RATING SITE QUALITY IN MICHIGAN WHITE PINE PLANTATIONS WITH FIVE-YEAR INTERCEPT MEASUREMENTS

Thesis for the Degree of M. S.
MICHIGAN STATE UNIVERSITY
William E. Miller

1961


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by

William E. Miller

AN ABSTRACT

Submitted to the College of Agriculture
Michigan State University of Agriculture and
Applied Science in partial fulfillment of
the requirements for the degree of

MASTER OF SCIENCE

Department of Forestry

1961

Approved U. V. Rudolph

ABSTRACT

Productive capacity or quality of the site is one of the variables determining the yield of wood from forest stands. To forecast yields, site quality must be quantitatively expressed. The only site quality rating system available for white pine in the Lake region is standard site index. This system has several drawbacks chief of which is the laborious direct measurement of total age and total height of sample trees.

Site quality of white pine plantings can be more rapidly rated with any of three regression equations developed in this thesis. The main independent variable in these equations is the 5-year span of height growth above breast height. This span, termed the 5-year intercept, is closely correlated with overall height growth rate. One regression supplies standard site-index estimates from 5-year intercept measurements alone. A second supplies slightly more accurate estimates if age above breast height is also known.

A third regression predicts height growth of white pine plantings at any future age from 5-year intercept measurements. Height estimated from this equation at 40 years above breast height is suggested as a new system of site quality rating in white pine plantings. This system supplies site quality ratings from 5-year intercept measurements alone.

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ACKNOWLEDGEMENTS

My indebtedness for help in conceiving and seeing this thesis through extends to many. In the early planning stages, V. J. Rudolph and C. H. Schallau gave me much good counsel, and J. L. Arend suggested the stem analysis approach which proved so fruitful. Those who kindly supplied me with locations of white pine stands were J. L. Arend, R. E. Lohrey, R. N. Stone, C. H. Schallau, V. J. Rudolph, H. J. Heikkenen, R. L. Talerico, D. B. Crockett, and R. D. Derks. Concerning data analysis and interpretation of statistical results, Miss Barbara J. Thompson, D. H. Urie, R. G. Buchman, and J. W. Wright gave me much valuable assistance. Miss Sonia A. Emilson and Miss Barbara J. Thompson loaned their skill in drafting, and Miss Emilson painstakingly typed and helped edit the manuscript. For reviewing the manuscript and making constructive suggestions, my thanks go to V. J. Rudolph, T. E. Avery, L. M. James, J. H. Beaman, and J. M. Hughes. My major professor, V. J. Rudolph, provided kind and understanding guidance throughout my academic career at Michigan State University. Without the nod from administrative officers of the Lake States Forest Experiment Station, which employs me, undertaking this thesis would not have been feasible. Finally, I am grateful for the forebearance of my family and the patience of Eric and Karla, my older children, who found ways to amuse themselves in white pine forests while I measured many of the trees.

TABLE OF CONTENTS

LIST OF FIGURES

RATING SITE QUALITY IN MICHIGAN WHITE PINE PLANTATIONS WITH FIVE-YEAR INTERCEPT MEASUREMENTS

REVIEW OF SITE RATING. Forecasting wood yields expected from stands of trees is a basic operation in forest management. Yield is essentially a function of stand density, stand age, and productive capacity or quality of the site. Productive capacity or site quality is commonly classified or rated by site index. The variables of stand density and stand age are not hard to estimate; they may already be available from planting records. The variable of site index may be harder to estimate if it has to be done directly. Site index is the average height of dominant and codominant trees at a standard reference age which for most eastern species is 50 years. It can be conceived as rate of height growth. Because site quality affects yield, site quality ratings may be used to appraise forestry practice investment opportunities (Stoltenberg, 1959; Marty and Allison, 1960). Although highly desired, rapid methods for rating site quality are not available for all commercial timber species.

Several procedures have been put forward which enable site index to be approximated for tree species not present on the site. These procedures rely on previously established correlations of site indexes with soil characteristics (Coile, 1952) or indicator plants (Kittredge, 1938). However, site classification for most species requires that tree measurements be made in the stand for which a site rating is desired.

Very likely conventional yield tables and site rating will one day be made obsolete by changing consumer demands and progress in the

science of forestry itself (Woods, 1961). But in the long interim during which present day forest management will prevail, foresters will be preoccupied with site quality estimation.

A detailed discussion of site classification can be found in Spurr (1952).

THE GROWTH INTERCEPT IDEA IN SITE RATING. In stands already present, site index and related measures of site quality may be estimated indirectly from a small span of height increment of known age. Height growth for the first few years above breast height is the span used, because, by the time trees are breast high, they are growing at a rate which accurately represents true site potential. This span of growth is termed the "intercept." Wakeley (1954) suggested using the sum of the 5 years' growth beginning with the year breast height is reached as a measure of site quality in southern pines. A little later, Wakeley and Marrero (1958) said the idea had proved successful in southern pine plantings, but they did not indicate the exact procedure.

Warrack and Fraser (1955) were the first to publish an exact procedure for estimating site index from growth intercepts. Their equations were developed in British Columbia for second-growth Douglas fir (Pseudotsuga menziesii (Mirb.) Franc.) stands. One equation used a 5- and the other a 3-year intercept. Next, Ferree et al. (1958) developed a procedure for using 5-year intercepts to classify sites in red pine (Pinus resinosa Ait.) plantings in New York. However, Day et al. (1958) gave a more practical procedure for red pine plantings in Michigan based on a regression of standard site index on 5-year intercept. Ferree et al. (1958) mentioned that the intercept method worked

satisfactorily on white pine (Pinus strobus L.), Scotch pine (Pinus sylvestris L.), and Norway spruce (Picea abies (L.) Karst.), but they said nothing about how to use it with these species.

Up to now, the intercept of 5 years has dominated in the application of this approach. Lesser intercepts could undoubtedly be used with little or no sacrifice of accuracy, and they would be easier still to measure in practice. Warrack and Fraser's (1955) 3-year intercept estimated standard site index as accurately as their 5-year one did. Further development of this handy method might profitably include more work on the lesser intercepts.

NEED FOR BETTER METHOD OF RATING WHITE PINE SITE QUALITY. The anamorphic site index curves given by Gevorkiantz (1957) are commonly used to estimate site quality of white pine stands in the Lake States region. Using these curves has certain drawbacks, chief of which are:

1. The site-index estimate is obtained by laborious direct measurement of total height and total age of sample trees.
2. Estimates can not be made in stands younger than 20 years.
3. No statistical error term accompanies site-index estimates.
4. The curves were developed in natural stands and their use in plantings has not been validated.

The above drawbacks are overcome as follows by the intercept method of site rating:

1. Only one type of measurement need be made, namely the intercept. This is easier than measuring total height and total age of trees. However, approximate age, when used with 5-year intercept, will give standard site-index estimates which are slightly more accurate.

2. Standard site-index can be estimated in stands as young as 5 years above breast height and sometimes younger. The total age of such stands will almost always be less than the 20-year minimum imposed by the Gevorkiantz curves.
3. A statistical error term accompanies estimates.
4. From the data collected to develop the method, there emerged a new system which rates site quality more consistently in plantations than the Gevorkiantz curves do.

THE DATA USED IN THIS STUDY. The basic data collected for this study were measurements of successive 5-year spans of height growth beginning with the node nearest breast height. To make the intercept a reliable site quality estimator over as wide a plantation age range as possible, the oldest available white pine plantations were sought. From 26 plantations scattered through 20 counties in Lower Michigan (Figure 1), 31 plots were taken. Exact locations of plantations are recorded in the Appendices.

A plot consisted of 5 trees. These trees were usually on 1/4-acre or less and were in the dominant or codominant crown classes. They exhibited regular, clearly defined height growth the first 5 years above breast height, and were as free of defect as any that could be found. No edge trees were taken.

All heights were measured with a Blume-Leiss altimeter to the nearest 0.5 foot. During use, this instrument was mounted on a tripod to insure accurate, uniform readings.

The type of measurements taken enabled a height growth curve above breast height to be constructed for every plot (Figure 2).

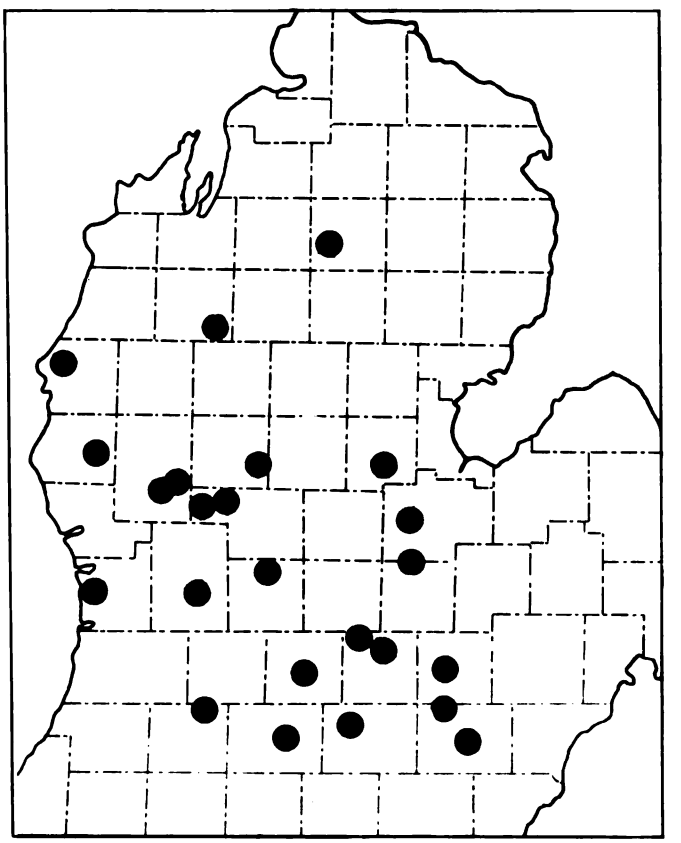

Figure 1. Geographic distribution of white pine plantings used in this study.

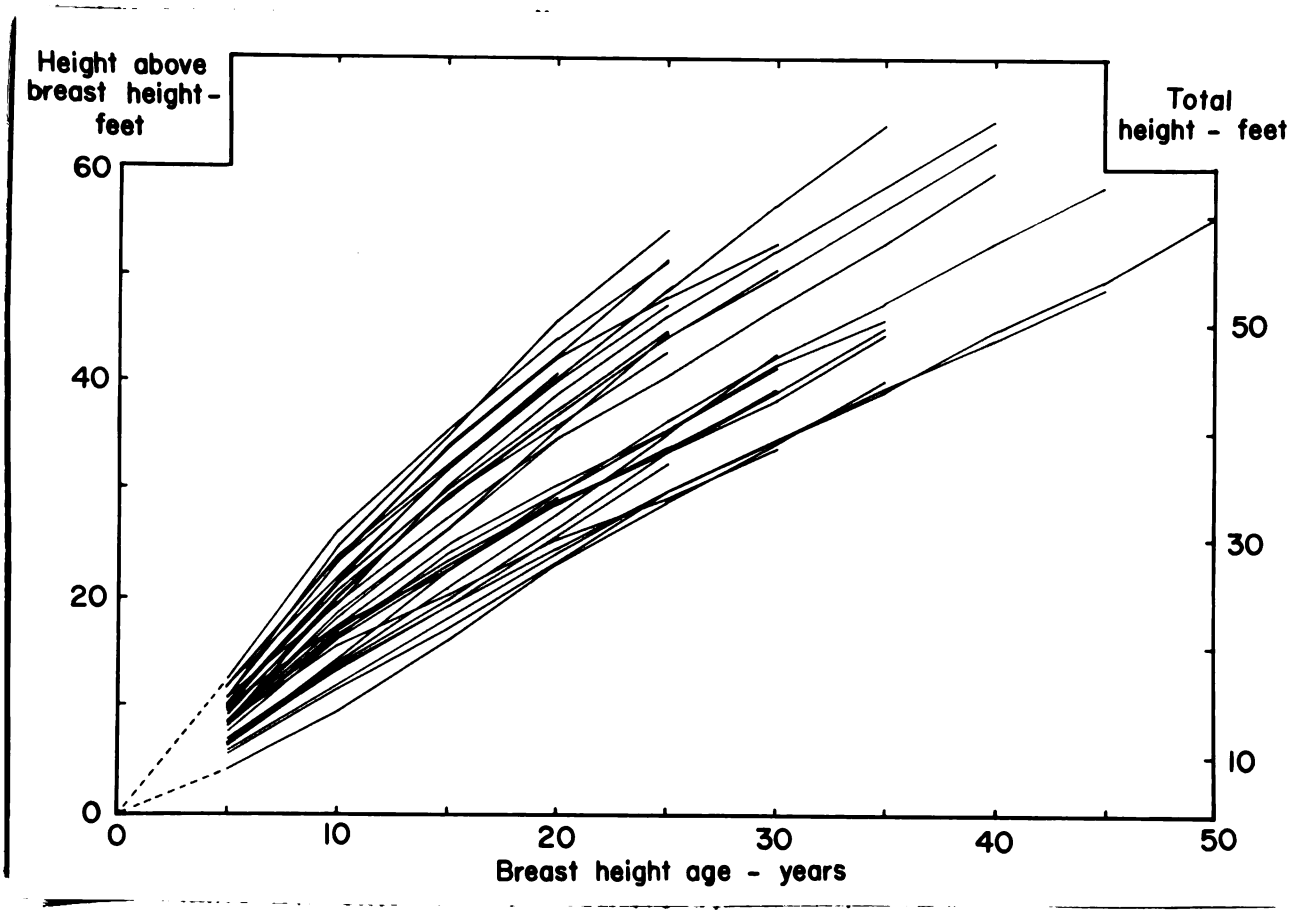

Figure 2. Height growth curves on the plots used in this study.

These curves illustrate the regularity of growth and the close relationship between early and later growth rates. The data collected from each plot are recorded in the Appendices.

It is important to note the average age of trees used to build the regression models in this study. Generally speaking, estimates of site quality become less reliable as the prediction age exceeds the mean age in the regression. The total age above breast height to which height growth was measured varied with the age of trees and the ease of measurement. Final breast-height ages to which height spans were measured on the 31 plots were as follows:

Breast-height age	No. of plots
20	4
25	10
30	6
35	5
40	3
45	2
50	1
	31

Ages at final height measurements ranged from 20 to 50 years and averaged 30 years. If white pine plantations are assumed to be 10 years old when they reach breast height, then the mean age of maximum height measurements is about 40 years.

Continuing with age of trees, it must be emphasized that on each tree a series of heights were measured to correspond to successive 5-year age increments above breast height. Each member of each series was considered an independent measurement, and therefore a total of 158 measurements from the 31 plots were available.

The breast-height age distribution among the 158 measurements is different from that of the 31 tabulated above:

Breast-height age	No. measurements
10	31
15	31
20	31
25	27
30	17
35	11
40	6
45	3
50	1
	158

Omitting the intercept, the ages ranged from 10 to 50 years and averaged about 21. Considering again that white pine plantations average about 10 years old at breast height, the average age of height measurements is then about 31 years, 9 less than before. This lesser average age is more than offset by its larger body of data. Better predictive equations resulted when every measurement was used in the regressions than when only the final plot measurements were.

A wide range of spacings was encountered on the study plots. Spacing was affected by planting interval, mortality, and thinning. It was impossible to separate these effects, so only current spacings were analyzed for effect on site ratings. The distribution of current spacings contained in the analysis was as follows:

Spacing interval in feet	No. of plots
5	5
6	23
7	16
8	38
9	16
10	44
11	3
12	4
13	
14	
15	6
16	
17	
18	
19	
20	3
	158

Spacing intervals ranged from 5 to 20 feet and averaged 9 feet. Spacing data on all plots are contained in the Appendices.

Regressions for estimating conventional site index from 5-year intercept required site index values based on the Gevorkiantz (1957) curves. In supplying these values, the usual problem of finding accurate total age of plot trees at any given height came up. Counts of growth rings from increment borings and counts of internodes were inconsistent and unsatisfactory for this purpose. Therefore, a more or less standard guide (Lake States Forest Experiment Station, 1960) was followed in assigning an age to that portion of stem below breast height. This guide gives 8 as the mean number of years white pine takes to reach breast height on "good" sites and 12 as the number on "poor" sites.

Stem deformities caused by the white pine weevil, Pissodes strobi (Peck), were common in nearly all plantations; in fact, several otherwise suitable plantations had to be rejected from the study

because of too much weevil damage. A slight height reduction occurs with every weeviling. Weeviling kills the leader, and height growth is continued by a lateral. Laterals usually are shorter than leaders, and the crook resulting when one takes over in place of a leader further shortens the next internode. Figure 3 illustrates a short internode caused by weevil attack.

No tree which had more than four weevilings in the total span measured was included in the study. The average number of weevilings per tree actually computed to only 1.8, and thus the effect of weeviling on the basic height measurements is negligible. The frequency of weeviling is recorded for each plot in the Appendices.

UTILITY OF 5-YEAR INTERCEPT IN ESTIMATING STANDARD WHITE PINE SITE INDEX. To estimate or predict one character from a knowledge of one or more other characters, a change in the variable to be predicted must be accompanied by some corresponding change in the other variable or variables. The quantification of such relationships among variables is accomplished by regression. All regression equations in this thesis were solved by the MISTIC digital computer, Michigan State University Computer Laboratory, East Lansing, Michigan.

"Standard white pine site index" in this discussion refers to values obtained from the Gevorkiantz (1957) curves. In the regression of standard white pine site index (termed the dependent variable and symbolized by Y) on 5-year intercept (termed the independent variable and symbolized by X), the regression model takes the form

$$Y = bX + a.$$

Figure 3. White pine stem damaged by the white pine weevil (Pissodes strobi (Peck), showing the resulting short internode.

The letter b is the regression coefficient of Y on X, and a is a constant. In all, 136 sets of observed Y's and X's were included in the solution of this equation. The standard site index or Y values were obtained from the Gevorkiantz (1957) curves in the usual way. Twenty-two of the 158 available measurements had been made at total ages of less than 20 years; hence they could not be assigned conventional site index values.

The predictive equation reads

$$\hat{Y} = 6.476(X) + 13.0. \qquad \text{(Equation 1)}$$

The regression line described by this equation is shown in Figure 4 along with the points on which it is based.

The utility of this regression model is indicated by several of its statistics: the standard error of estimate for standard site index, 6.1, which determines the accuracy of predictions; the simple correlation coefficient (Y with X), 0.911; and the index of determination, 0.83 (0.911 squared) which signifies that 83 percent of the variation of Y values around their mean is accounted for by X.

Another regression model was developed in which age was included as a second independent variable (X_2) along with 5-year intercept (X_1). This was done because plot site indexes being read from the Gevorkiantz (1957) curves tended to decrease as age of trees increased. The predictive equation is

$$\hat{Y} = 6.44(X_1) - .356\ (X_2) + 21.6. \qquad \text{(Equation 2)}$$

This equation produced the standard site-index lines in Figure 5. Readings from these lines are more accurate than when age is not considered.

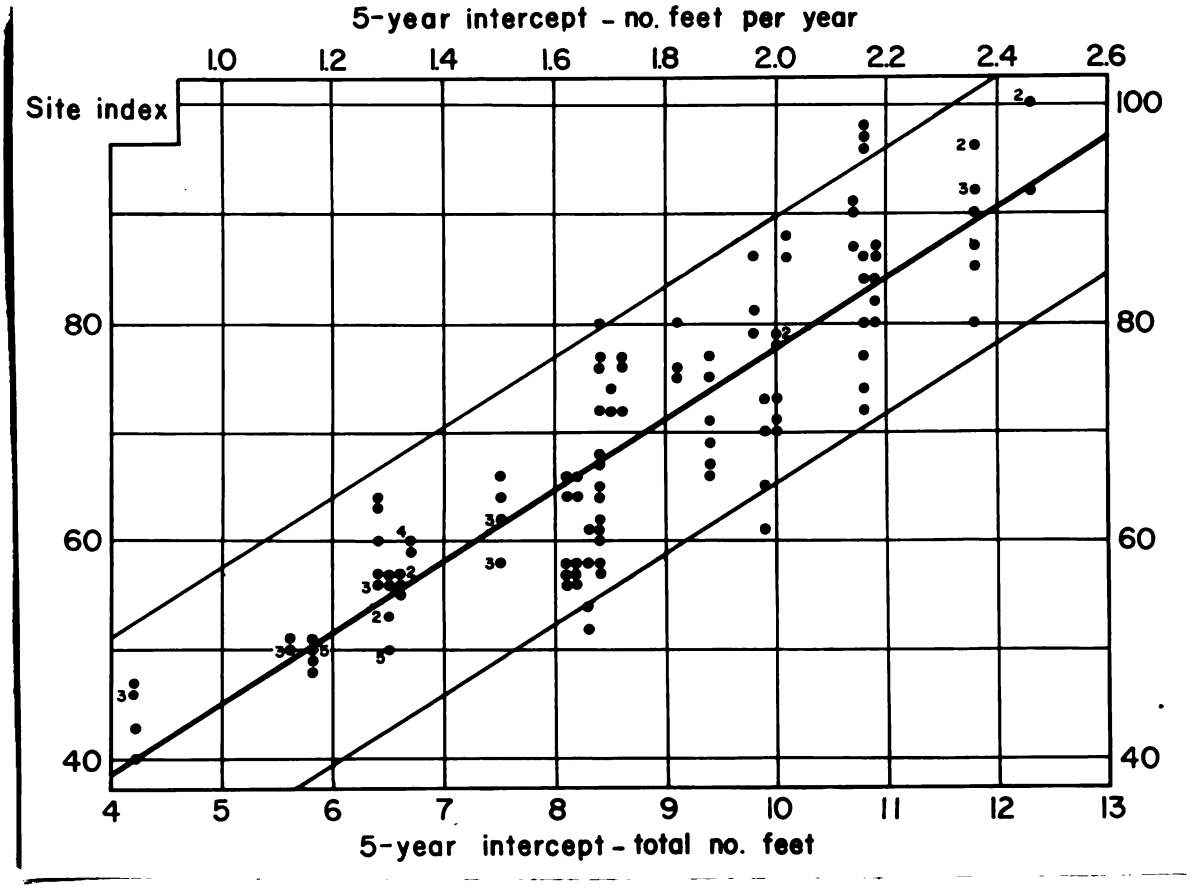

Figure 4. Relationship of standard site index to 5-year intercept in white pine plantings, with 95-percent confidence band.

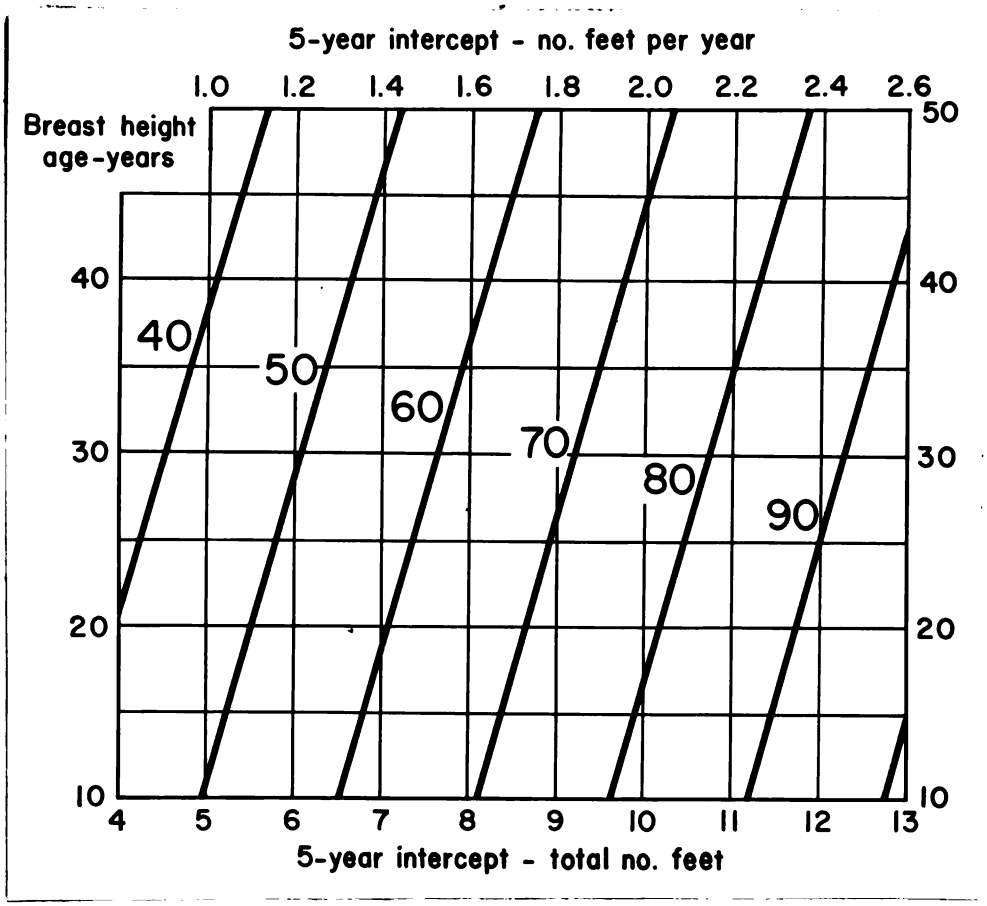

Figure 5. Relationship of standard site index to 5-year intercept and breast-height age in white pine plantings. The 95-percent confidence bands for every line were essentially straight and identical, varying only from ± 10.5 to ± 10.7.

(To illustrate the use of this graph, an intercept of 8 feet and a breast-height age of 30 years gives a site index of about 62. Site indexes are interpolated on an axis running perpendicular to the site index lines.)

This is indicated by the standard error of estimate, 5.3, which is smaller than that of equation 1; the higher multiple correlation coefficient (Y with X_1 and X_2), 0.935; and the higher index of determination, 87 percent. The contribution of age to this regression was not due to chance as was shown by a t test of its partial regression coefficient, 0.356. Its t value computed to -6.847, a large value, which for 135 degrees of freedom is significant at the .001 level.

The most plausible explanation for the decrease in conventional site index with increasing age is that young trees grow faster in plantations than in natural stands. In any case, the anamorphic site-index curves, with or without 5-year intercept, give biased estimates in plantations.

Spacing of trees was likewise tested for possible effect on the dependent variable. An equation containing spacing as a third independent variable (X_3) was solved, but the new term did not contribute significantly to regression. The t value of its partial regression coefficient computed to only 1.655 which was below the critical value of t at the .05 level for 135 degrees of freedom, ≈ 1.97.

UTILITY OF 5-YEAR INTERCEPT IN PREDICTING HEIGHT GROWTH OF PLANTED WHITE PINE. Besides predicting the height that dominants and codominants in a young white pine planting might attain at a future date, a height predicting equation can be used as a site-rating system. Therefore, another regression equation was solved where Y was total height, X_1 5-year intercept, and X_2 number of years above breast height to which the prediction would apply. The predictive equation is

$$\hat{Y} = 2.875(X_1) + 1.228(X_2) - 13.21. \qquad \text{(Equation 3)}$$

The height lines in Figure 6 were produced with this equation. Accurate height predictions are possible because of the low standard error of estimate, 3.39; the high multiple correlation coefficient (Y with X_1 and X_2), 0.963; and the high index of determination, 93 percent.

A NEW SITE-RATING SYSTEM FOR PLANTED WHITE PINE. If the age variable (X_2) of Equation 3 is held constant for height solutions (Y) over the range of 4- to 13-foot intercepts (X_1), then a new site rating system materializes. It can approximate the standard site-index system by estimating height near the 50-year total age if the age variable is stabilized at 40 years above breast height, and if plantings are reasonably assumed to average 10 years old when they reach breast height. Stabilizing the age variable also provides a simpler and more useful relationship where only the intercept need be known to obtain a site rating. This relationship is given in Figure 7.

USING THE EQUATIONS AND DIAGRAMS. The regression equations and their corresponding diagrams offer the user several possibilities.

Purpose	Data Needed	Equation or Figure
1. To roughly estimate standard site index in open planted stands.	a. Mean 5-year intercept as total or yearly no. feet from a sample of dominant and co-dominant trees.	Eq. 1, Fig. 4

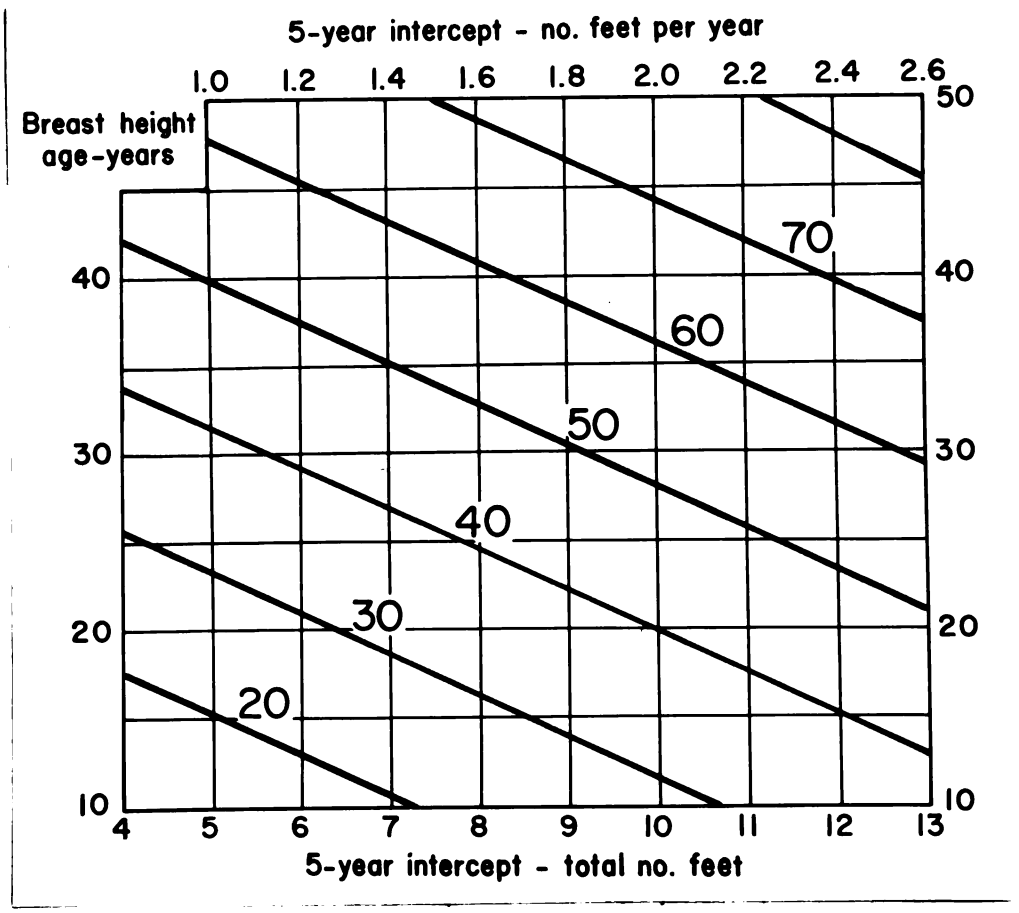

Figure 6. Relationship of total height to 5-year intercept and breast-height age in white pine plantings. The 95-percent confidence bands for every line were essentially straight and identical, varying only from±6.7 to±6.9.

(To illustrate the use of this graph, an intercept of 9 feet and a breast-height age of 35 years gives a height of about 56 feet. Heights are interpolated on an axis running perpendicular to the height lines.)

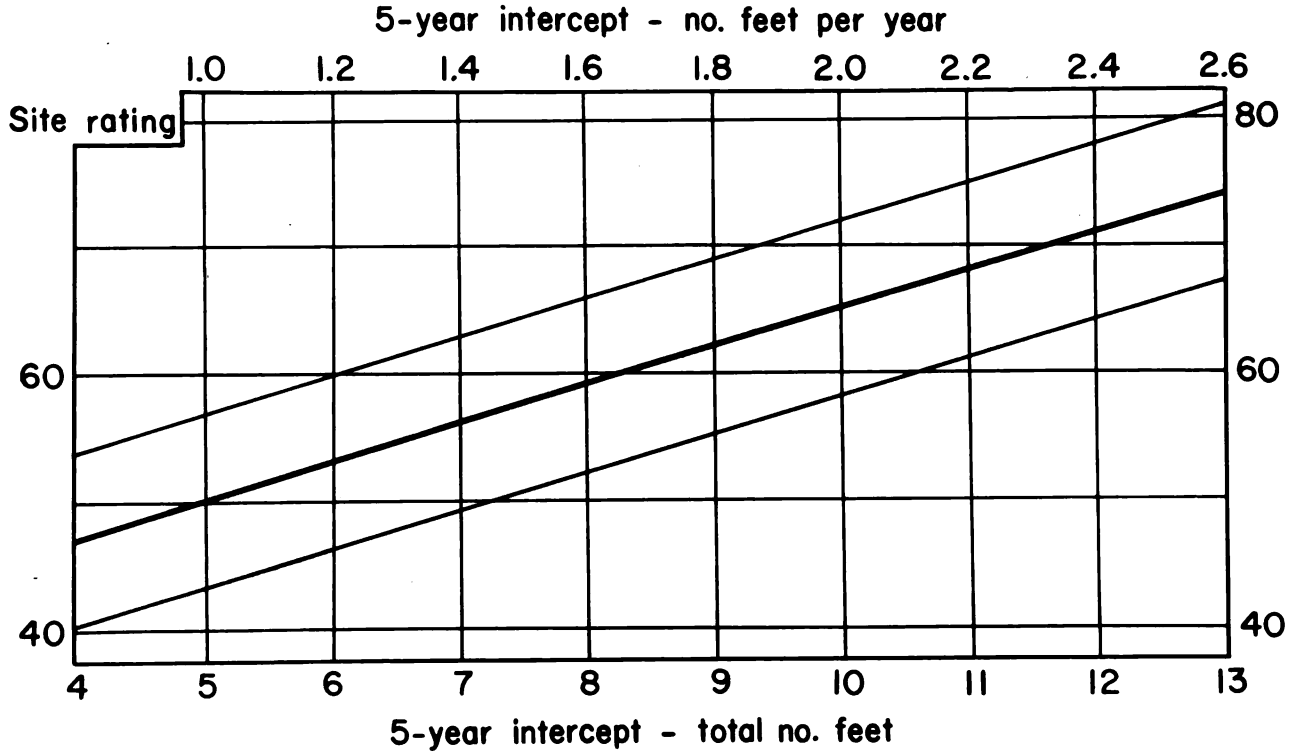

Figure 7. Relationship of new site rating to 5-year intercept in white pine plantings, with 95-percent confidence band.

2. To more accurately estimate standard site index in open-planted stands.	a. Mean 5-year intercept in either of above forms; b. Breast-height age of stand.	Eq. 2, Fig. 5
3. To estimate future height growth of open-planted stands.	a. Mean 5-year intercept in either form; b. Breast-height age to which the prediction will apply.	Eq. 3, Fig. 6
4. To rate sites by the new system in open-planted stands.	a. Mean 5-year intercept in either form.	Eq. 3, Fig. 7

The necessary data may be substituted in any of the three equations and the estimate computed, or the diagrams may be entered for graphically obtaining it. Only the total form of 5-year intercept can be used for computing a particular estimate, but all the diagrams have a scale which permits use of the yearly average form of the intercept as well as the total form. This will assist when less than 5 years' growth above breast height is available for measuring. Needless to say, caution and judgment are necessary when lesser intercepts are used in 5-year intercept formulas.

All diagrams indicate 95-percent confidence bands for estimated values of Y. This signifies that the chances are 95 in 100 that the true value lies within the band.

The confidence bands are derived from the data used in regression only; they do not take into account sampling error of intercepts obtained by the user. For most purposes, however, intercept sampling error may be disregarded. It averaged 5 percent in the 5-tree samples of this study. An intercept size of at least 5 trees is recommended, but each user may measure as many trees as he wishes according to his own standards of accuracy.

At present, the equations apply only to Michigan conditions. They could probably be used in neighboring states and perhaps in other regions. Their validity in another area might be checked by determining whether there is a statistically significant departure of estimated site ratings from actually measured ones.

EXPLANATION OF APPENDICES. For various reasons, other workers might wish to refer to the plot data collected for this thesis. To make these data available, they are appended. Appendices are numbered 1 through 31 and each contains data from one plot. Certain abbreviations are used in the Appendices as follows:

B.H. - breast height
A.M. - arithmetic mean
S.D. - standard deviation
C.V. - coefficient of variation (percentage)
S.I. - site index from the Gevorkiantz curves
S.E. - standard error (percentage)

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Appendix 1. Measurements on plot 1.

Location of plot: West edge of Howard City, Montcalm Co. North part of stand.
Spacing: 9 x 9 feet Date measured: April 1961
Mean number weevilings per sample tree: 0.4

Growth above B.H. in feet at successive 5-year intervals:

B.H. Age Interval	Tree No. 1	2	3	4	5	A.M.	S.D.	C.V.	S.I.	S.E.
5	7.0	8.5	7.5	7.5	7.0	7.5	0.6	8.2	--	3.6
10	16.5	16.0	15.0	17.0	16.0	16.1	0.7	4.6	62	--
15	23.0	21.0	21.5	25.0	23.0	22.7	1.5	6.6	66	--
20	30.5	26.5	30.0	31.5	30.0	29.7	1.8	6.1	64	--
25	38.0	34.5	35.5	38.0	35.0	36.2	1.6	4.4	62	--
30	45.0	41.5	41.5	45.0	39.5	42.5	2.4	5.7	62	--
35	49.5	47.0	47.0	51.0	44.0	47.7	2.7	5.6	58	--
40	55.5	52.5	52.0	55.5	50.5	53.2	2.2	4.1	58	--
45	--	58.5	56.5	62.0	56.0	58.3	2.7	4.7	58	--

Remarks: Not definitely known to be planted, but remarkably plantation-like if a natural stand. Two plots taken here; see Appendix 17.

Appendix 2. Measurements on plot 2.

Location of plot: Newaygo Experimental Unit, Newaygo Co., T13N-R12W, SE SW SW Sec. 35. South side of stand.
Spacing: 8 x 8 feet Date measured: April 1961
Mean number weevilings per sample tree: 2.6

Growth above B.H. in feet at successive 5-year intervals:

B.H. Age Interval	Tree No. 1	2	3	4	5	A.M.	S.D.	C.V.	S.I.	S.E.
5	5.0	6.0	6.0	5.0	6.0	5.6	0.5	9.8	--	3.9
10	12.0	13.5	11.0	10.0	11.0	11.5	1.3	11.3	50	--
15	18.0	20.5	17.0	15.0	16.0	17.3	2.1	12.1	50	--
20	23.5	26.5	23.0	21.0	23.0	23.4	1.9	8.2	50	--
25	30.5	31.0	29.5	28.0	30.5	29.9	1.1	3.7	51	--

Remarks: Two plots taken here; see Appendix 3.

Appendix 3. Measurements on plot 3.

Location of plot: Newaygo Experimental Unit, Newaygo Co., T13N-R12W, SE SW SW Sec. 35. North side of stand.
Spacing: 9 x 9 feet. Date measured: April 1961
Mean number weevilings per sample tree: 2.0

Growth above B.H. in feet at successive 5-year intervals:

B.H. Age Interval	Tree No. 1	2	3	4	5	A.M.	S.D.	C.V.	S.I.	S.E.
5	6.0	6.0	7.0	7.0	7.0	6.6	0.5	8.3	--	3.3
10	13.0	13.5	14.0	14.5	14.0	13.8	0.6	4.1	57	--
15	19.0	19.5	19.0	21.0	20.5	19.8	0.9	4.6	57	--
20	25.0	27.5	25.5	28.0	26.5	26.5	1.2	4.6	55	--
25	32.0	35.0	33.5	35.0	32.0	33.5	1.5	4.5	56	--

Remarks: Two plots taken here; see Appendix 2.

Appendix 4. Measurements on plot 4.

Location of plot: Cadillac Country Club on M-55, Wexford Co.
Spacing: 6 x 6 feet Date measured: March 1961
Mean number weevilings per sample tree: 2.0

Growth above B.H. in feet at successive 5-year intervals:

B.H. Age Interval	Tree No. 1	2	3	4	5	A.M.	S.D.	C.V.	S.I.	S.E.
5	9.0	8.0	8.5	9.0	8.5	8.6	0.4	4.9	--	2.1
10	19.0	19.0	18.0	19.5	18.0	18.7	0.7	3.6	--	--
15	26.5	26.0	26.0	26.5	27.0	26.4	0.4	1.6	72	--
20	34.5	35.5	37.0	36.5	35.0	35.7	1.0	2.8	76	--
25	43.0	44.0	44.5	46.0	45.0	44.5	1.1	2.5	77	--

Appendix 5. Measurements on plot 5.

Location of plot: Veterans Memorial Park, Charlotte, Eaton Co. West end of stand.
Spacing: 8 x 8 feet Date measured: November 1960
Mean number weevilings per sample tree: 1.0

Growth above B.H. in feet at successive 5-year intervals:

B.H. Age Interval	Tree No. 1	2	3	4	5	A.M.	S.D.	C.V.	S.I.	S.E.
5	10.0	10.0	12.0	11.0	10.5	10.7	0.8	7.8	--	3.3
10	22.0	23.5	25.0	23.5	22.5	23.3	1.1	4.7	--	--
15	32.5	33.0	36.5	35.0	33.0	34.0	1.6	4.7	91	--
20	41.0	41.0	46.0	43.0	42.0	42.6	2.0	4.7	90	--
25	51.0	50.0	55.0	51.0	50.5	51.5	2.0	3.9	87	--

Remarks: Two plots taken here; see Appendix 6.

Appendix 6. Measurements on plot 6.

Location of plot: Veterans Memorial Park, Charlotte, Eaton Co. East end of stand.
Spacing: 8 x 8 feet Date measured: April 1961
Mean number weevilings per sample tree: 1.5

Growth above B.H. in feet at successive 5-year intervals:

B.H. Age Interval	Tree No. 1	2	3	4	5	A.M.	S.D.	C.V.	S.I.	S.E.
5	8.5	8.0	7.5	9.0	9.0	8.4	0.7	7.8	--	3.7
10	20.0	22.0	18.5	20.5	19.0	20.0	1.3	6.5	--	--
15	29.5	31.5	28.5	28.5	29.0	29.4	1.2	4.1	80	--
20	38.0	39.0	36.0	36.5	35.5	37.0	1.4	3.8	76	--
25	46.0	48.0	43.0	43.0	41.5	44.3	2.6	6.0	77	--
30	51.0	53.0	50.0	51.0	48.0	50.6	1.8	3.5	72	--

Remarks: Two plots taken here; see Appendix 5.

Appendix 7. Measurements on plot 7.

Location of plot: South edge of Grayling, Crawford Co., T26N-R3W, NW NW Sec. 17.
Spacing: 9 x 10 feet Date measured: March 1961
Mean number weevilings per sample tree: 2.0

Growth above B.H. in feet at successive 5-year intervals:

B.H. Age	- - - - - Tree No. - - - - -									
Interval	1	2	3	4	5	A.M.	S.D.	C.V.	S.I.	S.E.
5	3.0	5.0	4.0	4.0	5.0	4.2	0.8	19.9	--	8.5
10	7.0	10.5	8.0	11.0	11.0	9.5	1.8	19.0	40	--
15	12.0	17.0	15.0	18.5	17.5	16.0	2.6	16.1	43	--
20	19.0	24.0	22.0	26.5	24.5	23.2	2.8	12.2	46	--
25	25.0	29.0	28.0	32.0	30.5	28.9	2.7	9.2	46	--
30	29.0	33.0	34.0	39.0	37.0	34.4	3.8	11.2	46	--
35	33.0	37.0	39.0	47.0	45.0	40.2	5.8	14.3	47	--

Appendix 8. Measurements on plot 8.

Location of plot: Consumers Power Co. Plantation No. 23 on M-47, south of Oakley, Shiawassee Co.
Spacing: 10 x 10 feet Date measured: November 1960
Mean number weevilings per sample tree: 2.2

Growth above B.H. in feet at successive 5-year intervals:

B.H. Age	- - - - - Tree No. - - - - -									
Interval	1	2	3	4	5	A.M.	S.D.	C.V.	S.I.	S.E.
5	9.0	9.0	11.5	11.0	10.0	10.1	1.1	10.9	--	4.9
10	20.5	21.0	22.5	23.5	20.0	21.5	1.7	7.9	--	--
15	30.0	34.0	33.0	33.5	30.0	32.1	1.9	5.9	86	--
20	39.0	41.5	41.5	43.5	38.5	40.8	2.0	4.9	88	--

Appendix 9. Measurements on plot 9.

Location of plot: Northwest edge of Remus, Mecosta Co., Southwest part of stand.
Spacing: 6 x 6 feet Date measured: March 1961
Mean number weevilings per sample tree: 2.5

Growth above B.H. in feet at successive 5-year intervals:

B.H. Age Interval	Tree No. 1	2	3	4	5	A.M.	S.D.	C.V.	S.I.	S.E.
5	8.5	8.0	7.5	7.5	9.0	8.1	0.7	8.0	--	3.9
10	15.5	16.0	17.0	18.0	16.0	16.5	1.0	6.1	--	--
15	21.5	23.5	23.0	25.5	22.0	23.1	1.5	6.5	66	--
20	26.0	30.0	28.0	32.0	27.5	28.7	2.3	8.0	64	--
25	29.5	35.0	34.0	36.5	32.5	33.5	2.7	8.0	58	--
30	35.0	41.0	40.0	42.5	37.5	39.2	3.0	7.7	57	--
35	39.5	48.0	46.5	48.0	44.0	45.2	3.6	7.9	56	--

Remarks: Originally spaced 4 x 5 feet; stand thinned several years before above measurements taken. Two plots taken here; see Appendix 10.

Appendix 10. Measurements on plot 10.

Location of plot: Northwest edge of Remus, Mecosta Co. Northwest part of stand.
Spacing: 6 x 6 feet Date measured: March 1961
Mean number weevilings per sample tree: 2.5

Growth above B.H. in feet at successive 5-year intervals:

B.H. Age Interval	Tree No. 1	2	3	4	5	A.M.	S.D.	C.V.	S.I.	S.E.
5	8.5	8.5	7.5	8.0	8.5	8.2	0.4	5.5	--	2.2
10	15.5	18.5	17.0	16.0	17.0	16.8	1.1	6.6	--	--
15	22.5	24.0	24.5	23.0	23.0	23.4	0.8	3.5	66	--
20	29.0	28.0	30.0	28.5	29.0	28.9	2.3	8.0	64	--
25	33.5	32.0	34.5	33.5	34.0	33.5	0.9	2.8	58	--
30	39.5	38.0	39.5	37.5	38.0	38.5	0.9	2.4	57	--
35	46.0	43.0	47.0	44.5	43.0	44.7	1.7	3.8	56	--

Remarks: Originally spaced 4 x 5 feet; stand thinned several years before above measurements taken. Two plots taken here; see Appendix 9.

Appendix 11. Measurements on plot 11.

Location of plot: Kellogg Farm headquarters (Michigan State University), near Gull Lake, Kalamazoo Co.
Spacing: 8 x 8 feet Date measured: April 1961
Mean number weevilings per sample tree: 1.0

Growth above B.H. in feet at successive 5-year intervals:

B.H. Age Interval	Tree No. 1	2	3	4	5	A.M.	S.D.	C.V.	S.I.	S.E.
5	9.0	13.0	10.5	11.5	10.0	10.8	1.5	13.9	--	6.2
10	23.0	25.5	24.5	25.0	25.5	24.7	1.0	4.1	--	--
15	34.0	35.0	34.5	34.0	37.0	34.9	1.2	3.4	97	--
20	45.0	45.0	45.5	45.0	48.5	45.8	1.5	3.3	98	--
25	54.0	54.0	53.5	54.0	55.5	54.2	0.7	1.4	96	--

Remarks: Original spacing 7 x 7 feet; stand thinned several years before above measurements were taken.

Appendix 12. Measurements on plot 12.

Location of plot: Farm on M-50 near West Olive, Ottawa Co., T7N-R16W, W Sec. 25.
Spacing: 5 x 5 feet Date measured: October 1960
Mean number weevilings per sample tree: 2.5

Growth above B.H. in feet at successive 5-year intervals:

B.H. Age Interval	Tree No. 1	2	3	4	5	A.M.	S.D.	C.V.	S.I.	S.E.
5	10.0	9.0	8.0	7.5	7.0	8.3	1.1	13.3	--	5.9
10	17.0	16.5	14.0	15.5	14.5	15.5	1.2	7.8	--	--
15	21.0	20.0	18.5	21.0	19.5	20.0	1.0	5.0	61	--
20	25.0	24.5	24.5	26.5	27.5	25.6	1.3	5.1	58	--
25	27.5	27.0	29.0	31.0	32.0	29.3	2.1	7.2	54	--
30	32.0	31.0	33.0	36.5	37.0	33.9	2.7	8.0	52	--

Appendix 13. Measurements on plot 13.

Location of plot: Near Tompkins Center, Jackson Co., T1S-R2W, SE Sec. 19.
Spacing: 10 x 10 feet Date measured: November 1960
Mean number weevilings per sample tree: 2.0

Growth above B.H. in feet at successive 5-year intervals:

B.H. Age Interval	Tree No. 1	2	3	4	5	A.M.	S.D.	C.V.	S.I.	S.E.
5	12.0	12.0	12.0	10.0	13.0	11.8	1.0	8.6	--	3.8
10	22.5	22.0	20.0	19.5	25.0	21.8	2.1	9.7	--	--
15	32.5	31.5	32.0	29.5	34.0	31.9	1.6	5.0	92	--
20	41.0	39.0	39.0	38.5	43.0	40.1	1.8	4.5	90	--
25	47.5	46.5	45.5	47.0	50.0	47.3	1.6	3.4	85	--

Remarks: Original spacing 6 x 6 feet; stand had been thinned several years before above measurements taken.

Appendix 14. Measurements on plot 14.

Location of plot: Beal Pinetum, Michigan State University Campus, East Lansing, Ingham Co.
Spacing: 8 x 12 feet Date measured: October 1960
Mean number weevilings per sample tree: 0

Growth above B.H. at successive 5-year intervals:

B.H. Age Interval	Tree No. 1	2	3	4	5	A.M.	S.D.	C.V.	S.I.	S.E.
5	13.5	12.0	10.0	12.0	11.5	11.8	1.2	10.2	--	4.5
10	24.5	24.0	22.0	24.5	23.0	23.6	1.0	4.3	--	--
15	33.0	36.0	32.5	34.5	33.5	33.9	1.3	3.9	96	--
20	39.5	45.5	41.5	42.0	42.5	42.2	2.1	5.0	96	--
25	43.5	50.5	48.0	49.0	49.0	48.0	2.7	5.6	87	--
30	48.0	57.0	53.0	53.5	54.0	53.1	3.2	6.1	80	--

Appendix 15. Measurements on plot 15.

Location of plot: Ringwood estate (University of Michigan), near St. Charles, Saginaw Co., T10N-R2E, SW NW Sec. 13.
Spacing: 7 x 7 feet Date measured: November 1960
Mean number weevilings per sample tree: 2.5

Growth above B.H. in feet at successive 5-year intervals:

B.H. Age Interval	Tree No. 1	2	3	4	5	A.M.	S.D.	C.V.	S.I.	S.E.
5	11.5	11.5	10.0	14.0	12.0	11.8	1.4	11.9	--	5.3
10	24.5	24.0	21.0	26.5	23.0	23.8	2.0	8.4	--	--
15	32.0	31.0	30.5	34.5	33.0	32.2	1.6	5.0	92	--
20	39.5	39.0	38.0	44.0	41.0	40.3	2.3	5.7	92	--

Remarks: Original spacing 6 x 6 feet; stand had been thinned several years before above measurements were made.

Appendix 16. Measurements on plot 16.

Location of plot: Residential property on M-46 west of Amble, Montcalm Co. West part of stand.
Spacing: 9 x 10 feet Date measured: November 1960
Mean number weevilings per sample tree: 3.0

Growth above B.H. in feet at successive 5-year intervals:

B.H. Age Interval	Tree No. 1	2	3	4	5	A.M.	S.D.	C.V.	S.I.	S.E.
5	7.0	5.0	6.0	6.0	5.0	5.8	0.8	14.4	--	6.1
10	13.0	12.5	11.0	12.0	10.5	11.8	1.0	8.5	50	--
15	18.0	19.0	18.0	19.0	17.0	18.2	0.8	4.6	50	--
20	25.0	23.5	24.5	25.0	22.5	24.1	1.0	4.2	51	--
25	30.0	30.0	30.5	31.0	28.0	29.9	1.1	3.7	50	--
30	35.0	35.0	35.5	36.0	33.0	34.9	1.1	3.2	50	--
35	39.0	39.5	41.0	40.5	38.0	39.6	1.1	2.8	50	--
40	42.0	44.5	46.0	45.0	42.5	44.0	1.6	3.7	48	--
45	46.5	49.0	51.0	--	--	48.8	2.2	4.6	49	--

Remarks: Not definitely known to be planted, but remarkably plantation-like if a natural stand. Two plots taken here; see Appendix 26.

Appendix 17. Measurements on plot 17.

Location of plot: West edge of Howard City, Montcalm Co. West part of stand.
Spacing: 15 x 15 feet Date measured: October 1960
Mean number weevilings per sample tree: 2.5

Growth above B.H. in feet at successive 5-year intervals:

B.H. Age Interval	Tree No. 1	2	3	4	5	A.M.	S.D.	C.V.	S.I.	S.E.
5	9.0	7.5	8.0	9.0	8.5	8.4	0.6	7.8	--	3.2
10	19.5	15.5	17.0	17.0	14.0	16.5	2.0	12.1	--	--
15	27.0	22.0	25.0	24.5	22.5	24.2	2.0	8.3	68	--
20	32.0	27.5	31.0	31.0	28.0	29.9	2.0	6.7	65	--
25	39.0	32.0	35.0	37.5	35.0	35.7	2.7	7.5	62	--
30	47.0	37.5	40.0	43.0	41.0	41.7	3.6	8.5	60	--
35	--	43.0	44.5	50.0	46.0	45.9	3.0	6.6	57	--

Remarks: Not definitely known to be planted, but remarkably plantation-like if a natural stand. Two plots taken here; see Appendix 1.

Appendix 18. Measurements on plot 18.

Location of plot: Farm near Walkerville, Oceana Co., T15N-R15W, NE NE Sec. 33.
Spacing: 20 x 20 feet Date measured: October 1960
Mean number weevilings per sample tree: 2.0

Growth above B.H. in feet at successive 5-year intervals:

B.H. Age Interval	Tree No. 1	2	3	4	A.M.	S.D.	C.V.	S.I.	S.E.
5	9.0	9.0	9.0	7.0	8.5	1.0	11.8	--	5.2
10	19.0	19.0	17.0	17.0	18.0	1.1	6.1	--	--
15	28.0	28.0	24.0	26.0	26.5	1.9	7.2	72	--
20	37.0	36.0	32.0	34.0	34.7	2.2	6.3	74	--

Appendix 19. Measurements on plot 19.

Location of plot: Estate on U.S. 27 at north edge of Marshall, Calhoun Co.
Spacing: 7 x 7 feet Date measured: November 1960
Mean number weevilings per sample tree: 2.0

Growth above B.H. in feet at successive 5-year intervals:

B.H. Age	- - - - - Tree No. - - - - -									
Interval	1	2	3	4	5	A.M.	S.D.	C.V.	S.I.	S.E.
5	9.0	8.5	11.0	9.0	8.0	9.1	1.0	11.0	--	4.9
10	21.0	18.0	22.0	20.0	20.0	20.2	1.4	7.0	--	--
15	28.5	28.5	30.0	30.5	29.0	29.3	0.9	3.0	80	--
20	34.5	35.0	36.0	37.5	36.5	35.9	1.1	3.1	76	--
25	--	43.0	--	--	--	43.0	--	--	75	--

Appendix 20. Measurements on plot 20.

Location of plot: Newaygo Experimental Unit, Manistee National Forest, Newaygo Co., T13N-R12W, NW SW Sec. 35.
Spacing: 12 x 12 feet Date measured: April 1961
Mean number weevilings per sample tree: 1.2

Growth above B.H. in feet at successive 5-year intervals:

B.H. Age	- - - - - Tree No. - - - - -									
Interval	1	2	3	4	5	A.M.	S.D.	C.V.	S.I.	S.E.
5	6.0	6.0	7.0	6.0	7.0	6.4	0.5	8.6	--	3.5
10	14.0	12.5	14.0	12.0	14.0	13.3	1.0	7.3	56	--
15	19.5	17.5	19.5	19.0	21.5	19.4	1.4	7.2	57	--
20	26.5	24.0	26.0	25.0	27.5	25.8	1.3	5.1	56	--
25	32.5	30.5	33.5	--	34.0	32.6	1.5	4.6	56	--

Appendix 21. Measurements on plot 21.

Location of plot: South of Demonstration Hall, Michigan State University Campus, East Lansing, Ingham Co.
Spacing: 8 x 8 feet Date measured: April 1961
Mean number weevilings per sample tree: 1.0

Growth above B.H. in feet at successive 5-year intervals:

B.H. Age Interval	Tree No. 1	2	3	4	5	A.M.	S.D.	C.V.	S.I.	S.E.
5	9.0	10.5	8.0	8.0	6.5	8.4	1.4	16.8	--	7.4
10	18.5	18.5	16.0	16.0	17.0	17.2	1.2	7.0	--	--
15	25.0	24.0	20.0	22.0	22.5	22.7	1.9	8.4	67	--
20	31.5	31.0	26.5	27.0	28.0	28.8	2.3	8.0	64	--
25	36.0	35.0	33.0	33.0	32.0	33.8	1.6	4.7	61	--
30	43.0	40.0	37.0	39.5	37.0	39.3	2.4	6.1	58	--

Appendix 22. Measurements on plot 22.

Location of plot: Lot No. 52, Stinchfield Woods (University of Michigan), near Dexter, Washtenaw Co., T1S-R4E, NW SW Sec. 11.
Spacing: 9 x 9 feet Date measured: April 1961
Mean number weevilings per sample tree: 0.5

Growth above B.H. in feet at successive 5-year intervals:

B.H. Age Interval	Tree No. 1	2	3	4	5	A.M.	S.D.	C.V.	S.I.	S.E.
5	13.0	12.0	12.5	11.0	13.0	12.3	0.8	6.8	--	2.9
10	26.0	27.0	25.0	25.0	27.5	26.1	1.1	4.2	--	--
15	36.0	36.0	33.5	34.5	37.0	35.4	1.3	3.7	100	--
20	45.0	45.0	41.5	42.5	46.0	44.0	1.9	4.3	100	--
25	51.0	51.0	49.5	51.5	54.0	51.4	1.6	3.1	92	--

Appendix 23. Measurements on plot 23.

Location of plot: Howell State Sanatorium, near Howell, Livingston Co., T2N-R4E, NW SW Sec. 3.
Spacing: 7 x 7 feet Date measured: May 1961
Mean number weevilings per sample tree: 2.2

Growth above B.H. in feet at successive 5-year intervals:

B.H. Age Interval	Tree No. 1	2	3	4	5	A.M.	S.D.	C.V.	S.I.	S.E.
5	10.5	9.0	10.5	9.5	10.0	9.9	0.7	6.6	--	3.2
10	19.0	15.0	18.5	16.0	17.5	17.2	1.6	9.3	--	--
15	27.5	23.0	25.5	23.5	25.5	25.0	1.8	7.2	73	--
20	33.5	28.0	32.0	28.0	31.0	30.5	2.4	7.9	70	--
25	38.0	33.5	37.5	32.5	36.5	35.6	2.4	6.8	65	--
30	44.0	38.5	44.0	37.5	43.5	41.5	3.2	7.8	61	--

Appendix 24. Measurements on plot 24.

Location of plot: Lot No. I-2b, Saginaw Forest (University of Michigan), near Ann Arbor, Washtenaw Co., T2S-R5E, S NE Sec. 26.
Spacing: 10 x 10 feet Date measured: May 1961
Mean number weevilings per sample tree: 1.5

Growth above B.H. in feet at successive 5-year intervals:

B.H. Age Interval	Tree No. 1	2	3	4	5	A.M.	S.D.	C.V.	S.I.	S.E.
5	10.5	8.5	9.0	11.5	10.5	10.0	1.2	12.0	--	5.4
10	22.5	19.0	19.5	22.0	20.5	20.7	1.5	7.3	--	--
15	30.0	27.5	28.0	30.0	29.5	29.0	1.1	3.8	79	--
20	38.0	36.0	35.0	38.0	37.0	36.8	1.3	3.5	79	--
25	44.5	45.0	42.0	44.5	44.5	44.1	1.1	2.5	78	--
30	49.5	51.0	48.0	52.0	50.0	50.1	1.5	3.0	73	--
35	56.5	56.0	55.0	57.0	57.0	56.3	0.8	1.5	71	--
40	--	62.0	62.0	63.5	62.0	62.4	0.7	1.2	70	--

Remarks: Original spacing closer than 10 x 10 feet; stand had been thinned.

Appendix 25. Measurements on plot 25.

Location of plot: Lot No. I-4, Saginaw Forest (University of Michigan), near Ann Arbor, Washtenaw Co., T25-R5E, S NE Sec. 26.
Spacing: 10 x 10 feet Date measured: May 1961
Mean number weevilings per sample tree: 1.0

Growth above B.H. in feet at successive 5-year intervals:

B.H. Age Interval	Tree No. 1	2	3	4	A.M.	S.D.	C.V.	S.I.	S.E.
5	9.0	8.0	10.0	10.5	9.4	1.1	11.7	--	5.2
10	19.0	17.0	20.0	21.0	19.3	1.7	8.8	--	--
15	28.0	25.0	27.5	29.0	27.4	1.7	6.2	77	--
20	34.0	37.5	35.5	37.0	34.7	1.9	5.5	75	--
25	39.0	39.0	43.0	42.0	40.7	2.0	4.9	71	--
30	44.0	45.5	49.0	49.5	47.0	2.7	5.7	69	--
35	49.5	51.5	55.5	56.0	53.1	3.1	5.9	67	--
40	56.0	58.0	62.0	63.0	59.7	3.3	5.5	66	--

Remarks: Original spacing closer than 10 x 10 feet; stand had been thinned.

Appendix 26. Measurements on plot 26.

Location of plot: Residential property on M-46 west of Amble, Montcalm Co. Southwest part of stand.
Spacing: 9 x 10 feet Date measured: June 1961
Mean number weevilings per sample tree: 3.0

Growth above B.H. in feet at successive 5-year intervals:

B.H. Age Interval	Tree No. 1	2	3	4	5	A.M.	S.D.	C.V.	S.I.	S.E.
5	6.0	6.5	7.0	7.5	5.5	6.5	0.8	12.2	--	5.5
10	11.0	13.5	13.5	13.5	14.5	13.2	1.3	9.8	56	--
15	16.0	20.0	20.0	19.0	21.0	19.2	1.9	9.9	57	--
20	21.5	27.5	24.0	23.0	26.5	24.5	2.4	9.8	53	--
25	27.0	33.0	29.5	29.5	31.0	30.0	2.2	7.3	53	--
30	31.0	37.5	34.5	34.5	36.0	34.7	2.4	6.9	50	--
35	35.0	42.0	39.0	39.0	41.5	39.3	2.8	7.1	50	--
40	40.0	48.0	44.0	44.5	47.5	44.8	3.2	7.2	50	--
45	44.0	52.0	50.5	50.0	51.5	49.6	3.2	6.5	50	--
50	47.5	58.0	56.5	57.0	58.0	55.4	4.5	8.1	50	--

Remarks: Not definitely known to be planted, but remarkably plantation-like if a natural stand. Two plots taken here; see Appendix 16.

Appendix 27. Measurements on plot 27.

Location of plot: Farm, intersection of M-55 and M-44, Ionia Co., T8N-R7W, SE SE Sec. 13.
Spacing: 6 x 6 feet Date measured: June 1961
Mean number weevilings per sample tree: 1.8

Growth above B.H. in feet at successive 5-year intervals:

B.H. Age Interval	Tree No. 1	2	3	4	5	A.M.	S.D.	C.V.	S.I.	S.E.
5	12.5	9.0	11.0	9.5	12.0	10.8	1.5	13.9	--	6.2
10	21.0	17.5	18.5	19.0	21.0	19.4	1.5	7.8	--	--
15	31.0	28.0	26.5	32.0	34.5	30.4	3.2	10.5	86	--
20	37.5	36.5	36.5	41.5	42.0	38.8	2.7	7.0	84	--
25	44.5	44.0	43.5	47.5	51.5	46.2	3.3	7.2	80	--
30	51.5	50.0	48.0	55.5	57.0	52.4	3.8	7.2	77	--
35	57.5	57.0	52.0	--	66.5	58.3	6.0	10.3	74	--
40	64.0	65.0	56.0	--	72.0	64.3	6.5	10.2	72	--

Appendix 28. Measurements on plot 28.

Location of plot: Estate near Grand Rapids, Kent Co., T7N-R10W, SE NW Sec. 29.
Spacing: 8 x 8 feet Date measured: August 1961
Mean number weevilings per sample tree: 2.0

Growth above B.H. in feet at successive 5-year intervals:

B.H. Age Interval	Tree No. 1	2	3	4	5	A.M.	S.D.	C.V.	S.I.	S.E.
5	14.0	8.5	9.5	11.0	11.5	10.9	2.1	19.3	--	8.6
10	28.5	18.0	20.0	24.0	25.5	23.2	4.2	18.2	--	--
15	39.0	27.5	27.0	31.0	34.0	31.7	5.2	16.4	86	--
20	48.0	33.0	36.5	42.0	42.0	40.3	5.8	14.3	87	--
25	56.0	39.5	46.0	52.5	49.5	48.7	6.3	13.0	84	--
30	64.0	46.0	55.0	59.0	59.5	56.7	6.8	12.0	82	--
35	72.0	55.5	63.0	65.5	--	64.0	6.8	10.7	80	--

Appendix 29. Measurements on plot 29.

Location of plot: Farm near Millwood, Mason Co., T19N-R17W, NE NE Sec. 9.
Spacing: 10 x 12 feet Date measured: August 1961
Mean number weevilings per sample tree: 1.8

Growth above B.H. in feet at successive 5-year intervals:

B.H. Age Interval	Tree No. 1	2	3	4	5	A.M.	S.D.	C.V.	S.I.	S.E.
5	7.0	6.0	4.0	7.0	8.0	6.4	1.5	23.5	--	10.5
10	16.0	14.0	10.0	17.0	14.0	14.2	2.7	18.9	60	--
15	26.0	23.0	19.0	24.5	21.0	22.7	2.8	12.2	63	--
20	34.0	30.0	25.5	29.5	27.5	29.3	3.2	10.8	64	--

Appendix 30. Measurements on plot 30.

Location of plot: Houghton Lake State Forest, Roscommon Co., T21N-R3W, NW NE Sec. 5.
Spacing: 8 x 8 feet Date measured: August 1961
Mean number weevilings per sample tree: 2.4

Growth above B.H. in feet at successive 5-year intervals:

B.H. Age Interval	Tree No. 1	2	3	4	5	A.M.	S.D.	C.V.	S.I.	S.E.
5	5.5	6.5	6.5	6.5	8.5	6.7	1.0	15.1	--	6.7
10	12.0	13.5	13.5	14.5	16.0	13,9	1.4	10.1	60	--
15	18.5	19.5	23.0	20.0	24.0	21.0	2.3	11.0	60	--
20	24.0	25.5	31.5	27.0	31.5	27.9	3.4	12.4	59	--
25	31.5	32.5	40.0	32.0	39.5	35.1	4.2	12.1	60	--
30	38.5	39.5	48.0	38.0	48.5	42.5	5.3	12.4	60	--

Remarks: Original spacing about 4 x 5 feet; stand had been thinned several years before above measurements were made.

Appendix 31. Measurements on plot 31.

Location of plot: Kiwanis Forest on M-30, Midland Co., T14N-R1W, N SE Sec. 24.
Spacing: 7 x 7 feet Date measured: August 1961
Mean number weevilings per sample tree: 1.0

Growth above B.H. in feet at successive 5-year intervals:

B.H. Age Interval	Tree No. 1	2	3	4	5	A.M.	S.D.	C.V.	S.I.	S.E.
5	10.0	8.5	10.5	11.0	9.0	9.8	1.0	10.2	--	4.5
10	22.0	19.0	22.0	23.0	20.0	21.2	1.7	8.1	--	--
15	32.0	26.5	30.5	32.5	28.5	30.0	2.5	8.3	86	--
20	39.5	33.0	39.0	40.5	35.5	37.5	3.1	8.4	81	--
25	46.0	39.5	47.0	48.0	43.0	44.7	3.5	7.7	79	--