 51-80 years old on low sites (70-95) indicate that this regression formula should be regarded as not too precise.

Application

The check trees are measured for height and age to determine the height superiority of the selected tree and to estimate the site index. Form values such as straightness, pruning, branch angle, and branch diameter are in comparison to the stand average. In order to use the regression technique, the present WGFTIP standards could be adapted as follows:

1. Scores for height and form (straightness, pruning, branch angle, and branch diameter) would require no change in grading methods except that the selected trees would be evaluated against the stand average rather than against five check trees.

2. "Crown Index" would be eliminated because adjustments have been made in the regression formulae for differences in crown size. "Dry Matter Index" would have to be re-calculated, using the "growth-efficiency unit" in the calculation. At present

$$\text{Dry-matter index} = \frac{\text{10-year basal-area increase x specific gravity}}{\text{crown length x crown diameter.}}$$

Again, by regression, adjustments have been made for differences in crown size. The denominator is no longer necessary. A suggested change would be:

$$\text{Dry-matter index} = \frac{\text{10-year basal-area increase x specific gravity x}}{\text{"growth-efficiency units"}}$$

With these adjustments, the problem remaining is what weights to place on the various scores. Presently WGFTIP weights form qualities 1/3, volume qualities 1/3, and efficiency 1/3 of a total score potential close to 60 points. Rarely if ever will this 60-point potential be achieved, as most accepted trees score between 25 and 35 points.

To equalize "growth efficiency," "dry-matter index" and form qualities, each should be worth a maximum of approximately 20 points. Maximum values of "growth efficiency" will be between 2.5 and 3 standard units. Assigned values as follows will accomplish equalization:

Growth-efficiency units	0	1	1.5	2	2.5	3
Assigned values	0	4	8	12	16	20

Dry-matter index values can be weighted by multiplying by a factor of 4, as these maximum values approximate 5.

CONCLUSIONS

In practice, the best application for WGFTIP may be a compromise. In tight stands, the original grading method is probably as good as or better than the regression method. In partly cut variable stands, the regression method is probably best. The low R^2 value (.458) for regressions of older trees on lower sites indicates that a good deal of error is still to be expected in this category. As more trees are graded, site-class and age-class categories can be more restrictive, which should help to reduce error variance and increase the precision of the regression formulae.

The most promising application of the regression method is in stands of low density and high variability, where selection of check trees is difficult. In these stands, the regression formula provides a means of evaluating a candidate against a calculated standard. This standard should be reasonably consistent, as it is based on a large number of trees.

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